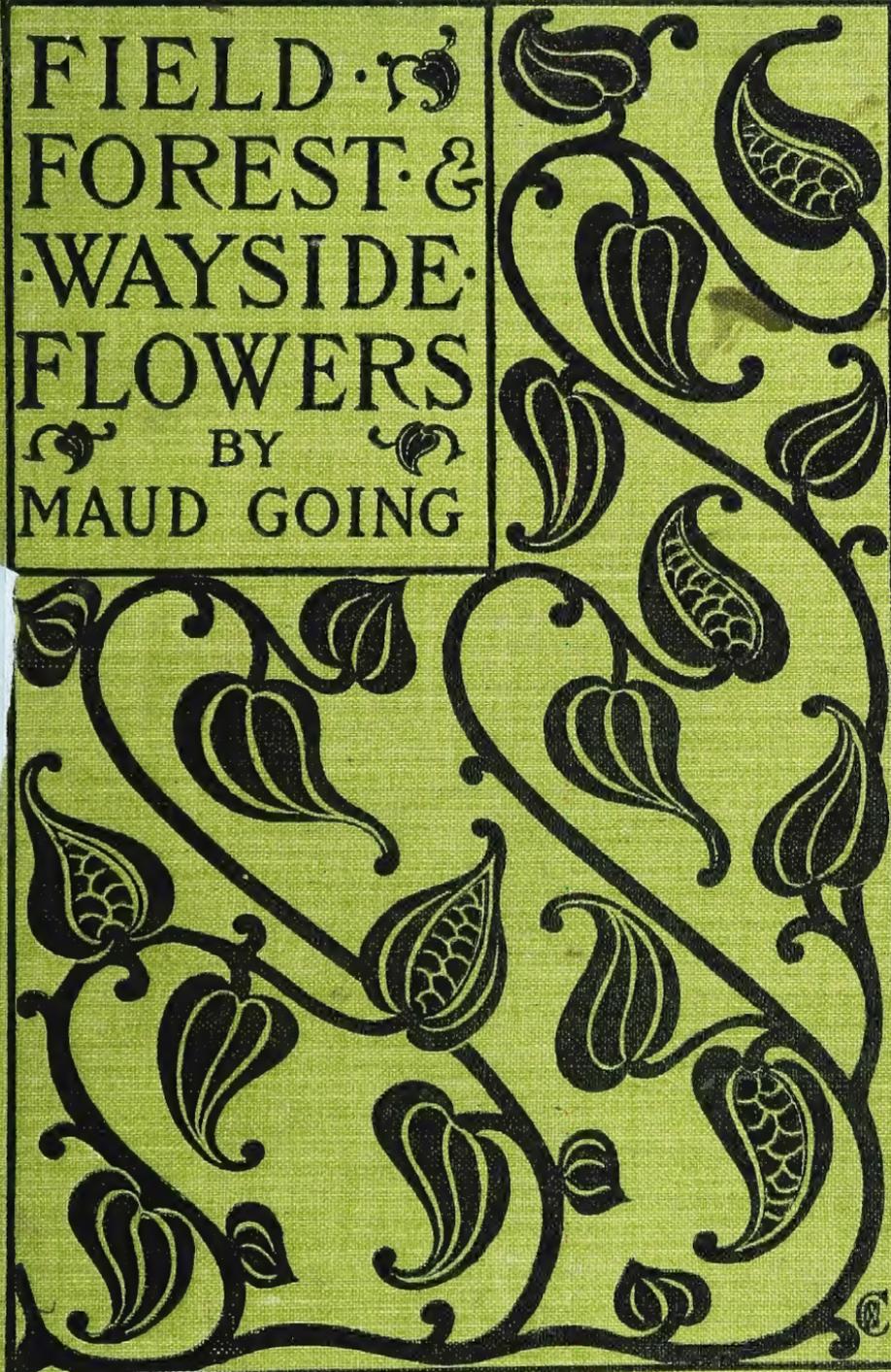


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Field, Forest, and Wayside Flowers

By Maud Goepp

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MAY-APPLE (*Podophyllum peltatum*). (See p. 56.)

Field, Forest, and Wayside Flowers

With Chapters on Grasses, Sedges
and Ferns

*Untechnical Studies
for Unlearned Lovers of Nature*

BY

MAUD GOING

(E. M. HARDINGE)

Illustrated in part with Drawings from Life by
Julia S. C. Porter and Photographs
by Edwin W. Lincoln

NEW YORK
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Foreword

THE chapters of this book are so arranged as to follow the waxing and waning of plant-life during an average season in the northeastern United States.

By this plan a few repetitions have been absolutely unavoidable, and for these the author apologizes to the—she hopes—“gentle” reader. The only other arrangement possible would have been a systematic one, adopting the most recent views as to the relationship and development of plant-families. I hardly had courage for such an enterprise as this, and moreover the thing has been done so fully, so ably, and so recently, that the student who seeks a systematic botany will find his wants already amply supplied.

This book is written more especially for people who have not time, or, perhaps, inclination, to become actual students, who have not familiarized themselves with botanic nomenclature and technical terms, and who yet love to observe the beauties and the wonders of familiar plant-life.

“A little learning is a dangerous thing,” was written before the days of Nature-study. In that domain “a little learning,” provided always that it be accurate as far as it goes, is a stimulus to much interesting work, opens the eyes to many beauties, and proves an every-day delight; for what one finds in the fields depends largely upon what one takes into them, and in field and forest, as elsewhere, “the eye sees that which it brings with it the power of seeing.”

The young hero of an old German fairy-tale wandered far and wide, seeking the key-flower which he had seen in dreams, and which was to open for him a treasure-house of riches. And when he returned from his long and fruitless quest he found the magic blossom blowing at the threshold of his door.

Perhaps this means that we shall find our purest joys, after all, in the simple things which are in reach of most of us—such as the love of kindred, the friendship of books, and the companionship of Nature, which, constant through all changes, ever shows us the same winsome face.

My sincere thanks are due to the publishers of the “Popular Science Monthly,” the New York “Evening Post,” “Arthur’s Home Magazine,”

and "Merry Times," for permission to issue, in their present guise, such portions of this book as have appeared in their respective publications.

M. G.

Contents

	PAGE
CHAPTER I.	
CROCUSES	17
CHAPTER II.	
DANDELIONS.....	36
CHAPTER III.	
IN APRIL WEATHER	49
CHAPTER IV.	
THE FLOWERING OF THE FOREST-TREES.....	64
CHAPTER V.	
GREEN LEAVES AT WORK	87
CHAPTER VI.	
LILY-KIN AND ROSE-KIN.....	116
CHAPTER VII.	
GRASSES.....	149
CHAPTER VIII.	
RUSHES AND SEDGES.....	177
CHAPTER IX.	
NIGHT FLOWERS.....	199
CHAPTER X.	
CLIMBING PLANTS.....	232

CHAPTER XI.	
THE SPORING OF THE FERN.....	246
CHAPTER XII.	
THE SENIORS OF THE FOREST.....	268
CHAPTER XIII.	
DOGBANE AND MILKWEED.....	300
CHAPTER XIV.	
THISTLES AND NETTLES.....	317
CHAPTER XV.	
A HANDFUL OF WEEDS.....	347
CHAPTER XVI.	
THE SLEEPING OF THE FIELDS.....	363
CHAPTER XVII.	
MARTINMAS SUMMER.....	373
CHAPTER XVIII.	
IN WINTER WOODS.....	384

List of Illustrations

Frontispiece, May-apple (*Podophyllum peltatum*).

FIG.	PAGE
1. Golden crocus (<i>Crocus aurens</i>), with analysis of the flower	20
2a. Calyces of differing forms, Fox-glove, aconite, fuchsia, valerian, flax, and loose-strife	21
2b. Corollas of various form, Tobacco-plant, lilac, sage, arbutus, pea, convolvulus, pink, and geranium	23
3a. A pollen grain of the melon (much magnified)	24
3b. Pollen grains of the European hazel (<i>Corylus Avellana</i>) putting forth their pollen tubes	26
4. Florets and fruits of the dandelion	41
5. Some altered calyces of composite flowers. Groundsel calyx altered into down. Bur marigold calyx altered into prongs. Orange hawk-weed calyx altered into bristles (all magnified)	46
6. Fruit of the elm	50
7. (a) Sleeping and (b) expanding buds of the horse-chestnut	55
8. Apple twig showing old bud-scale marks	58
9. Blossoms of the butternut	67
10. Blossoms of the oak (a) pistillate, (b) staminate	70
11. Details of the blossoming butternut, (a) A cluster of pistillate flowers, (b) one stamen bearing scale detached from the staminate flower-chain, (c) a single stamen	72
12. Buds of the ash	76
13. Perfect (a) staminate (b) and pistillate (c) flowers of the European ash (<i>Fraxinus excelsior</i>)	77
14. Young horse-chestnut bur and young acorns	83
15. Twinned fruit of the maple	85
16. Magnified section of the green tissue of a leaf	90

FIG.	PAGE
17. Some common fresh-water algæ; (a) zygnuma; (b) mon- geotia; (c) spirogyra (much magnified).....	95
18. Pine-sap (<i>Monotropa hypopitys</i>).....	99
19. Starch grains of the potato (a) and of wheat (b).....	104
20. Epidermal cell and one stoma of a fern (much magnified)	107
21. Stoma of a cycas (much magnified).....	108
22. Four natives of South Africa: 1. A South African groundsel; 2, a typical cactus; 3, a sponge; 4, a milkweed.....	111
23. A climbing spray of the pea.....	114
24. Parallel-veined leaves of the Indian shot.....	122
25. Net-veined leaves of the lime tree.....	124
26. Blade-like leaves of the Iris with clasping bases.....	125
27. Crosswise section of a Palmetto trunk.....	127
28. Crosswise section of the trunk of a young oak tree showing growth rings.....	135
29. Wild roses.....	137
30. A lily-flower.....	140
31. Seed-vessel of the tulip.....	140
32. Sweet-flag (<i>Acorus Calamus</i>).....	141
33. A single floret of the sweet-flag (magnified).....	144
34. June aspect of the cat-tail flags.....	145
35. Single florets of the cat-tail flag (magnified).....	147
36. Some familiar grasses.....	150
37. "Marram grass," "beach grass" or "sea-sand" reed (<i>Ammophila arundinacea</i> of Gray).....	152
38. Stems of the rye, showing the knots or nodes.....	158
39. Ligula of millet-grass.....	161
40. Oats and yarrow with analyses of their flowers.....	163
41. Single flower of a grass (magnified).....	167
42. Caryopsis of the wheat (magnified).....	168
43. Sand-bur grass (<i>Cenchrus tribuloides</i>).....	170
44. Squirrel-tail grass (<i>Hordeum jubatum</i>).....	171
45. Common reed (<i>Phragmites communis</i>).....	174
46. Five familiar water-rushes.....	178
47. A wood-rush (<i>Lazula campestris</i>).....	180
48. Lengthwise section of the tubular leaf of a "knotty- leaved" rush (magnified).....	182
49. Flower-cluster and flower analysis of a common water- rush (<i>Juncus articulatus</i>).....	184

List of Illustrations

XV

FIG.	PAGE
50. Rush-seeds (much magnified).....	186
51. Some New England sedges.....	189
52. From low-lying fields "Wool-grass" and "Beak-rush,"	192
53. A typical carex (<i>Carex hystricina</i>).....	195
54. Nocturnal guests of the honeysuckle (<i>Sphinx ligustri</i> and <i>Sphinx convolvuli</i>).....	203
55. Pollen of the honeysuckle (magnified).....	204
56. "Day" or "Japan" lilies (<i>Funkia Japonica</i>).....	205
57. Adam's Needle and Thread (<i>Yucca filamentosa</i>).....	209
58. A wild evening primrose (<i>Enothera biennis</i>).....	215
59. Jimson weed (<i>Datura stramonium</i>).....	217
60. Nightly visitor to the jimson weed (<i>Sphinx Carolina</i>)..	218
61. Hedgebind weed (<i>Convolvulus sepium</i>).....	219
62. Bouncing Bet (<i>Saponaria officinalis</i>).....	223
63. Day lichen or corn-cockle (<i>Lychnis githago</i>).....	226
64a. A flower-clock (morning).....	228
64b. A flower-clock (afternoon and evening).....	229
65. English ivy (<i>Hedera helix</i>).....	234
66. Bind-weed and hop-vine.....	238
67. Scaling hooks of the Virginia creeper (<i>Ampelopsis</i> <i>quinquefolia</i>) and of the wild clematis (<i>Clematis</i> <i>Virginiana</i>).....	241
68. Prothallus of a Southern fern (<i>Pteris serrulata</i>).....	251
69. Antherozoids of <i>Pteris serrulata</i> (much magnified)....	253
70. Young archegonium of a garden maiden-hair (<i>Adi-</i> <i>antum cuneatum</i>) (much magnified).....	255
71. "Male-fern" (<i>Aspidium felix maas</i>).....	260
72. Opening sporangium of a Florida fern (<i>Pteris cretica</i>)..	262
73. Vegetative and spore-bearing fronds of the sensitive fern (<i>Onoclea sensibilis</i>).....	263
74. Spores of a club-moss (<i>Lycopodium complanatum</i>) (mag- nified).....	267
75. A seedling pine.....	271
76. Leaf-cluster and bud-scales of the white-pine (<i>Pinus</i> <i>strobus</i>).....	275
77. A spray of the balsam-fir (<i>Abies balsamea</i>).....	277
78. Crosswise section of the trunk of a fir-tree showing growth-rings.....	281
79. Tracheids of the fir-tree.....	284
80. Winged pollen of the fir (much magnified).....	287

FIG.	PAGE
81. Flowers of the Scotch pine (<i>Pinus sylvestris</i>).....	288
82. A large ("macro") and two small ("micro") spores of <i>Selaginella martensi</i> (much magnified).....	291
83. Young carpel, mature carpel, and part of a mature cone of the silver fir (<i>Abies pectinata</i>)	297
84. Spreading dogbane (<i>Apocynum androsæmifolium</i>).....	301
85. Trap of the spreading dogbane (magnified).....	305
86. Common milk-weed (<i>Asclepias cornuti</i>).....	307
87. Trop of the milk-weed (magnified).....	310
88. A dogbane flower and its captive.....	315
89. Nettle and Canada thistle (<i>Urtica dioica</i> and <i>Cnicus</i> <i>arvensis</i>).....	318
90. Burdock (<i>Arctium Lappa</i>)	321
91. Common wild teasel (<i>Dipsacus sylvestris</i>).....	324
92. Irish gorse, furze or whin (<i>Ulex Europæus</i>).....	327
93. Single blossoms of the nettle.....	331
94. Common thistle (<i>Cnicus lanceolatus</i>).....	334
95. White clover blossoms gathered in latter summer.....	340
96. Pasture thistles (<i>Cnicus pumilis</i>).....	343
97. Amaranth and sow-thistle (<i>Amarantus retroflexus</i> and <i>Sonchus asper</i>)	348
98. "Ribwort" (<i>Plantago major</i>) and "ripple grass" (<i>Plan-</i> <i>tago lanceolata</i>)	358
99a. Cork cells from the leaf scar of the horse-chestnut (much magnified)	367
99b. Leaf scar of the horse-chestnut (magnified).....	369
100. Witch hazel (<i>Hamamelis Virginica</i>).....	374
101. Lengthwise section of a root-tip showing root hairs (much magnified)	391
102. Branches of the alder and of the poplar-leaved birch showing numerous lenticels	393

“ And 'tis my faith that every flower
Enjoys the air it breathes.”

WORDSWORTH.

FIELD, FOREST, AND WAYSIDE FLOWERS

CHAPTER I

CROCUSES

“As sweet desire of day before the day,
As dreams of love before the true love born,
From the outer edge of winter over-worn,
The ghost arisen of May before the May
Takes through dim air her unawakened way.”

—*Swinburne.*

IT seems, at first, an inconsistency that so many of the monastic communities of old should have owned and tended gardens. A garden:—the word suggests roses and honeysuckles, early peas and luscious strawberries, summer days passed amid fair surroundings, whatsoever is most opposite to the unbeautified life, meagre fare, and narrow cell of the ascetic.

Even if the gardens grew only bitter herbs for fast-day pottages the south wind wafted perfumes over them, the butterflies danced in them, and the birds sang in them joyous strains, likely to lead

the listener's thoughts far away from sin, death, and judgment.

Only experience teaches what, it seems, the early fathers of the church well knew, that tending garden is at once a school and a test for all the great Christian virtues.

In hope one lays out hard-earned dollars for seeds, roots, tools, fertilizers, re-enforcements to the fence, and wages of a man to "spade up."

Faith in Nature and in the florist's integrity is sorely needed when, day after day, the beds show only a few sticks, upholding scraps of paper seed-bags, and marking the locations of hoped-for crops.

And charity towards that florist is severely tested when those crops fail to appear for all the wooing of the south wind—and we begin to suspect him of foisting off superannuated seeds upon our guileless simplicity.

But the gardener might as well be charitable with a good grace, for he must be charitable whether or no.

The result of the sweat of his brow and the emptying of his pocketbook is shared with all creation. He is almoner to countless creatures which give him no gratitude.

The moles and slugs nibble his vegetables. The

birds sample his fruit, and a host of bees, moths, beetles, and butterflies share his pleasure in his flowers.

These insect visitors, however, are respectable wage-workers. It would be unjust to call them pensioners of the garden, for the flowers would be as ill off without them as they without the flowers, and next year's borders will be all the brighter and sweeter, thanks to this year's butterflies and bees.

The few glimpses of sunshine which this March day vouchsafes us have already tempted out an enterprising bee. Her contented droning comes from the cup of an equally enterprising yellow crocus (Fig. 1)—to her a pavilion of gold wherein is spread a feast of nectar fit for the gods.

Six yellow leaves, joined at their bases and separate above, form the dainty cup of the crocus-flower.

Three of these are generally somewhat larger than the rest, and in the bud they enfolded the smaller trio within them.

The larger and outer leaves are the "calyx" of the crocus-blossom and the inner and smaller ones are its "corolla." But the calyx now in question is exceptionally big and beautiful.



FIG. 1.—Golden crocus (*Crocus aureus*).
(From Curtis' *Botanical Magazine*.)
 α , the blossom split lengthwise; b , one stamen; c , the pistil.

That of most flowers is a modest affair (Fig. 2*a*), composed of tiny green leaves, or sepals, which

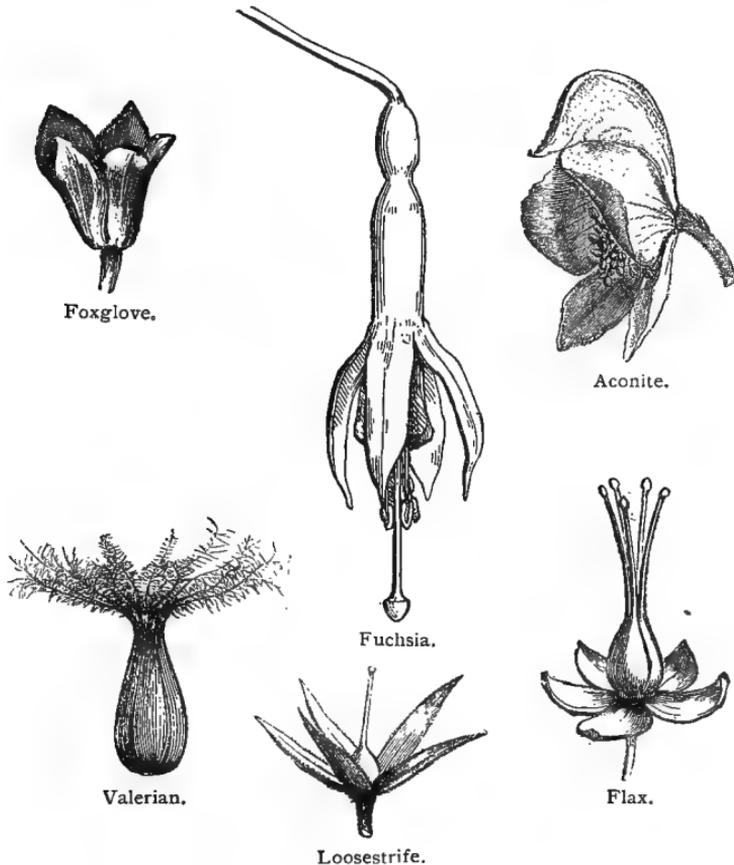


FIG. 2*a*.—Calyces of differing forms.
(From the *Vegetable World*.)

are quite eclipsed by the superior size and brilliancy of the petals or flower-leaves within them (Fig. 2*b*).

22 Field, Forest, and Wayside Flowers

In this crocus, however, the sepals not only rival the petals, but outdo them in prettiness.

Within the flower's chalice are three stalks, each topped with a long, golden head. These are the stamens.

The long heads are powder-boxes, and the yellow dust which they contain has a power as wonderful as that of any fairy's wand.

At the very heart of the crocus is a column, tall and erect, surmounted by a fluted capital tipped with gold. This is the pistil. Its duty, in the floral division of labor, is to form, protect, and, in due time, distribute the young seed. In its lower part, at flowering time, we will find a number of tiny green bodies destined to become seeds, if all goes well.

This crocus has just unfolded, and the baby seeds within its pistil are not quickened yet. They may never live at all, but wither with the perishing flower, and thus die before they are really born. Life can be given to them only by the magic powder which the stamens contain.

In the older works on botany this powder is called "pollen," but the most recent books on the wonders of plant-life give it a name more ponderous and technical, but well worth remembering,



Tobacco plant.



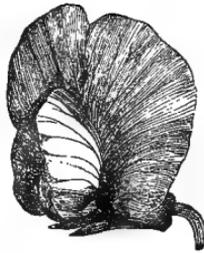
Lilac.



Sage.



Arbutus.



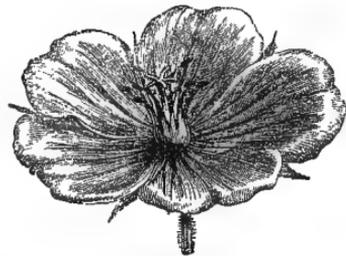
Pea.



Convolvulus.



Pink.



Geranium.

FIG 2b.—Corollas of various forms.

(From the *Vegetable World*.)

24 Field, Forest, and Wayside Flowers

because whoever invented it had in mind the relationship which binds together all plants, from the humblest to the highest.

So in the “up-to-date” writings on flower-lore these little grains—brown or golden—are called “microspores.”

Each microspore is a simple cell,—a little bag,—generally lined with a delicate membrane, and always filled with a colorless jelly.

Under a powerful microscope the microspores of many flowers look as if they had been daintily carved, like the beads of a rosary.

On the surfaces of very many of them there are tiny holes, or slits, or little lids, which fall off readily (Fig. 3*a*) and expose the delicate lining membrane.



FIG. 3*a*.—A pollen-grain of the melon. (From the *Vegetable World*.)

The boxes, or “anthers,” which hold the microspores of the crocus split open as soon as the bud expands and shed their golden store. The bee, blundering about inside the flower, gets herself well sprinkled, and, when she flies off, with powdered body, to find and visit another courageous crocus, she will be almost certain to rub off a few yellow grains upon the tip of its pistil.

This spot,—the stigmatic surface,—is the goal of the microspores. It is very various in its appearance in different flowers. Sometimes it is a little knob, sometimes a small point, sometimes, as in this crocus, it spreads into many rays like a star. In many flowers it is covered with short hairs, or with minute knobs, among which pollen-grains may be caught and held fast. In the orchids it is just a little surface of bare tissue. But, whatever is its outward semblance, Nature has prepared it to receive pollen by moistening it with a sugary fluid, so that any grains which touch it may adhere, and may germinate upon it.

Directly a speck of the life-giving dust settles down on the stigmatic surface it begins to do its appointed work there. In most instances the thin inner coat of the little bag swells up at one place into a hump, which thrusts itself through one of the holes in the outer case, or pushes off one of the lids, or, it may be, forces its way outward through a thin spot (Fig. 3*b*). The hump grows bigger, becoming a sac, and, at last, a tube, which, in some flowers, attains a length of several inches. This tube grows downward into the substance of the pistil, much as a strong rootlet burrows into rich light soil.

26 Field, Forest, and Wayside Flowers

All is ready for its reception. The part of the pistil which it must penetrate is never filled with anything more substantial than a loose mass of large cells, called "conducting tissue," and, in some

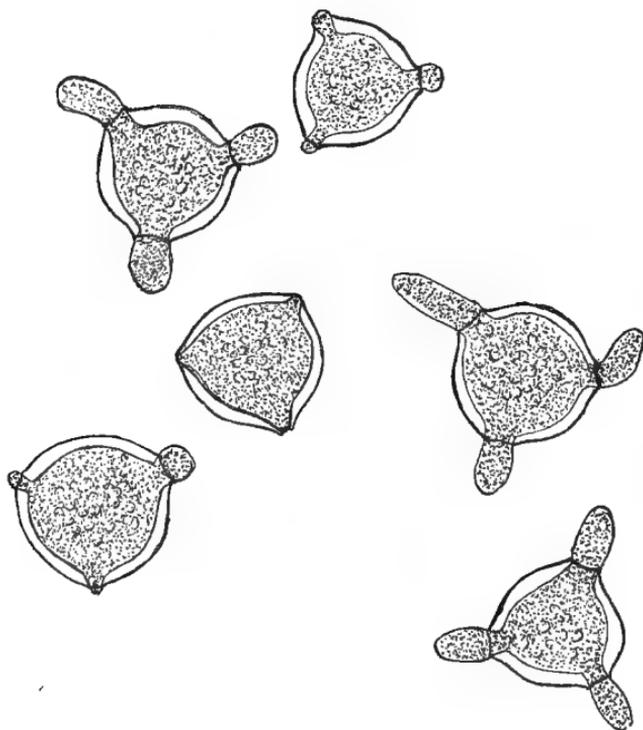


FIG. 3*b*.—Pollen-grains of the European hazel or filbert (*Corylus Avellana*) putting forth their pollen-tubes.

few species of blossom, it is empty. So in due time the end of the pollen-tube reaches one of the baby seeds in the pistil's base, and enters it by a minute orifice in the seed-coat.

Inside the baby seed is another little globe or sac filled with colorless jelly—the “macrospore” or embryo-sac. The pollen-tube pushes its way downward till it touches and pierces this little globe. Then part of the drop of jelly which has filled the pollen-grain or microspore enters the macrospore and fuses with its jelly, and when this union takes place the purpose for which the blossom blew has been achieved. From the fusion of microspore and macrospore comes life, or rather the possibility of life, for from their united substance Nature begins to mould and build a tiny plant within the young seed.

The time which elapses between the first touch of the microspore upon the stigmatic surface and the quickening of the seed that is to be, varies greatly in flowers of different species. The pollen-tube of the crocus takes from one to three days in finding its way to the macrospore. But this is not because the crocus pistil is long, for in the great night-blooming cereus, which has a pistil nine inches in length, the pollen-tube penetrates to the macrospore in a few hours, while in some flowers, as in certain varieties of orchid, weeks elapse while the tube is descending a very short distance.

Each macrospore can be vitalized by the con-

28 Field, Forest, and Wayside Flowers

tents of one single tube, so but one microspore is necessary to the development of a seed.

But Nature provides the golden dust in lavish profusion. It has been estimated that twenty thousand grains are contained in one single stamen of a peony, and some stamens yield the vitalizing powder in even greater abundance.

This is because Nature must provide microspores enough to meet the needs of all the macrospores in all the flowers that blow, after an enormous amount of the precious powder has been wasted.

Some blows away, some is washed earthward by rain or dew, some is eaten by ants and other crawling intruders, much is gathered by the bees, to be made into "bee-bread," and many grains are dropped by flying insects, before the pistil of a sister blossom has been reached.

The use of pollen in the floral economy was suspected,—at least in the case of certain blossoms,—even in classic times. And the fact that the pollen-grain must give of its substance to the pistil before the seed can be vitalized has been known for two centuries. But only in recent times have Nature-students made a discovery which casts a flood of light upon the mysteries of the flowers,—and it is this: The macrospore in

most cases is vitalized not by the pollen of the flower in which it is formed, but by the pollen from some other flower of the same species.

And even those flowers which can make shift to get along with home-made pollen achieve better results with the imported article.

Thus the pistil of the crocus will form larger and stronger seeds if it can get pollen from a sister blossom, or, better still, from another crocus plant altogether. So the flowers wish to send the yellow powder about, from one to another, for their mutual benefit, and the bee behaves as if she had been taken into their confidence. She has flown out of our yellow crocus now, as dusty as a miller, and has gone droning into another one, which is growing on the opposite side of the garden walk. As she reaches down into the bottom of its chalice, for the sweets she hopes to find there, some grains of the pollen she has brought in with her will be rubbed off her velvet jacket onto the waiting pistil.

Crocus number two accepts this unintentional donation with pleasure, pays for it with a drop of nectar, and gives also a sprinkling of pollen from her own stamens. The bee, carrying the powdered gold which has just been bestowed upon her, flies

30 Field, Forest, and Wayside Flowers

off to make a call upon a third crocus, and when she departs she leaves some of her dusty load behind her, as a souvenir of her visit.

So each crocus "sets" its seed by aid of pollen brought from another flower.

Each flower has gratified its preference for yellow dust of foreign manufacture, and has received enough of the imported article for its dainty uses, and each has sent the pollen of its own making to the exact spot "where it will do the most good." The bee meantime has been entertained everywhere with pretty shows and luxurious fare, and she is another well-satisfied member of the mutual benefit society.

Bees are by no means the only pollen-carriers employed by flowers.

A large number of blossoms entrust their fate, or rather the fate of their posterity, to the mercy of the wind. Others, which grow and blow in ponds or streams, confide their pollen messages to the water. Flowers which conduct their affairs after these methods need be at no special pains to please the insects, whose services they neither ask nor need. So "wind-fertilized" and "water-fertilized" blossoms have not bright colors, nor fragrance, nor nectar. But, on the other hand, they must produce enormous quantities of pollen to

ensure enough for Nature's needs, after a large proportion has been blown or washed away.

The wind-fertilized flowers of the poplar shed so much pollen that it may be seen, on breezy spring days, blowing from the branches in light clouds. And at one time in the summer the floating pollen of the eel-grass, and of some other pond weeds, is spread in sheets over the surface of still water. It has been shed by those aquatic flowers which blow at the surface of the water. There are other aquatic blossoms which expand beneath the surface. Their pollen grains are of much the same weight, bulk for bulk, as the surrounding water, so that they will neither float nor sink, but will remain poised at about the level of the flower they seek. And the individual pollen grains of such blossoms are often long and narrow in form, so that they cut their way through the water, as does a modern ocean greyhound.

Wind-fertilized flowers are adapted in various ways to their chosen assistants, the breezes. They have, for the most part, enormously developed stigmas, which project in the form of tails or brushes. The pollen of such flowers is light and dry, that it may blow easily, and the brush-like stigmas are covered with points or hairs which catch it as it flies past.

32 Field, Forest, and Wayside Flowers

But the pollen grains which are to be entrusted to insect messengers are often sticky or roughened all over with little points, so that they catch on the hairy bodies of their winged porters, and cling.

The interdependence between flowers and their guests has lasted for so many generations, that certain insects have modified their chosen blossoms somewhat, and the flowers, in their turn, have modified their messengers. Thus there have come so be hereditary friendships in the outdoor world, so strong and so enduring that Delphino, who gave the subject much study, has made a rough classification in which flowering plants are graded "according to the company they keep."

His "first class" are adapted for the larger bees. They have diurnal flowers, with colors and scents attractive to man also.

Flowers of the second class are the particular friends of the lesser bees, though they also show hospitality to many other small insects. "These flowers," says Delphino, rather disparagingly, "have quite incomprehensible attractions for their visitors."

The third class comprises the big-fly flowers. These are often in dull shades of yellow and red, and exhale an odor disagreeable to man and to bees.

Another category of flowers are adapted for fertilization by smaller flies and lay wait for these foolish visitors with traps and snares, as does our familiar "Jack-in-the-Pulpit."

There are a few native plants which use carrion and dung-flies as their messengers. The carrion-flower of New England thickets is one of these. They have a putrid smell, often very strong, and dull-colored or greenish blossoms.

Delphino's sixth class includes those plants which seek to snare the fancy and secure the services of beetles. These have large diurnal blossoms with striking colors, very abundant pollen, and nectar so placed that it is within easy reach. Among these beetle-flowers is the magnolia.

Next come the butterfly-flowers, with bright corollas, and with their nectar concealed at the base of a tube so long and narrow that only their chosen guests can reach and sip it. And in the eighth class Delphino places those flowers which seek to please twilight and nocturnal moths.

Some plants have become so dependent on the ministrations of insects that they are no longer able to set seed by aid of their own pollen. It lies upon the pistil as powerless to awaken life as if it were mere roadside dust. Some of the

orchids go even further in their repudiation of the pollen which they themselves have produced. The pistil seems poisoned by it, and withers at its touch.

Many flowers have special devices for securing pollen from other blossoms and for avoiding the use of their own.

In a number of species the stamens ripen, open, and shed their store, while the pistil is yet too young to make use of any pollen grains it may receive. Then when the pistil is old enough to commence business, and asks for gold, the surrounding stamens are a bankrupt community, with none left to give. But "all things come at last to one who knows how to wait." Pollen will be wafted to the pistil by a summer breeze, or carried to it by a winged messenger—beetle, fly, wasp, moth, butterfly, humming-bird, or bee. But it will be pollen from another flower, and that is exactly what wise Mother Nature has been planning from the first.

So the insects which flit through our gardens are combining business with pleasure and doing important errands for the flowers. The flowers vie for their attentions with charming toilettes, and pay for their services with free lunches.

The iris, geranium, gladiolus, and salvia, which make their début later in spring when there are many beauties in the field, must be gay if they would be observed. They must appear in costumes which "shout," as the French say.

But the crocus has not needed a bewilderingly splendid dress in order to secure attention, because she has scarcely a rival thus early in the season, and it is rather Hobson's choice with the bee.

Thus there is scarcely a single brilliant or conspicuous blossom among all the first begotten of the spring. The early wild flowers which we find in sheltered sunny hollows are white, or pale-yellow, or lilac, or delicate sea-shell pink. The spurred columbines, in their brilliant uniforms of red and gold, will not appear upon the rocks till May. They have but coward hearts, for all their martial colors, and dare not come out so long as Jack Frost and the North Wind prowl abroad.

But the Joans of Arc among the flowers, which lead summer's hosts and brave winter's last desperate onslaughts, look as tender and demure as Priscilla "the Mayflower of Plymouth."

CHAPTER II

DANDELIONS

Gold such as thine ne'er drew the Spanish prow
Through the primeval hush of Indian seas,
Nor wrinkled the lean brow
Of age, to rob the lover's heart of ease.
'Tis the spring's largess, which she scatters now
To rich and poor alike.

—*Lowell's lines "To a Dandelion."*

AMONG the works of man whatever is accurately planned and exquisitely made is costly, and therefore uncommon. We are apt to think that the same rule holds in Nature, and that it is only the rare things which are marvellous in design and in construction. But in Nature it is the commonest things which are the most wonderfully made. They are common just because they are so nicely adapted to the conditions of their lives that they are able to starve down and crowd out rivals which are not so well equipped for the battle of existence. Hothouses and horticultural exhibitions can show nothing more wonderful than some vagabond and outcast weeds. A plant which

has been fighting the gardeners for many generations has naturally developed more fertility of resource than has its aristocratic relation which the gardeners cosset and coddle. The gamin of the slums can take care of himself and of his little sister, too, at an age when a rich man's son would not be trusted out of his nurse's sight.

The dandelion is a gamin of the fields, sunny-faced, uncared for, and getting but a rough life of it amid cold spring rains and east winds. Like the human gamin it must look out for number one in adverse circumstances, and therefore Mother Nature expended much ingenuity on the outfit of this humble plant before she sent it forth into a hostile world.

The dandelion gets its name not from the golden blossom, with its sweet promise of spring's return, but from the foliage. The word is a corruption of the French *dent de lion* (lion's tooth), and refers to the jagged edges of the leaves.

Taraxicum is the plant's botanic cognomen, and the nauseous medicine of the same name is extracted from the root. The same bitter principle is in leaves and stalks, but our Irish citizens extract the nauseous taste by long, gentle boiling, and make of dandelion leaves a wholesome and

38 Field, Forest, and Wayside Flowers

not unpalatable spinach. It is not an uncommon sight in spring to see some native of green Erin equipped with a bag or basket and a big knife, gathering tender dandelion tops, destined to furnish forth the frugal dinner. Our Hibernian friends thus circumvent Nature, and upset all her plans, for the dandelions were filled with bitter juice expressly in order that they should not be eaten. The precaution works well as far as gnawing rabbits and moles or hungry caterpillars are concerned, for we never find dandelion roots bitten by rodents or tunnelled by grubs, and dandelion leaves are never eaten into holes such as disfigure the succulent foliage of the rose. Moreover, the plant enjoys this immunity just at a time when vegetable food is scarce, and the few plants which have ventured up are overwhelmed with attention from everything that is abroad, vegetarian and hungry. Man is the only animal who cooks his food, and owing to this accomplishment his bill of fare is far more extensive than that of his neighbors in feathers and fur, who take things as they find them.

If we pick one of the golden dandelion flowers, we find that the stem is a hollow column, and this structure, as every engineer knows, combines

the strictest economy of material with the utmost strength. This contrivance enables the stem to uphold the proportionately large and heavy flower, in spite of all the onslaughts of March winds. "Flower," we have said, but the dandelion is really a community of blossoms. It belongs to the order of Compositæ, a large and mixed family, which numbers among its members such flower plebeians as the burdock, groundsel, and ragweed, and on the other hand includes that flower-aristocrat, the dishevelled and expensive chrysanthemum.

For all these flowers have this peculiarity—that what looks like one blossom proves on examination to be a whole floral mass-meeting.

They furnish an object-lesson on the evils of "individualism," and on the advantages to be gained by coöperation. The single flowers of the dandelion are not larger around than small pins. If each were anti-social, and grew upon an independent stalk, in lonely dignity, they would attract no attention from the passing insect. But the yellow florets do not mean to be neglected, so they crowd compactly together, and by joining decorative forces they make quite a brave show in the (as yet) colorless world. There are from one to two hundred tiny blossoms in a single

40 Field, Forest, and Wayside Flowers

dandelion. Each is like a slender, hollow staff of silver, surmounted by a little flag of gold. The yellow banner finishes in a row of neat little scallops, and from this decoration we can infer a chapter in the flower's history.

Once upon a time the tiny blossom was composed of five leaves or petals, one for each of these scallops. After a while, for good and sufficient reasons doubtless, the little leaves combined into a tube, marked with five seams, or lines of union. Later still it was found that the blossom's purposes would be better furthered if the tube were split open. So it has altered itself into a little flag, which answers somewhat the same purpose as does the red banner of the auctioneer. It advises the passing insect that certain goods can be obtained here in exchange for value received. Inside the floret stands a close ring of stamens with their heads or anthers united so as to form a long, narrow tube. The anthers open towards the centre of the flower, so that this tube is soon filled with pollen.

The pistil matures a little later than the stamens do. It is long and narrow, and is divided at its summit into two arms, which at first are raised upright and closely pressed together (Fig. 4). In

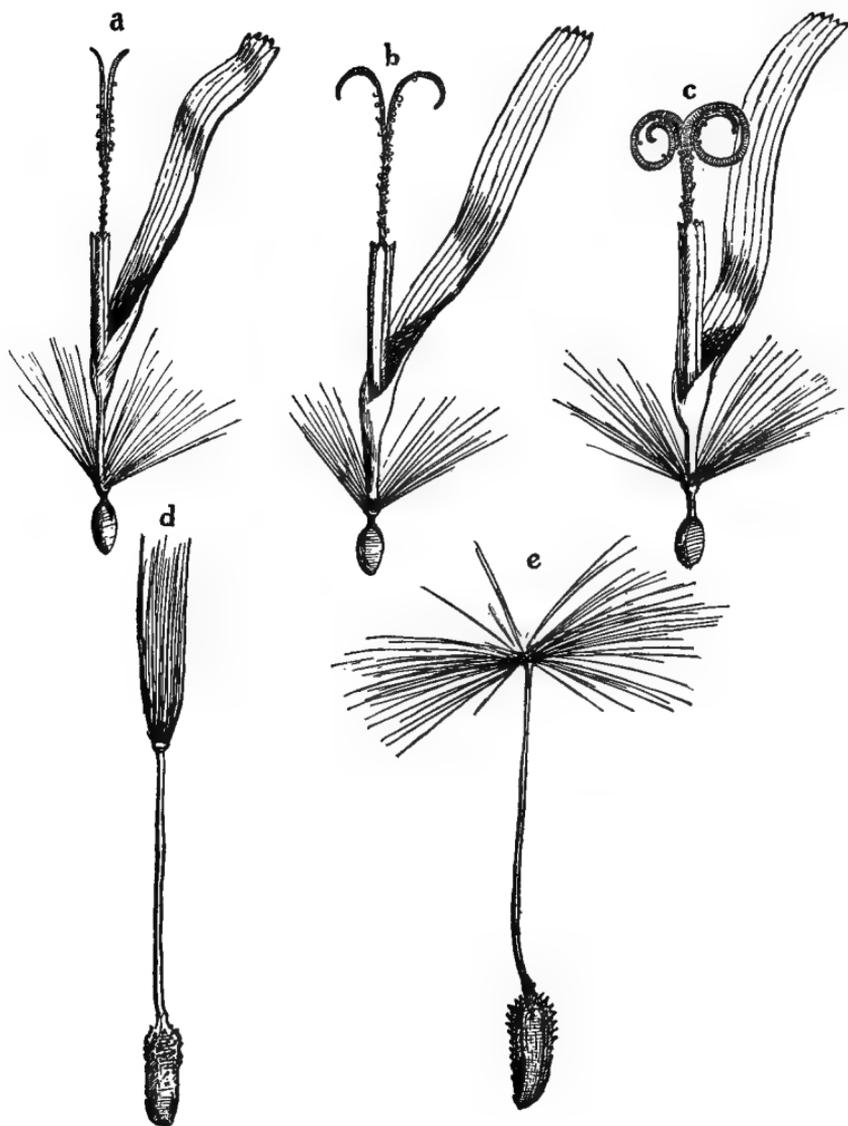


FIG. 4.—Florets and fruits of the dandelion.

this position each little arm covers the sticky inner surface of the other, so that no grain of pollen can be dropped between them, and only these inner surfaces are receptive to the pollen's vitalizing touch. On the outer surface of the pistil, especially towards its tip, are short, scattered hairs pointing upward. As the growth of the pistil carries it up through the anther-ring, these hairs collect the pollen which remains clinging to the outside of the pistil after its full growth is attained. Now the pistil projects far above the anther-ring and corolla, so that the pollen which covers its surface can scarcely fail to be brushed off upon the body of any visiting insect (Fig. 4, *a*). And the dandelion is a general favorite, almost certain of a run of company. The honey is very abundant, and rises high in the little tubes, and this feast is offered at a time when nectar is scarce in the chill and windy world. Ninety-three species of insect have been observed by Müller paying their attentions to the dandelion.

After a while, when most of the home-made pollen has been carried away by insects the arms of the pistil bend downward, till they are in the position of the crosspieces of the letter T (Fig. 4, *b*). Now their sticky or stigmatic surfaces are

extended to touch the insect as he flits by, pollen freighted. But if no winged wayfarer comes along, the arms of the pistil bend downward still further, and as the flower grows older they curl backward like the horns of a ram (Fig. 4, *c*).

Coiled up in this way the sticky inner surface of each little arm is brought into contact at several points with its outer surface. And on the outer surface there will probably be pollen-grains brought from other florets by the same enterprising insects which carried off the golden store of this one. So the Dandelion pistils help to gather pollen for themselves, and can supplement the good offices of flies and bees.

The very first dandelions are apt to appear in the bleak days of early spring, which are not tempting to insect-rovers, so that they may receive no visitors at all. In that case the little florets make shift to do without them. The arms of the pistil when they curve downward will come into contact with the sweeping hairs still covered with the pollen from the anther-tube. And this will be turned to account to meet the needs of the case, for the dandelion floret can, at a pinch, set its seed by means of its own pollen.

Many flowers, especially many spring flowers,

44 Field, Forest, and Wayside Flowers

droop, and thus save their treasures of pollen and honey from being injured by rain and dew. But the dandelion florets stare straight at the sky, and they come at a very rainy season. If Nature took no preventive measures, the gold and silver tubes would speedily resolve themselves into little water-jars; pollen and honey would be spoiled or washed away altogether, and the insect when he called would get nothing but disappointment. But the little blossoms are so constituted that during rainy weather and at night they close completely, and thus all their treasures are preserved. Before the dew begins to fall the dandelions in the grass seem to vanish. The florets in each yellow head are sleeping, and tucked into bed, too, for a ring of little leaves (botanists call it an involucre) which surrounds the mass of tiny blossoms has bent over so as to enclose and enfold them.

The dandelions seem to have turned to buds again, and in their green outer covering they are undistinguishable from the surrounding grass and leaves. Their night's rest is a long one. They rarely awaken before seven o'clock, even on a sunshiny morning, and they close about five in the evening.

An involucre is present in all the members of

the great composite family. It serves as a public calyx, filling for the floral coöperative society many duties which are filled by the calyces of solitary blossoms.

It shelters the florets in their infancy, it helps to guard their nectar from crawling thieves, and, in many species, it screens their pollen from the rain, and encloses and cradles them at night. The calyces thus "thrown out of their jobs," are placed in a position somewhat akin to that of a community of work-people, whose many individual tasks have been taken up and synthetized by some piece of labor-saving machinery.

They must learn some new way of making themselves useful, or they will perish—following a general law of all disused organs.

So throughout the great family of composite flowers we find the calyx of the floret so modified as to help in the great work of plant distribution (Fig. 5). In the bur-marigold it is converted into barbed prongs, which fasten onto the passer-by, and force him to aid the plans of the parent plant for placing its offspring in life. In the dandelion and in some of its cousins the calyx is so modified that by means of it the wind is forced to act as a sower. Below each dandelion

floret is a little oval, white body, which is the baby fruit, and around each floret a circle of silky hairs, the reminiscence of an ancestral calyx. After the yellow corolla has withered away, these hairs

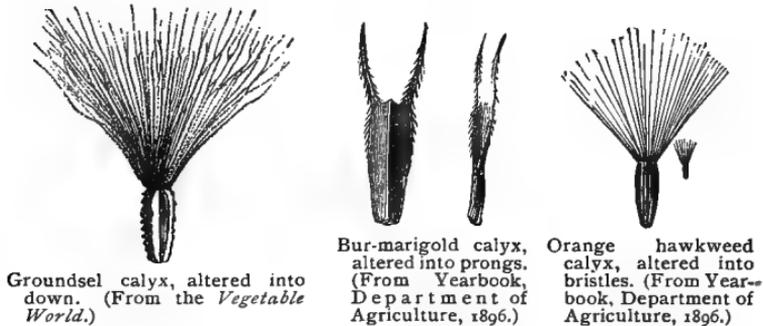


FIG. 5.—Some altered calyxes of composite flowers.

remain at the post of duty, for they have still a task to fulfil in the plant's economy. They are to aid the wind in distributing the little dry fruits—not seeds—which develop after the disappearance of the yellow florets.

For the word "fruit" to the public at large suggests a juicy edible, with a rich or delicate color, and with, generally, a pleasant taste. But "fruit" to the botanist means whatever comes as the normal result of the fertilization of a flower. It may be a tiny brown object unadorned, desiccated, and quite destitute of gastronomic interest. The little freights of the dandelion blow-aways,

being each the developed and ripened seed-case or "ovary" of a fertilized floret, are fruits.

The feathery balls of ripe dandelion fruits are frequently in requisition among children anxious "to find out what time it is." Hence it is, perhaps, that dandelions have been nicknamed "peasant's-clocks" and "blow-balls." The shaven and shorn aspect of the remnant, after the winged fruits have departed, has suggested two other local English names for the flower, "monk's-head" and "priest's-crown."

The tip of each young fruit elongates into a slender beak, raising the tuft of hairs, which are laid together, side by side, like the ribs of a closed umbrella (Fig. 4, *d*). But when the fruit is ripe the hairs bend downward and assume the position of the ribs of an open umbrella (Fig. 4, *e*). Thus the fruits become provided with a silken parachute apiece, and are ready to fly on the wings of the wind and sow themselves far and wide. They will not drop beside the parent plant into soil which has been drained of the substances which are particularly necessary and wholesome to dandelions. They will emigrate, flying on gauzy wings to "fresh woods and pastures new."

Each fruit, let us notice, is roughened with little

48 Field, Forest, and Wayside Flowers

thorny projections; so if the "blow-away" ends its flight against any moving object with a rough surface, the coat of an animal, for instance, or the clothing of a traveller, the attached fruit will catch and cling, and thus be carried still further from its starting point.

These methods of pushing the family fortunes have proved so successful in the past that the dandelion is now distributed as a weed in all civilized parts of the world.

So Nature has cared for the gamin of the fields. How could the queenliest orchid be better cared for by the most scientific gardener of them all?

CHAPTER III

IN APRIL WEATHER

There is no summer fulness in the winds,—
Only the dreamy stirring of the dawn,—
When sweet, ecstatic spring awakes and finds
The winter gone.—*C. B. Going.*

IN earlier April the country is apt to look as if spring had "struck" it in patches. As the suburban resident rides from home to business through field, orchard, and woodland, he sees here a pasture as green as it will be in June, with a group of willows or poplars already burgeoned out into spring decorations; there a patch of the later forest trees, as unawakened as they were in midwinter.

The first evidence of awakening life, given by the woods and copses, is the appearance of the blossoms on the boughs. The tender foliage does not issue from the bud till later. For divers and sufficient reasons it is the habit of most trees to produce their flowers before their leaves, and the expanding buds of earliest spring are almost invariably flower-buds.

The swamp or pussy-willow often blossoms in later March, braving high winds and leaden skies.

The red maple and the poplar bloom at about the same time, and the sugar-maple a little later. By later April, in ordinary seasons, the young seeds of the poplar are formed, and dangle from the branches in long, green clusters, so many and so dense that they impart their color to the tree.

The elms, too, finish flowering betimes, and cover themselves with young seed-pods, which hang

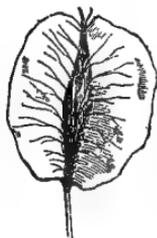


FIG. 6.—Fruit of the elm.
(From the *Vegetable World*.)

in bunches from the boughs and twigs (Fig. 6). They are thin and flat and of a vivid, tender green, and will be mistaken by nine observers out of ten for expanding leaves. The real leaves meantime are finishing out their winter's nap inside the leaf-buds, which are still very small and show scarcely a tinge of green.

In the country west of the Alleghanies the silver poplar or "abele" (*Populus Alba*) is one of the most familiar trees and one of the first to respond to the wooing of the south wind and the sun. Its flower-buds are covered with shining brown scales, which split apart, in latter March or early April, and show rifts of gleaming gray.

After a few gentle showers and a few days of sunshine, these brown spring parcels open wide enough to show us what Mother Nature has been hiding there. And before one has realized what is happening some of the trees are covered with woolly dangles, soft and gray as goslings which have just chipped the shell. Looking closely at one of these we see that it is a close chain of scales, each clear and brown as a bit of tortoise-shell, and each bordered with a silvery fringe.

Under each scale is a bunch of stamens which, when they first appear, are shrimp-pink, so that the whole dangle, closely examined, is a lovely harmony of soft color. But on the poplars which bear such catkins as these there are no pistils at all, and there will be no seeds later in the year.

On other poplars, meantime, the pistil-bearing flower-buds, which hold the seed that is to be, are opening. Their contents are at first much less attractive to the eye than are the soft dangles of pink and silver which issue from the staminate buds.

Each pistillate bud consists of about six brown scales, which presently separate, and let out into the April weather an humble green catkin about

52 Field, Forest, and Wayside Flowers

half an inch long, composed of many hairy, green pistils, each partially covered with a scale.

These scales, like those on the far prettier staminate catkin, are fringed with silky hairs, and have been making themselves very useful earlier in the season.

Now they are separated by the lengthening of the catkin, but in the bud they lay so close together as to overlap, and their fringes made a soft, warm fur, which protected the young stamens or pistils from the frost.

The pistillate tassels of the poplar grow in clusters, usually on the tips of the branches and twigs. In this position of vantage each green pistil waits for the breeze to bring it pollen from the catkins of the stamen-bearing trees. As soon as the vitalizing dust is received the pistils begin to grow. In a few days, if the weather is bright and breezy, the insignificance of their earliest youth is a thing of the past.

The tassels lengthen, and become so vividly green that they are noticeable not only on the branches, but in the landscape. In the yet colorless world the trees stand forth clothed all in living green, as if they had burst into luxuriant leaf. But the leaves are still fast asleep, and tucked

tightly away in little silvery buds. What appears to be foliage is innumerable seed-pods, hanging from the branches in countless chains. Later these pods will split open, and give to the spring breezes a great number of minute seeds, winged with cottony down. In localities where the white poplars abound, these seeds are sometimes shed in such numbers that they lie in sheltered places, blown into light heaps like the first snow before a November gale.

The blossoms of the elm appear in great profusion in latter March or early April. They grow huddled together in bunches, are of a delicate green, and are often mistaken for unfolding leaves. The buds whence they issue are dark-colored and large, and are scattered closely along the sides of the twigs, but seldom borne on the tips. Every one of these big buds is covered with a few brown scales, which separate in early spring, and let out into the sun ten or twelve slender stalks, each supporting a shallow green cup with a rim of golden-brown. Each cup is a flower, always pretty when one looks at it closely, and sometimes as perfect as the stateliest tulip. For it may contain from four to nine stamens, and in their midst a green, flat, heart-shaped pistil, forking into two

54 Field, Forest, and Wayside Flowers

feathery prongs. But almost every cluster contains some flowers which have no pistils at all—only stamens. These have no use for their pollen at home, and will send it all out into the world. Sir John Lubbock says it flies on the wings of the wind. Another excellent authority reckons the elm-blossom among honey-bearing flowers, and says its pollen travels on the bodies of early-roving flies and bees.

Probably both authorities are right, and the habits of the trees are even now undergoing a change. It may be that the elms, which are gradually learning to bear stamens and pistils in separate flowers, are also, by slow degrees, dispensing with the services of that wasteful pollen-carrier, the wind, and learning to utilize those safer and surer messengers, flying insects. In some future day they may reach the condition of the red maples, which are almost wholly dependent upon insect ministrations.

All the earliest tree-blossoms, poplar, swamp-willow, elm, and red maple, come out of buds which contain flowers only. On the trees which bear them are other buds from which the foliage expands later. But some buds contain both foliage and flowers. The great horse-chestnut buds, those

of the pear-tree, and those of the buckeye, let out into the sun a whole cluster of leaves, surrounding a pyramid or bunch of buds. Mother Nature's spring parcels are coming undone, and we see, with astonishment, how much they have held. Their opening is as surprising as the unpacking of that hat from which

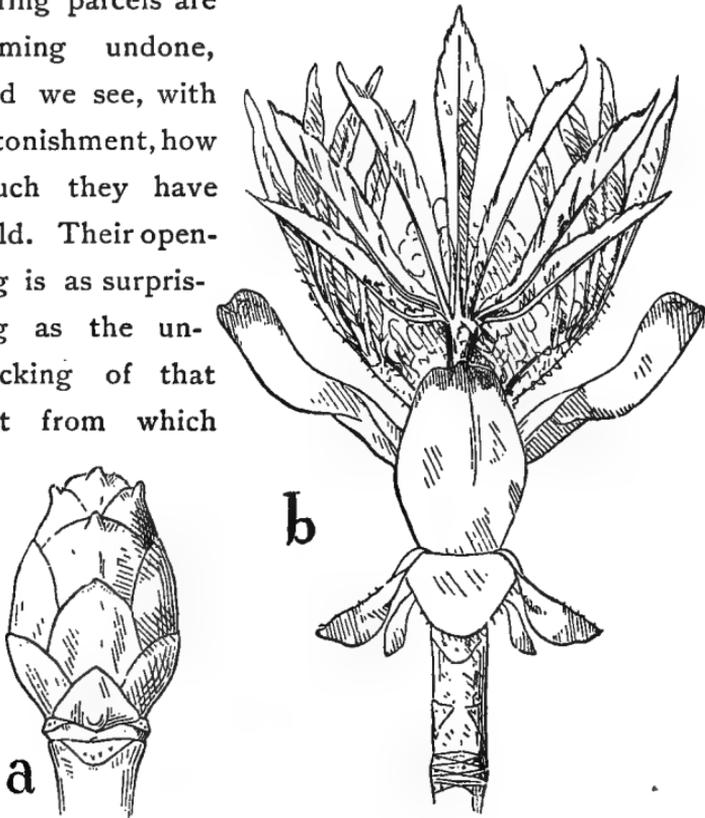


FIG. 7.—(a) Sleeping and (b) expanding buds of the horse-chestnut.
(From the *Vegetable World*.)

the conjurer draws enough articles to fill a Saratoga trunk. The horse-chestnut buds, in latter March, are no bigger than thimbles, yet from

them issue in April weather four, or even six, broad, fan-like leaves, surrounding a cone-shaped cluster of flowers (Fig. 7).

When the young leaves first begin to expand we can see the folding creases in them, and thus get an idea how they were packed into the very small spaces which they occupied all winter. We see that maple and currant leaves have been plaited like fans. Those of the cherry and oak have been folded lengthwise down the middle, so that their sides come together like the covers of a closed book. The circular May-apple leaves (*Frontispiece*) have been folded back against their stalks, like closed umbrellas, and will open just as umbrellas do. Plum-leaves have been rolled from one edge toward the other, as one rolls sheets of music. Some of the tender young leaves are clothed or surrounded with vegetable down. This is the blanketing which Nature provided to prevent them from being "winter-killed." The horse-chestnut leaves have been particularly well protected, and from seeing them so snugly wrapped we infer that this tree's ancestors lived in the north, where winters were long and severe. Its cousin, the buckeye, is a fair southerner, and the young buckeye leaves are unprovided with coverings of vege-

table wool, which, in a mild climate, are unnecessary.

But we must not infer that every unprotected bud found in northern woods is borne on a vegetable stray from a milder climate. A few northern plants have become so thoroughly case-hardened to winter and rough weather that they have dispensed with protective bud-wrappings. Like some intrepid folk of our acquaintance they get through the cold season without an overcoat, or independent of furs and flannels.

The winter buds of the blackberry are protected only by a few thin scales, often too short to cover the tips of the young leaves within. Four, or at most six, soft scales have defended the elder leaves and the clustered blossom-buds from last winter's frost. The tender foliage of the "wayfaring-tree" or "hobble-bush" has had no protection save a coating of scurf, and with this scant clothing it can survive a Maine winter. But as a rule, when naked buds occur in our climate they are small, and during winter they lie in hiding, sunk into the bark or even partly buried in the wood.

The scales which enclose most native buds are imperfect leaves, detailed to do guard duty. Through the winter they have been wrapped

closely around the baby foliage to protect it from rotting damp, and from sudden changes of temperature. Now their work is done, and in a few days they will fall off, or shrivel away, leaving scars upon the twigs to mark



the place where they grew. The traces left

by fallen

bud - scales

look as if a

string had been wound

with the utmost tightness around

the branch, so as to encircle

it four or five times, and

had remained long enough

to cut into the bark (Fig. 8).

By counting these marks

one can tell how many years

a branch is old. After a

while, by the peeling away

of the outermost layers of

bark, the scars upon it dis-

appear. In the Willow we

can scarcely find them at

FIG. 8.—Apple twig, showing
old bud-scale marks.

any stage of the branches' growth, as the bud-

scales are too small to leave well-defined marks. But in maples and horse-chestnuts the marks of the bud-scales of vanished springs are easily seen. The spaces between them vary from one inch to six or eight, for growth differs in different years, in different trees, or in different branches of the same tree, according to the humidity and heat of the season, the richness of the soil, or the inherent vigor of the individual.

At the very heart of each bud which tips a bough or twig is the "apex of growth," a group of generative cells on whose strength and activity the prolongation of the branch depends. The extension of the bough for the season is over and done at a comparatively early period. In many trees it is completed a month after the first little leaves unfold.

By mid-July even the most procrastinating of trees and shrubs have made the growth of the year, and formed next season's buds. Their subsequent efforts are devoted to perfecting and strengthening the young parts, and to laying by a store of nourishment against the needs of another spring.

A leaf-bud is generally formed just above the foot-stalk of a leaf. On a very young branch the

60 Field, Forest, and Wayside Flowers

twigs spring from the places whence leaves fell in bygone autumns. But some of these twigs will be snapped off by gales, or blighted by insects, and some will be starved and crowded out by more vigorous neighboring twigs. In early spring many leaf-buds of forest-trees are eaten by squirrels, which have waked up hungry after their long winter's nap, and find that the world as yet contains little provender for them. And as every one of these devoured buds is a potential branch, their taking-off will affect the shape of the trees in years to come.

So from various causes the trees of the wood do not show that symmetry in the positions of their boughs which we admire in the arrangement of their leaves. Indeed, the branching of a full-grown tree bears little relation to the positions of the buds from which those branches sprang.

The symmetry of the adult shrub or tree is further marred by the occasional development of what are called "supernumerary" or "accessory" buds. These are found especially on low-growing plants, likely to be browsed upon by cattle.

When a leaf drops off the bramble, for instance, it leaves a group of buds, a larger one in the

centre with one, or, it may be, two smaller ones on either side.

These are understudies, as it were, to the middle bud, ready to take up its work in the world if it be killed or disabled. Normally it grows and they remain quiescent. But it may be that one of the side buds is the strongest of the group and lives down all its fellows. It is a question of survival of the fittest.

The common locust has several "accessory buds" under the leaf-stalk, and a principal bud in the scar left by the leaf of last summer. This axillary bud may be overtaken in growth by the strongest one in the group below it, so that in years to come the tree will have two branches almost together.

In the poplar, elm, and willow extra buds are potentially present in the bark, and will develop in numbers if the tree is maimed. Such buds and growths are called "adventitious," and have no relation whatever to the ordinary position of the leaves. Those of the elm sometimes appear on the trunk in dense tufts of whip-like branches.

The basket-makers turn the willow's ability to produce adventitious buds to excellent account. They cut off the crown of the tree, and the ends

62 Field, Forest, and Wayside Flowers

of its principal branches, and there results an outgrowth of the tough, lithe osiers from which baskets and chair-seats are woven.

The willow is about the first of our native trees to put forth foliage. The elm, ash, and oak—canny northerners all—are late, and their leafing has given rise to some quaint rural sayings. The peasantry of the old world have been accustomed from time immemorial to arrange their farming pursuits according to indications given by certain trees and flowers. “The leafing of the elm,” says Thistleton Dyer, “has for generations been made to regulate agricultural doings, and hence the old rule:

‘When the elmen-leaf is as big as a mouse’s ear,
Then to sow barley never fear.’”

With which may be compared another piece of weather-lore:

“Whenthe oak puts on his gosling gray,
’Tis time to sow barley night or day.”

The oak and the ash come into leaf almost together, and rural folk used to watch the trees to find out whether the coming summer would be a rainy or a dry one.

“If the oak is out before the ash,
’Twill be a summer of wet and splash;

If the ash is before the oak,
'Twill be a summer of fire and smoke,"

says an old piece of weather-lore.

Nourishing gums and starches are stored away all winter in the tree-trunks and branches, and toward spring they feel their way along the least twigs and into the buds where life has begun to stir.

The store of nourishment which sustains this year's expanding foliage was collected last summer by the leaves which have now rotted away under the winter rains, or drifted into sheltered hollows, where they lie, withered and sere.

When this year's leaves have attained full strength and maturity, they in their turn will gather food which is to be put by, not for themselves, but for those which come after them. So some labor and others enter into the fruits of their labor, not only among humanity, but even in the vegetable world. And so the great lesson of Easter-tide, the lesson of self-sacrifice, is suggested by the story of the awakening April woods.

CHAPTER IV

THE FLOWERING OF THE FOREST-TREES

“And now in age I bud again,
After so many deaths I live and write;
I once more smell the dew and rain,
And relish versing. O my Only Light,
It cannot be
That I am he
On whom Thy tempests fell all night.”

—*George Herbert.*

THE veteran oak, which has weathered many gales, is the time-honored symbol of hardihood. The flowers which bloom between its mighty roots have served rhetoricians, since the memory of man goeth not to the contrary, as symbols of tender grace and helpless, evanescent prettiness. So the idea of the forest-trees themselves bourgeoning forth into blossoms is to the unbotanical public almost a contradiction in terms, perhaps even involving a trace of absurdity, as if some war-worn veteran were to take his walks abroad with a knot of ribbons at his throat, and a lace-trimmed parasol forming a background to his weather-beaten visage.

Nevertheless, all the forest-trees bloom. After the long, bitter December nights, and after the beating tempests of the equinox, they, too, like dear, quaint George Herbert, "bud again." They respond fully to the call of spring, and break forth not only into tender leaf, but into blossom, too.

But the floral efforts of the trees receive little attention from the public at large. Their flowers are, as a rule, small, green, and inconspicuous, and appearing, as they do, just when we are looking for the bursting of the leaf-buds, they are often mistaken, by the casual observer, for half-unfolded leaves; and they are often almost inaccessible, growing on the swaying tops of upper branches.

Even when one gathers these tree-blossoms, and examines them closely, few of them are found to look at all like flowers, as that term is "understood of the people." For "a flower" to the laity means a cluster of delicate or brilliant little leaves, generally conspicuous, and often fragrant. But "a flower" to the botanist may mean a bunch of tiny greenish or brownish threads, insignificant-looking and odorless.

Few of the blossoms borne by the forest-trees have either petals or fragrance.

66 Field, Forest, and Wayside Flowers

Many sorts are what botanists call "naked," having neither calyx nor corolla.

Many sorts are also what botanists call "imperfect,"—that is, having either stamens and no pistils, or else pistils and no stamens.

One flower may be a pistil or cluster of pistils, surrounded by a few scales, and its "affinity" is a bunch of stamens and a scale or two; and these two incomplete blossoms may grow, not only on separate branches, but in separate trees.

As these forest-tree flowers have, generally speaking, neither bright colors, nor honey, nor fragrance, we surmise that their messenger is the wind, which blows when and where it lists, and is not to be coaxed by the methods which "take" with insects.

And because the wind is their go-between, these blossoms appear, sometimes before the leaves issue from the buds, and almost always before they expand, for foliage would be seriously in the way of pollen as it flew from bough to bough or from tree to tree. The stamens are borne in long, drooping dangles or "catkins," which sway with the lightest breath, so that the pollen is shaken out even by the faintest zephyrs of a spring day.

The pollen of most forest-trees is light and dry,



FIG. 9.—Blossoms of the Butternut (*Juglans cinerea*).

so that spring breezes can easily detach it from the stamens and carry it fast and far.

And their stigmas are more or less branched and hairy, so that they can readily catch the pollen as it flies by.

By time the tender leaves are large enough to cast their shadows on the ground, the pollen messages of the trees have been delivered by the wind, and the precious seed is set (Fig. 9).

The walnut, butternut, hickory, oak, beech, hazelnut, and ironwood trees are all what botanists call "monœcious." That is to say, their stamens and pistils are borne on the same tree, though not in the same blossom. The stamens of all these trees grow in little, close clusters, which are dotted, like rosary beads, all down the length of a slender, pendulous cord. Each stamen cluster is partly covered by a scale or hood, which in a measure prevents the pollen from being washed away by spring rains.

On the walnut, two or three of these stamen-chains come out of one bud; on the oak, six or seven issue from a single ring of bud-scales (Fig. 10). Indeed, as a rule these dangles, which are each and every one a whole community of associated stamens, grow in family groups, so that the



FIG. 10.—Blossoms of the oak.
a, pistillate; *b*, staminate.

idea of fraternity and coöperation is carried throughout.

But the pistillate flowers of the forest-trees are less gregarious. They grow singly, or in small, compact clusters, which almost invariably terminate the branches and tip the twigs, so that they are in the best possible position to catch some of the wind-blown pollen as it flies by. Those of the walnut, "pig-nut," and hickory are bright-green, like the unfolding foliage. At the heart of each is a single pistil, forking into two plume-like heads, which look downy, but prove unexpectedly solid to the touch. The pistil plumes of the butternut are dull-red, and might easily be mistaken for a pair of unfolding baby-leaves (Fig. 11).

The pistillate flower, or little nut, of the beech tree is one green ovary, capped with three thread-like styles, and walled about with scales which will become the bur of the nut one of these days. The young acorn is a three-celled ovary (and thereby hangs a tale), containing the first beginnings of six seeds, and capped by a stigma which forks into three. Around its base is a little scaly covering, the acorn-cup that is to be.

The embryo nuts of the walnut, butternut, hickory, and beech, and the baby-acorns, appear

on this year's new wood. The buds from which they have issued tipped the branches and con-

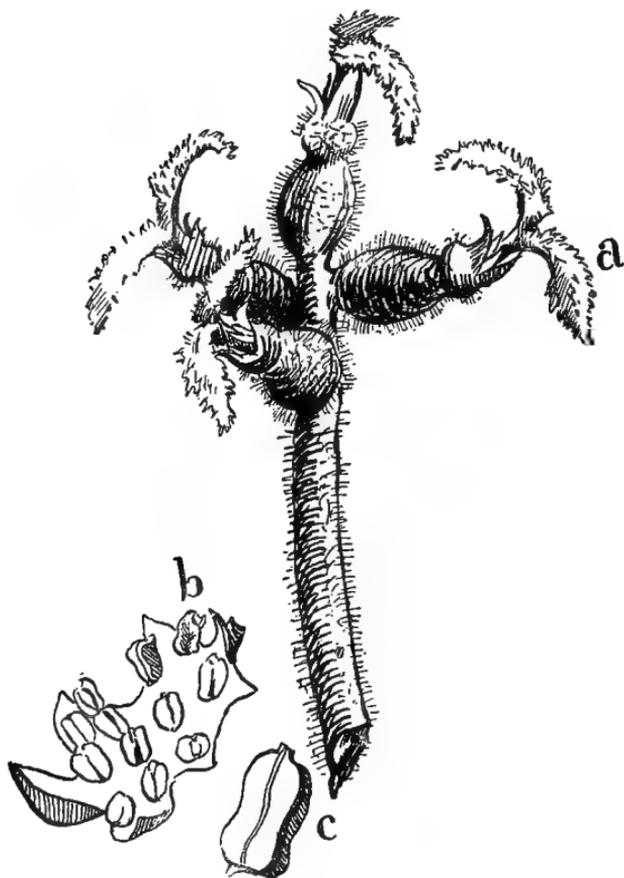


FIG. 11.—Details of the blossoming butternut.

a, a cluster of pistillate flowers; *b*, one stamen bearing scale detached from the staminate flower-chain; *c*, a single stamen. (All magnified.)

tained, besides the pistillate flowers, a few of this year's tender leaves. The staminate flowers in all

these trees issue from other buds, which grow lower on the boughs, on the old wood of last year.

But in all these trees we notice that the pendulous chains of stamens are more numerous on the upper branches and the pistil-bearing flowers grow more plentifully on the lower boughs. So the swing of the tree-tops in spring winds helps to shake the pollen out of the stamens, and the natural falling of the golden grains helps them to find their way to the waiting pistils.

The seedlings of these trees may have but one plant-parent apiece, and every healthy and mature tree of these species yields seed.

The poplars, as we have seen, conduct their affairs after a different fashion, and so do the willows, their nearest of kin. They bear stamens on one tree, and pistils on another. Each seedling-poplar or willow has had two tree-parents, and only certain individuals among the poplars and willows yield seed.

But some spring-flowering trees are apparently in a curious state of indecision and transition. Their habits are described by the technical botanist as "monœciously" or "dicœciously" polygamous.

Sometimes their blossoms contain both stamens and pistils, sometimes they have only stamens and

74 Field, Forest, and Wayside Flowers

devote all their energies to the production of pollen, and sometimes they have only a pistil or pistils, and attempt nothing else except the perfecting of their own seed.

The perfect blossoms which bear both stamens and pistils may live in a household of staminate brother-flowers, or in a household of pistillate sister-flowers, or all three sorts of blossoms may grow together on one tree.

The red maple and the elm among early-flowering trees, and the holly, prickly-ash, and hackberry among the later trees, are thus unsystematic in their mode of conducting their affairs.

Their seedlings are born by the crossing of two flowers, or by the crossing of two trees, as circumstances may determine.

The seedling born of two flowers has a double advantage over the one which springs from a seed set by aid of pollen from the flower in which it grew. The offspring of two flower-parents is the stronger, and also the readier to accommodate itself to change in its circumstances and surroundings. It is therefore likely to live to maturity, and to bear many flowers, which will take after their "forebears" in a decided inclination to produce pollen in one blossom and seeds in another.

The seedling born of two plant-parents is even stronger and more adaptable than the one born of two flower-parents, and in the struggle for existence it is the likeliest of the three to survive. And its plant-children will follow the parental habit of setting seed by aid of pollen brought from another plant. So age by age the "diœcious" flowers have been separating their stamens and pistils more and more widely, and if the world lasts long enough the elms and red maples may reach the condition of the willows and poplars, with all the stamens borne on one tree, and all the pistils on another.

In Nature's school, elms and red maples seem to occupy an intermediate class with the walnuts and hickories below them, and the willows and poplars above.

The white-ash trees, which blossom in latter March or early April, are somewhat unsettled in their habits. Like the elms, they use both breezes and insects as pollen-carriers, and they have generally, but not entirely, adopted that plan of bearing stamens and pistils in separate flowers, which has become a fixed rule among the poplars.

The staminate flower-buds of the ash are very noticeable in earliest spring, when they are inky-

black, as Tennyson, that close observer of Nature, knew, for beautiful Judith in his "Gardener's Daughter" had hair "blacker than ash-buds in the front of March" (Fig. 12).

Under the purplish-black wrappings which enclose these spring parcels, there is brown wool, which has protected the bud's contents from wintry blasts, and under this blanketing we shall find stamens innumerable, but, as a rule, stamens only. These are minute at first, but they begin to stretch as soon



Fig. 12.—Buds of the ash. (From the *Vegetable World*.)

as the bursting of the black case sets them free, and soon the stamen cluster becomes a conspicuous greenish-purple plume, branching freely, and composed of many long anthers on slender filaments. Towards the end of April these stamen-plumes fall, having shed all their pollen, and on the trees which have borne them seeds are not to be expected. For the pistils of most of the ashes grow on separate trees, in green, branching bunches, and by the time the leaves unfold each pistil will have developed into a winged fruit.

But the April aspect of the common or "white" ash hints to us that once upon a time ash-trees

bore both stamens and fruits. For here and there on the boughs of this species a pistil can be found standing between two stamens. The modest trio attract no attention, by color, petals, or fragrance. Yet the technical botanist calls the little group "a perfect flower," and the evolutionary botanist sees in it an indication that once all ash-flowers contained both stamens and pistil and each tree was sufficient to itself.

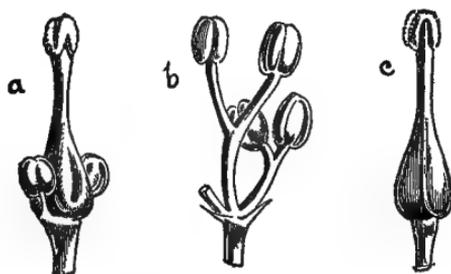


FIG. 13.—Perfect (a), staminate (b), and pistillate (c) flowers of the European ash (*Fraxinus excelsior*). (All magnified.)

The European ash, frequently cultivated in parks and gardens, is an individualist even to this day. Parted from all its kind by leagues of sea, like Crusoe on his island, it could take entire charge of its own affairs and carry them to a successful conclusion. The stamens and pistils are borne always on the same tree, and often in the same flower (Fig. 13).

But in all our native species, except the white ash, the future of the race depends upon the mutual helpfulness of the present generation. The stamen-bearing trees, which yield no seed, exist entirely for the benefit of the family. And the pistil-bearing trees, which are the hope of the race, cannot accomplish their task without help from their neighbors. The trees are learning co-operation, just as individuals do in a society which is emerging from savagery toward civilization.

The horse-chestnut blossoms also coöperate. The pyramidal bunch of bloom is not a crowd of individuals each self-contained and self-sufficient. It is more like the ant and bee communities, in which each individual has duties to be performed for the good of all.

Most of the white blossoms, flecked with rose or gold, have no individual future. Their prospects are sunk for the public good. They have no pistils and will ripen no seed.

Their prettiness is merely a lure to attract some flying insect to the spire of bloom. She will carry away their pollen, for which they can receive no return in kind, as they have no stigmas and can set no seed. And having been en-

ticed to the boughs by them, and bearing their powdered gold on her body, she will visit some sister-flower, which is in botanical language "perfect," and from which will develop, later, the horse-chestnut bur.

On the blooming spire there are scores of flowers, but if we look at the branch again, in later summer, we will see that only six or eight of them have set their seed. The rest have perished, as the worker-ants do, leaving no descendants; the only memento of their lives will be the work done for the community into which they were born.

The perfect blossoms of the horse-chestnut grow near the base of the spire of bloom. Their friend, the bee, works from the ground upward, and all the bee-flowers, which grow in spikes or bunches, have adapted themselves to this habit of their favorite messenger.

When she comes to a branch of horse-chestnut blossoms she is probably already dusted with pollen from another cluster. With this she flies to the lowest flowers of the spire, which are pistil-bearing, and therefore want pollen and have a use for it. Then, rising into the top of the spire, she takes on a fresh load of pollen from the stamen-

80 Field, Forest, and Wayside Flowers

bearing flowers there, and when she visits another spire of bloom this will be carried to its lowest blossoms, which are pistillate.

Besides the perfectly developed pistil these lower flowers bear a number of stamens which, according to Dr. Ogle, never open, and never shed their stores of pollen. And the upper flowers, which nowadays do nothing except produce pollen and make a brave show, hold in their hearts little green rudiments which are significant signs of abandoned habits.

For each of these is a pistil almost dwindled to nothingness—a reminiscence of the time when the horse-chestnut flowers had not yet learned co-operation.

The long stamens of these topmost flowers have an upward curve which brings their anthers against the hairy hinder parts of their favorite visitor, the bumble-bee. And when the insect flies to the lower florets of the next spire, the long, curving pistils touch the same spot on her body and receive the pollen they need,

When the upper flowers of the spire have given away all their pollen they fall and strew the ground beneath the trees. The horse-chestnuts are cousins to the maples, and are not even distantly related

to the chestnuts, which they resemble only in dependence upon the ministrations of insects and in the custom of late blooming.

For the chestnuts, too, blossom much later than most of the forest-trees, hanging out long, pollen-bearing flower-clusters, which are odorous and conspicuous to lure the flies, upon whose ministrations the life of the species depends.

The heavy scent of the blossoms is unpleasant to most people, but we are not the individuals concerned in the case. The faint suggestion of putridity is attractive to the many flies which hum around the branches in the warm June sunshine. They dust their bodies with pollen from the creamy spires, and then carry the life-giving dust to the pistillate flower-cluster, which ripens, later, into the chestnut-bur and its contents.

The prickly bur is developed from a little circle of scales which has surrounded a pair or a trio of pistillate flowers. Each chestnut is a ripened ovary, and the little tail atop is the remains of the style and stigma.

It is surmised that the chestnut flowers, like those of the ash-trees, once had both stamens and pistils, alike perfect in development, so that each blossom produced both pollen and ovules. What

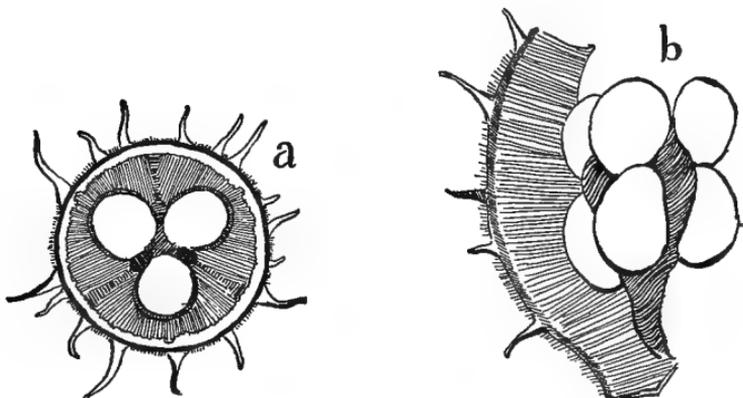
82 Field, Forest, and Wayside Flowers

seems a reminiscence of such a condition of things is still to be seen in the pistil-bearing flowers; for each has from five to twelve "abortive" stamens—undeveloped things which are of no use in the trees' present domestic economy, but which are still produced, probably from sheer force of habit.

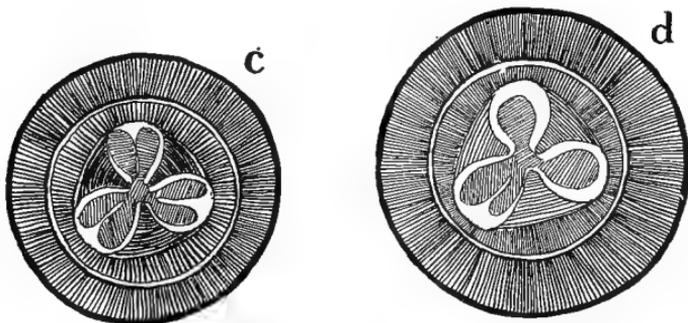
We have seen that some of our familiar trees seem to be passing through changes in the structure and mode of fertilization of their flowers. Others are even now diminishing the number of their seeds. Nature, keeping up an age-old habit, forms a large number of germs; but the trees, having adopted a newer habit, neglect most of these germs, and bring only a remnant of them to maturity. But these comparatively few offspring are sent into the world better nourished, better provided for, better equipped for the battle of life than they would have been had the parent tree undertaken the maintenance of a larger number of descendants, and thus they profit by the fate of their little brothers which perished untimely.

The horse-chestnut blossom has a three-celled ovary, with two ovules in each cell; but the ripe horse-chestnut bur never holds more than three nuts, and sometimes only two, or even a solitary

one. "Yet the vestiges of the seeds which have not matured," says Prof. Gray, "and of the wanting cells of the pod, may always be detected in



Very young horse-chestnut bur cut crosswise (*a*) and lengthwise (*b*), showing that it is at this stage a three-chambered pod enclosing six seeds.



Very young acorn cut crosswise (*c*), showing its three chambers and six ovules. Older acorn cut crosswise (*d*), showing that two of the original six ovules have vanished and that a third is dwindling.

Fig. 14.—Young horse-chestnut bur and young acorns.

the ripe pod." The very young acorn is divided into three compartments, and each compartment has two ovules hanging from its summit. One might, therefore, expect the mature acorn to be a

84 Field, Forest, and Wayside Flowers

husk enclosing six small nuts or seeds. But, in fact, five of the cells are all but obliterated in the forming fruit, which thus becomes one-celled and one-seeded.

But if we strip the shell off a mature acorn we can generally see near its base three irregular lobes, which are a reminiscence of the three chambers of the young ovary.

And between these lobes are the last vestiges of the partitions which once completely trisected the baby-acorn.

The pistil of the maple blossom is a double affair, with two styles, two stigmas, two ovaries, and four ovules, two in each ovary; but the winged twin-fruit which results from its development contains but two seeds (Fig. 15).

It is not unusual for atrophy to go still further and for one-half of the double fruit to stop growing very early in the season, so that in the end the fruit turns out to be an unsymmetrical thing, with one side swelled into firmer and plumper proportions, because nourishment has been withheld from the other.

In the acorns and horse-chestnuts which come to maturity, the baby-plant is supplied with a particularly rich and plentiful stock of starches on

which to feed while it does its first growing, and it is protected from damp and from insect enemies by a tough, horny shell. The maple germ is also provided with sustenance for its first days of life, is wrapped in a strong covering, and is provided with a wing, so that it can fly far before the autumn gales. When the descendants of these trees



FIG. 15.—Twinned fruit of the maple
(From the *Vegetable World*.)

are so well started, a large proportion of them will survive, and thus the oak, horse-chestnut, and maple families are quite as well kept up as are the families of other trees, which cast to the winds a large number of seeds less fully equipped for the battle of existence.

For when a plant, in shiftless and stepmotherly fashion, hands its offspring over to those untender

86 Field, Forest, and Wayside Flowers

nurses, luck and chance, it follows that an enormous proportion of the offspring will die.

By investigating the blossoms of the oak, horsechestnut, and maple, we see that these trees, ages ago, bore very many seeds, which must have received but a scant provision apiece wherewith to start themselves in life. Under these circumstances, the majority of the seedlings would die young, giving the parent-plant the expense of putting an enormous family out into the world, and all to little purpose. To-day, evolution is teaching them "a more excellent way."

"It is a fatal habit," says Grant Allen, "to picture evolution to one's self as a closed chapter. We should think of it rather as a chapter that goes on writing itself for ever. Our fields are full of degenerate flowers which retain some memorial of their old estate, pointing backward, like the fasces of the Byzantine emperors, to the past glories of their race in earlier times." They are also full of plants which bear somewhere about them half-obliterated traces which tell the story of their progress from a lower to a higher form of life.

CHAPTER V

GREEN LEAVES AT WORK

“Between the budding and the falling leaf,
Stretch happy skies,
With colors and sweet cries,
Of mating birds in uplands and in glades.
The world is rife.”—*T. B. Aldrich.*

WHEN spring, long waited for, has come indeed, and young leaves are unfolding in May sunshine, we find the ground beneath the branches strewn with half-transparent green or brownish scales. In city parks they litter the asphalt walks, and drift along their edges into little heaps.

They are bud-scales, whose day of usefulness is over. They have braved all the rigors of storm and frost, while, folded safe within them, lay the foliage of the coming summer, destined to expand in tender colors under happy skies.

But the bud-scales seldom have any beauty, save the beauty of fitness.

They and the sleeping life which they enfold

88 Field, Forest, and Wayside Flowers

together constitute the winter bud. It contains very little water in its tissues, and so can withstand low temperatures without freezing.

The bud-scales live in a chill and sombre world, and when the sky is blue and full of light they fall and perish in the heart of spring.

Yet, they are themselves imperfectly-formed and partially-developed leaves. Under certain exceptional circumstances they have shown their possibilities, and developed into typical leaves. And under most circumstances there is in them the arrested power to become like the green foliage of summer.

Stunted, as they are, these scales have done work which perfect leaves could never do. Their horny substance has shed the cold rains of winter, resisted the frost, and protected the tips and shoots in which the life of the branches lay dormant.

We owe to the bud-scales most of the beauty of the summer world. Their highest usefulness has been attained through sacrifice of their complete development. Now their brief lives of service are ended, and as they fall the summer leaves unfold.

As soon as these new leaves have stretched and

shaken themselves after their long winter sleep; they set to work, for, fair though they are, beauty is not their sole excuse for being, and there is plenty for them all to do in Nature's great garden.

Through every leaf there runs a network of delicate woody threads, curving, branching, and interlacing.

Its ramifications continue beyond the limits of unaided vision. We call it the "skeleton," and it does fulfil an office similar to that of the bones in the human frame, for it supports the leaf and gives it shape and strength.

But it also serves the leaf as veins and arteries serve the body, for the life-giving sap creeps through these woody threads in slow but continuous circulation.

With the aid of a powerful microscope we can see that the green pulp of the leaf looks somewhat like a honeycomb, as it consists of numberless cells laid row above row. Those on the upper side of the leaf are generally long and narrow, and stand upright, pressing together almost as closely as the bricks in the side of a house (Fig. 16).

But the lower leaf cells differ greatly one from

another in shape and size, and they are laid together loosely, like the boulders in those gray walls which separate New England pastures.

In this lower leaf-tissue there are generally a number of irregular cavities or air-spaces.

Each separate leaf-cell is a little bag of delicate, transparent skin, filled with colorless jelly.

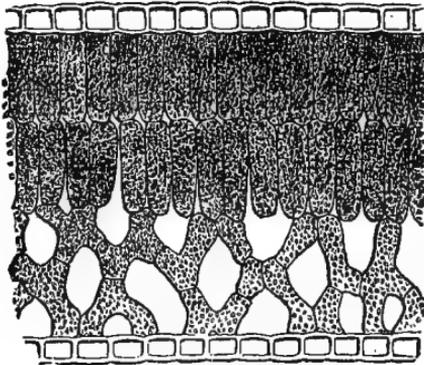


FIG. 16.—Magnified section of the green tissue of a leaf.
(From the *Vegetable World*.)

This jelly is protoplasm, which Huxley has called “the physical basis of life.” The living creature, animal or plant, is largely built of it. Science teaches that its chemical composition is closely akin to that of the white of an egg, and that its elements are oxygen, hydrogen, carbon, nitrogen, phosphorus, and sulphur.

But the proportions of these ingredients vary almost from moment to moment, and with them

are mingled various accidental substances in varying proportions. For while the plant or animal lives new tissue is always being built up or old and waste tissue is being resolved into its elements and cast out of the body. This unceasing work is accompanied by unceasing changes in the protoplasm, which makes up the bulk of the living creature, and when death puts an end to these forms of activity decomposition sets in, and the protoplasm begins to change again. So the exact proportions in which six lifeless substances are blended in order to make the "basis of life" can never be accurately known, and the jelly which fills the cells of the summer leaves is one of the great mysteries of the physical world.

Because they are forever changing protoplasm and its chemical allies are called "proteids."

When protoplasm, existing alone, or mingled with other substances, is surrounded by a wall, we call the little bag and its contents a "cell." But the living jelly is the chief part of the combination. The wall which encloses it is of secondary importance, and is sometimes dispensed with altogether, for the Nature-student makes the acquaintance of cells, so called, which are merely little naked masses of protoplasm.

So "cell" is regarded as a sad misnomer for the minute particles of living substance which build up the animal or plant body, and some modern scientists are striving to get rid of it.

The name was chosen, in the first place, by a microscopist who looked through his lenses at a bit of cork, and found that it was made up of plates of thin tissue, meeting one another at right angles and enclosing empty chambers. He thought that the walls were the important part of the combination, as indeed they were in this particular case, so he called the tissue "cellular" and its component parts he named "cells."

Modern science teaches that in most cases the cell-wall is as subordinate to the cell-contents as a picture-frame is to the picture it encloses, and also that the living units which go to build up a plant or animal have a special form for each kind of tissue, so that "cells," far from being uniformly square, or uniformly six-sided, as their name might lead us to expect, assume shapes of almost infinite variety. But the old, misleading name is still in use, mainly because no one has yet been able to think of a satisfactory substitute for it.

In the jelly which fills the leaf-cells there are floating specks of green, so vivid in color, and so

numerous, as to give their hue to the whole leaf. These specks are chlorophyll bodies, and they are the cause of the rich and tender green in summer fields and woodlands.

The closely-packed tissue of the upper side of the leaf contains many cells, and hence many chlorophyll bodies.

But Nature has not economized space in the arrangement of the lower leaf-cells,—and where cells are comparatively scarce chlorophyll is scarce also. Hence, the under surfaces of leaves are often pale in hue.

Chlorophyll is formed only under the direct light of the sun. Tender young leaves, which have been shut up under bud-scales in the dark, contain as yet but few of the useful little green grains. The sun has not yet given them their working outfit, so expanding foliage is seldom really green. The budding oaks are of a warm reddish-brown or gosling-gray, according to their species. The new leaves of the poplars are silvery, and those of the willows are almost golden.

Even the vegetable garden, when things are beginning to wake there, is a symphony of delicate color. The very smallest carrot-leaves are yellow or golden brown.

The asparagus, when it makes its *début*, is of a bluish or purplish color, and the sprouting beets are of a rich Tyrian red, too sumptuous for such plebeians.

But as soon as the leaves come out into the sunlight, chlorophyll begins to form in them, and they grow greener and greener.

In some of the smaller fresh-water algæ the chlorophyll bodies are flattened plates of very distinctive and beautiful forms (Fig. 17). But those which color the leaves of the wood are generally disk-shaped or oval, and are often called "grains" of chlorophyll.

Whatever its shape, the chlorophyll body consists of two substances, the green coloring-matter itself, and a small, dense, jelly-like mass which holds it.

If a leaf is put into alcohol the spirit draws the coloring-matter out of the chlorophyll bodies, and the leaf gradually becomes pallid while the liquor in which it flows shows a deepening tinge of green.

Now if we examine a piece of the leaf tissue with a powerful microscope we shall see that the chlorophyll bodies are still there, and are unchanged in form and size, but the green pigment which tinted them is gone.

In autumn, Nature withdraws the coloring-matter from the chlorophyll bodies, and at last the bodies themselves disintegrate, so that by time the leaf

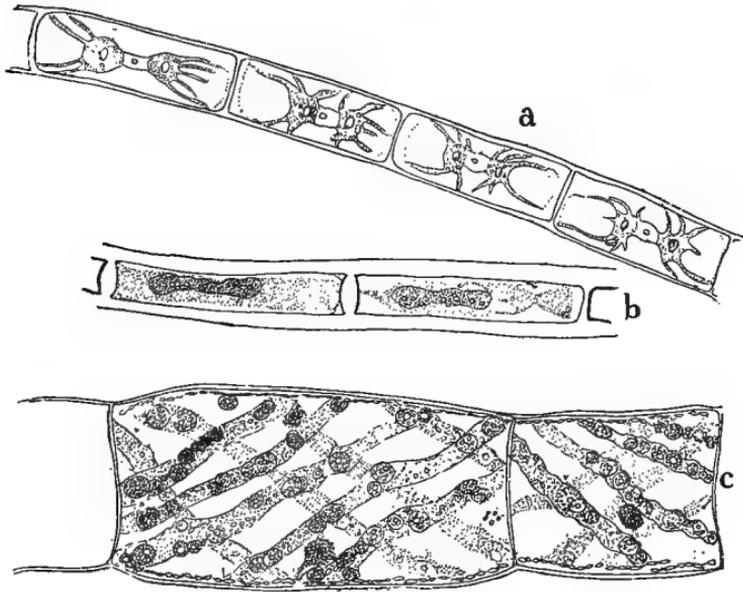


FIG. 17.—Some common fresh-water algæ. (Much magnified.)

a, *Zygnema*, with two star-shaped chlorophyll bodies in each cell; *b*, *Mougeotia*, with a single oblong chlorophyll body in each cell; *c*, *Spirogyra*, with chlorophyll bodies in the form of spiral bands.

falls nothing is left of them but a few yellow granules.

When a plant which has been growing in the light is subjected to continued darkness, the green pigment fades out of the chlorophyll bodies so that they become pallid, and finally white. Eventually the little disks or ovals themselves disorgan-

ize and disappear, and then the hapless plant begins to starve to death.

For the office of chlorophyll in the vegetable economy is digestion. By its action lifeless gases and lifeless mineral-matter are changed into living vegetable tissue.

Green is essentially the color of life. Wherever we see it in the living world we know that inorganic substances are being changed into organic substances, and thus life is preparing the material which it will mould into many forms.

The tissues built up by green plants feed herbivorous animals, which in their turn feed carnivorous animals, and so vegetable life mediates between the mineral and the animal worlds.

Organisms which have no chlorophyll are entirely dependent for their food upon organisms which have chlorophyll. The living chain binding the live creature to Mother Earth may have as many links as there are in the chain of phases connecting the "priest all shaven and shorn" with "the house that Jack built." But always at the end of the chain we find a green plant.

In the teeming life of the ocean the same rule holds, for marine flesh-eaters feed upon marine vegetarians, and these in their turn are fed by

minute chlorophyll-bearing seaweeds, which live near the surface of all but the very coldest waters, and are the floating pastures of the sea.

In plants which habitually bear richly-colored leaves—in the copper-leaved beech, for instance, or the copper-hazel—chlorophyll bodies are present and busy, just as they are in those plants which bear green foliage; but the leaf-sap contains some strong pigment which overpowers and masks the green. Some of those minute plants which have a great and evil reputation under the name of bacteria contain a purple coloring-matter which seems able to fulfil the office of chlorophyll.

By aid of this pigment they can form organic matter when they are exposed to the light.

A few other bacteria can form organic matter in the dark, and unaided by any pigment, green or purple.

But such “exceptions being excepted,” the vividness of the green in stem or leaf is in direct proportion to the plant’s self-helpful activity, for in the vegetable world the very young and the very shiftless are *not* green.

But when a plant begins to form habits of parasitism the leaves grow dim, and the more confirmed these bad habits become, the less chlo-

rophyll is to be found in stems and foliage. The mistletoe is still of a dingy or yellowish-green, because it has not yet sunk to the lowest depths of shiftlessness. It steals its food from the tree upon which it grows, but steals it in an undigested or half-digested state, and does its own digesting. The yellow-rattle and the pretty painted-cup practice a like sort of thieving. Their roots draw moisture from the roots of their next neighbors, instead of taking it direct from the soil. But the sap thus appropriated cannot be used in the building of vegetable tissue till it has been worked over in the leaves, and as yellow-rattle and painted-cup make use of their foliage, they have retained it.

There is a lower depth of parasitism than this, in which the plant steals digested food from its victim. When this stage of degradation is reached the foliage of the parasite dwindles, and its green color disappears. We have seven or eight native plants which suck their food, already prepared, from the roots of herbs and trees. They are representatives of three widely-differing botanical families, but similarity of practice has brought about among them a certain similarity of aspect, so that we may almost say that there is a rogue

type, even in the vegetable world. All these plants are destitute of green coloring-matter, and are of creamy hues, tinged with purple, straw-color, or golden-brown, and the leaves of all are mere reminiscent scales. It is believed that the Indian-pipe and its next of kin, popularly known as pine-sap (Fig. 18), begin life as parasites on living roots; but, as they mature, their habits undergo still further deterioration, till the full-grown plants suck their nourishment from the decaying leaves which carpet the forest. The Indian-pipe is entirely white all over, and though it is own cousin to the bonny heather, its substance looks like that of the fungi, which stand far below it in the scale of nature, and yet share its tastes and bear it company.

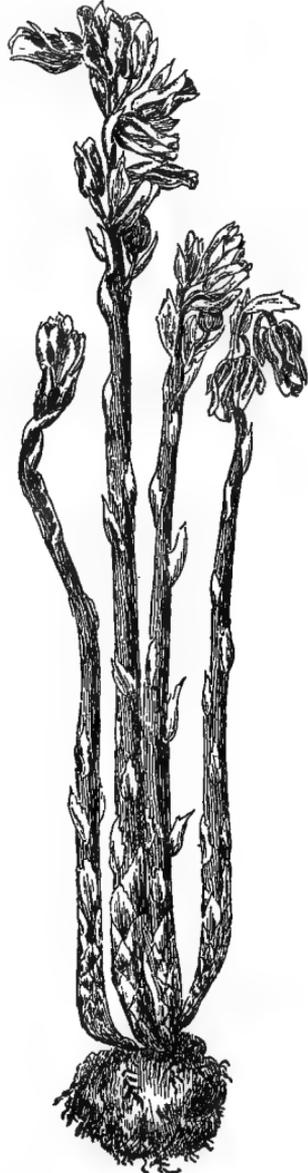


FIG. 18.—Pine-sap (*Monotropa Hypopitys*).

(From *Natural History of New York*.)

But green plants make their own food. The chlorophyll which they contain is a lure to catch the sunbeams, which, when caught, are set to work to help the protoplasm in the work of food-making and tissue-building.

This work can prosper only under certain conditions. Sunshine must fall upon the plant, carbon dioxide gas must be mingled with the air which surrounds it, the temperature must not be too low, and water must come up from the roots into the leaves and green stems. Under these circumstances food-making goes merrily on.

The first evident product of the plant's industry is starch. This is a much less complex substance than the proteids, for it contains but three elements, carbon, hydrogen, and oxygen, and they are mingled in accurately known and unvarying proportions.

The carbon comes out of the carbon dioxide which the leaves breath in; the hydrogen is a chemical constituent of the water which the roots suck up, and the oxygen comes in as the other element of the water, or is inhaled from the atmosphere by the green stems and the foliage.

Some surplus oxygen is left after the starch-making, and this is exhaled by the leaves. When

the sun shines brightly upon a pool, in which pond-weeds are growing lustily, we can see oxygen rising in bubbles from the submerged leaf-laboratories to the surface of the water.

Oxygen-making is carried on even more actively by the smallest of the fresh-water algæ. These little plants are fine green filaments, which have no roots and float in tangled bunches near the surface of still and sunny water. When the weather is warm and bright, the oxygen given out by these little algæ forms great bubbles, which become entangled in the cobwebby meshes and float the plants to the surface.

Here algæ and bubbles together form a green scum, which froths as we look at it. One might readily suppose that all manner of impurities were festering in the water, and that evil gases and malaria were being distributed throughout the neighborhood. But, as we learned in our copy-book days, "appearances are deceitful."

The frothing is caused by one of the most active processes of constructive life. The bubbles which are being cast up are life-giving oxygen, which enables the grass to grow and the animal's heart to beat.

And the little algæ, so busy and beneficent,

102 Field, Forest, and Wayside Flowers

are seen under the microscope to be beautiful also (Fig. 17).

The newly-made starch in leaves appears in tiny grains inside the chlorophyll bodies, or close beside them. It does not remain there and grow into larger starch-grains, but with the withdrawal of sunlight it seems to melt away and disappear. The starch has been dissolved, or rather changed, into fluid glucose, and this is gradually drawn through cell-wall after cell-wall till it reaches some actively-growing part of the plant, where it is used at once, or some permanent tissue, where it is turned into starch again, and stored away to meet the needs of the future.

In spring all the starch which the leaves can make is changed to glucose and used immediately for growth. But in latter summer the plant puts it away. In some cases the starch is saved in wood, pith, bark, or tubers to feed next spring's shoots; in others it is packed into seeds, where it supports the plant's children in their infancy.

If a tree is hewn down in winter the cells of its wood are found to contain innumerable starch-grains. When nature takes her course these are converted into glucose during the first warm days of spring, and the pushing buds are fed with it.

But even when man has interfered with this programme the starch-grains are not without their use. They close the pores of the wood, making it almost impenetrable, and hence peculiarly adapted to certain economic uses. "Winter-hewn timber is almost exclusively employed for staves," says the *Scientific American*. "With staves made from summer-wood the contents of the barrel are subject to evaporation through the pores."

The stored-up starch-grains in tubers and seeds have very characteristic forms.

Those which we find in the tubers of the Indian-shot look like clam-shells, and those of the potato are uneven ovals. Those which we find in grains of corn are very small and angular, like particles of sand, and those of barley, wheat, and rye are lens-shaped (Fig. 19). When these starchy roots and seeds begin to grow the starch will be changed into fluid glucose and then drawn from cell to cell till it reaches the pushing tips of stems and roots.

The water which ascends from the roots of a growing plant into its leaves holds in solution about as much mineral matter as is contained in ordinary well-water. The warmth of the summer

air causes some of this water to evaporate from the foliage. More comes up to supply the loss,

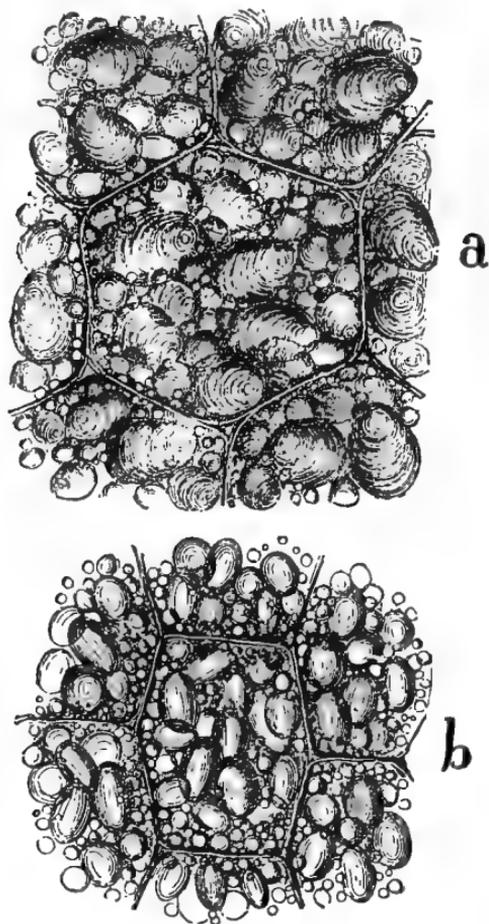


FIG. 19.—Starch-grains of the potato (*a*) and of wheat (*b*).
(Much magnified.)
(From the *Vegetable World*.)

and this also dries out slowly through the sunlit hours. As the water evaporates the mineral sub-

stances (salts) which have come up with it from the soil remain behind in the leaf-cells. These will enter into the composition of the living protoplasm which is filling the new cells of shoot and root.

Though we know how plants make starch, comparatively little has been learned about the more vital process of protoplasm-making. But it is believed that in green plants this work, too, can go on only in the presence of light.

As the water from the roots is to go directly to the leaf-laboratories, Nature has taken care that the precious fluid shall not be wasted on the way. So the trunks and branches of trees and shrubs are wrapped in a skin of cork, which prevents the ascending nutritive water from evaporating. But once in the leaves it is desirable, in most cases, that the water may evaporate and give up its chemical and mineral treasures. So the leaf, broad and thin, exposes the largest possible proportion of surface to the light and air.

Over the whole leaf—veins, cells, and all—there is stretched a transparent skin. A powerful microscope shows this skin to be itself a sheet of cells, often very irregular in form and generally destitute of chlorophyll.

In tropical plants it is comparatively thick; for were it not so, the ardent sun would soon parch all the juices out of the foliage. The oleander, in its native soil, has to endure long droughts, and its leaves are provided with skins four times as thick as those of some leaves which grow in moist climates. But, thick or thin, the leaf-skin must not keep the air away from the green cells, or the little chlorophyll-grains would get no carbonic acid to digest, and the luckless vegetable would die of starvation. Neither must it totally check the evaporation of the water which has ascended from the roots. So the leaf-skin is full of pores, through which air and vapor can pass freely. To these openings botanists give the name of "stomata" or "mouths" (Fig. 20). They open into passages which are channelled out, as it were, in the fleshy part of the leaf, and their office is best described by the term transpiration. They enable the leaves to breathe out any moisture which may be contained in them over and above the plant's immediate needs. Thus the "transpiration" of a plant-body is comparable to the perspiration of an animal body.

During rainy or misty weather, when leaves naturally contain more fluid than they need, these

stomata gape open ; and during times of drought, when it is desirable that the plant's fluids shall be saved, they close. This timely opening and shutting is effected by a mechanism extremely simple, yet perfect in its working.

Each breathing pore is like a double door,

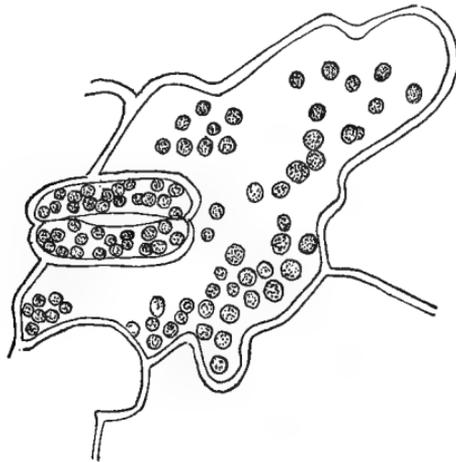


FIG. 20.—A cell of the leaf-skin and one stoma of a fern
(*Pteris cretica*)

whose leaves to left and right are cells. And these cells, like their neighbors in leaf-skin and tissue, become distended in moist weather, and shrink in time of drought. As soon as they become flaccid they collapse, like an empty pair of bellows, and their sides bulge like the bellows-leather. This bulging brings the walls of the two

stoma cells into contact, so that the double door is shut (Fig. 21).

But when damp weather causes the cells to swell again, they stand erect and their sides are drawn apart. Then the double door is open, and the



FIG. 21.—Closed stoma of a *Cycas*.
(From the *Vegetable World*.)

superabundant moisture in the leaf can pass out freely.

Each stoma opens into one of the spaces in the leaf-tissue.

In general these little holes are irregularly placed, but on grass-blades and lily-leaves they are ranged in long, straight rows. The number of them in a square inch of leaf-surface varies from two hundred in the foliage of the mistletoe to two hundred thousand in that of the lilac. In the white lily they are unusually large, and easily seen by a simple microscope of moderate power, and some one has had the patience to compute that on the lower surface of the leaf there are sixty thousand of these little breathing-pores to every

square inch. In land-plants they are most numerous on the lower or shadowed side of the leaf, where moisture can not be drawn through them too fast by the ardent rays of the sun. But the floating leaves of water-plants have all their stomata on their upper surfaces, which alone come into contact with the air, and leaves which grow under water have no stomata at all.

Beach and desert plants must live between glaring skies and parching sands. So, whatever their more favored relatives do, these plants develop succulent leaves. Such foliage is born by the South African groundsel (Fig. 22 (1)), which has so adapted itself to circumstances that it is singularly unlike the too-familiar groundsel invading our gardens.

The moisture which fate vouchsafes such plants must be treasured for times of need, not drawn speedily away by high winds or scorching sun. So the stomata in their leaves are very few, and the leaf-skin is thick and tough, so that vapor may not exude through it.

The cactus family has a few representatives which grow wild as far north as Nantucket, but most of its members live in the hottest situations in tropic or semi-tropic lands. In such localities there is danger that the plant's juices be scorched or

dried out, and Nature guards against this by exposing the least possible proportionate surface to the rays of an ardent sun. The plant substance, instead of being spread out into a great number of thin, flat leaves, is collected into a solid mass, almost globular in some varieties, and this living lump is covered with a skin, which is richly colored with chlorophyll, and acts as one all-enfolding leaf.

The real leaves, superseded in their original work, have become converted into spines or prickles, and act as a deterrent to vegetarian enemies.

A member of the widely-differing family of the spurges, which lives on dry ground under an African sun, has adopted like habits. Its branches are succulent, spiny prongs, whose surfaces contain chlorophyll, and the plant, when not in bloom, might be mistaken for one of the many varieties of cactus, while the exigencies of the South African climate have driven a native milkweed to do as the cactuses do. In all three of these plants the vegetable substance is condensed into a mass, the inner tissues are full of juice, the bark is converted into an all-enfolding leaf, and the plant body is protected from thirsty vegetarians by thorns, hairs, or prickles (Fig. 22).

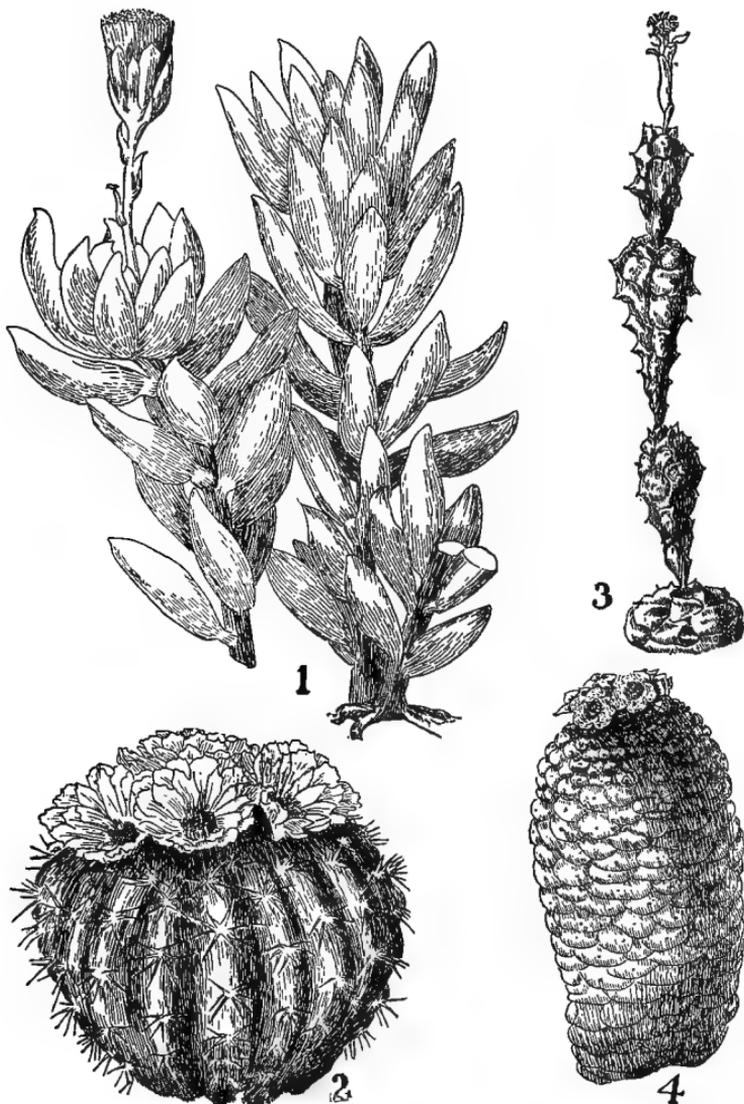


FIG. 22.—Four natives of South Africa.

1, a groundsel (*Senecio (Kleinia) Haworthii*); 2, a typical cactus (*Echinocactus corynodes*); 3, a spurge (*Euphorbia globosa*); 4, a milkweed (*Stapelia cactiformis*).

112 Field, Forest, and Wayside Flowers

Only the blossoms show that the plants are representatives of four widely-divergent botanical families.

Of all parts of the plant, the leaf is most subject to change, and the readiest, like Poo Bah, to fill all offices at once.

The same plant may bear two kinds, differing in form and in habits.

Some water-plants have both floating and submerged leaves. The floating foliage breathes atmospheric air, and the submerged foliage lives, as fishes do, by breathing the air which is in the water. The water-crowfoot, for instance, bears some floating leaves, and some which live beneath the surface. The floating leaves are broad, like those of the plant's near relations, the meadow buttercups, but those which live in the water are fringed.

In the common arrow-head, another amphibious vegetable, the submerged leaves are long and narrow, like blades of grass, and the terrestrial ones are arrow-shaped. Every leaf which spends its life under water, whatever its family habits and traditions may be, and whatever its ærial sisters may look like, is either a fringe or a narrow ribbon. Thus submerged foliage is doubly fitted for

its habitat. The slender blades and delicate fringes are adapted, like fishes' gills, to bring the greatest possible area of surface into contact with the water, and thus, also, with the air, which is diffused through it.

And the waves and currents, which might tear a broad leaf to ribbons, glide harmlessly through these blades and fringes, just as the ocean gales, which rip the *Canna* leaves in our summer cottage-gardens into "smithereens," sough harmlessly through the slender needles of the coast pines.

The thick, fat foliage of the house-leek, the aloe, and the century-plant does double duty. These leaves not only prepare nourishment for the plant, but also serve as storehouses to hold it.

Their whole interior is white as that of a potato, and, like that useful vegetable, they are heavily loaded with starch, while their green surfaces fulfil the ordinary use of foliage—transpiration and digestion.

As an Irishman might put the case, there are leaves which are not leaves at all—but are something else.

At the end of a climbing spray of the pea or vetch the topmost leaf—or a part of it—becomes (Fig. 23) a tendril by means of which the vine clings

to whatever it can reach. Always on the Irish Gorse, and sometimes on growing tips of our native barberry bushes, leaves are metamorphosed



FIG. 23.—A climbing spray of the pea. (The topmost leaflets are converted into tendrils.)

(From the *Vegetable World*.)

into thorns. In the case of the cactus, and some other succulent dwellers in thirsty lands, they are transformed into prickles.

And a whole category of plants bear leaves which are traps for the luring and snaring of insects.

So the functions of leaves vary widely, and their forms vary still more. "The leaves of the herbage at our feet," says Ruskin, "take all kinds of strange shapes, as if to invite us to examine them. Star-shaped, heart-shaped, spear-shaped, arrow-shaped, fretted, fringed, cleft, furrowed, serrated, in whorles, in tufts, in wreaths, in spires, endlessly expressive, deceptive, fantastic, never the same, from footstalks to blossom, they seem perpetually to tempt our watchfulness, and take delight in outstripping our wonder."

CHAPTER VI

LILY-KIN AND ROSE-KIN

“Let us change the subject, and talk about lilies and roses.”
—*E. Buxton.*

FROM time out of mind there has been a close companionship between the lily and the rose. They have bloomed together in all gardens of delight, from Mother Eve's, where the rose was “without thorn,” to grandmamma's, where they lived with single pinks, and gillyflowers, prince's-feather, and love-lies-bleeding, behind prim hedges of clipped box. They have been together in heraldry, where the Rose of England and the Lily of France were blazoned on the same Plantagenet shields and banners, together in mediæval art, where they have bloomed side by side at the feet of the Virgin, and together in the love-poetry of all times and lands from the Hebrew “Song of Songs” to Tennyson's “Maud.”

But botany breaks up this immemorial fellowship and puts them far asunder. It tells us, indeed, that they have nothing in common.

Each represents one of the two great classes, into which most flowering plants are divided. The lily's tribe is described by the ponderous term "Monocotyledons," and includes palms, rushes, sedges, grasses, the Calla-lily and her kin, the queenly orchids, and many simple flowers, better known and better loved than either.

The rose is a "Dicotyledon," and member of a series whose names are legion.

The differences between these two great classes of plants, of which lily and rose are types, begin while they yet lie dormant in the seed and may be clearly seen at every point in their subsequent development.

Every seed, of whatever variety, contains a little plant, completely formed and snugly folded into the smallest possible compass. Packed around this little plant, or incorporated into its substance, there is (in most cases) a store of starchy food which will nourish it till it grows large and strong enough to shift for itself. And wrapped about the outside of the seed there are generally two coats, the inner very thin and fine, and the outer comparatively firm and tough.

The peculiarities which distinguish the seeds of the Monocotyledons may be readily seen in a

118 Field, Forest, and Wayside Flowers

grain of Indian corn which has been soaked in water till it is swollen and softened. If now we split it down lengthwise with a sharp penknife we can see something of its inner economy, without the aid of a microscope. Near the smaller end of the grain, and at one side, is a pale, tiny corn-plant. It has one leaf rolled into a hollow cone, and enclosing a little bud, whence other leaves would have developed had the plants sprouted in the ground. There is a short, thick stalk, and, at its base, a blunt point.

At this point lies a little group of cells, full of vital power, whence the roots of the seedling should have sprung.

But the whole young plant or germ occupies but a small proportion of the seed's interior, and all the rest of the space is filled with stored food for the seedling's first growth.

The wheat germ lies in a similar position to that of the baby corn-plant, in the narrower end of the seed, and pressed against its wall. And in it, as in all the grains and grasses, Nature has provided very liberally for the first needs of the sprouting plant. This is the reason why the seeds of grasses—corn, wheat, rye, barley, rice, and oats—are among the chief food products of the world.

In all these seeds the store of nourishment is packed around the little plant, close to it, but distinct from it.

Scientific botanists call such seeds as this "albuminous," and they are produced by the majority of the lily's kin.

The seeds of most dicotyledons, on the contrary, contain little or nothing, except the baby-plant, and are called "exalbuminous."

But we must not infer from this term that the kin of the rose send their offspring out portionless into the cold world. Food for the seedling during its feeble infancy is generally present, and often abundant. Peas, beans, and acorns are fat and firm with starches for the young plant. Rape, flaxseed, and castor-oil beans are rich in vegetable oil, and nearly all seeds contain nitrogenous nourishment in the form of aleurone.

But this nourishment is stored, not around the baby-plant, but within the tissues of the first leaves. And these leaves, in the kin of the rose, are always two in number. Their substance has formed part of the seed, and therefore they are called seed-leaves or "cotyledons," and all the plants which have two of them are distinguished as dicotyledons (two-seed leaves). When we take the

120 Field, Forest, and Wayside Flowers

woody shell off an acorn, or strip the skin from a bean, we find that the white substance which remains splits naturally into halves. These are the two first leaves of the young plant, so distended by the nourishment stored within them that their true character is not at once discernible. Folded between them lie two more leaves, almost white and very tiny, which will be unfolded to the light as soon as the young plant gets its head fairly above ground, and between these inner and younger leaves is that portion of the plant which will carry on the work of development—the growing point.

Sometimes, when the cotyledons are very large and heavy, the tender stem of the seedling seems unequal to the task of lifting them above ground. This is the case with germinating acorns and horse-chestnuts.

The nut remains beneath the ground or on its surface, and the first leaves which the seedling-oak or horse-chestnut unfolds to the light correspond to the first pair of soft, green leaves which appear on the little bean-plant.

The halves of the sprouting bean, which appear above ground as two thick, oval seed-leaves, correspond to the halves of the sprouting horse-chestnut, which lie half buried beneath the soil.

After the dicotyledon has formed its roots and is fairly started in life, its leaves may grow up the stem singly or in pairs, and new ones may unfold one at a time or two together. But whatever individual eccentricities or family characteristics appear in the arrangement of later foliage, the seed-leaves of the rose's kin are always two, alike and opposite.

But the lily's many kin have each, as the ponderous term monocotyledon implies, but a single seed-leaf. In the ripe grain- or grass-seed it has a peculiar shield-like form, and it is wrapped completely around the second leaf and the stem that is to be. When the grain begins to sprout the upper end of the cotyledon remains in the seed and feeds on the nutriment which has been stored there. But its lower part lengthens and pushes all the rest of the little plant out into the world.

This cotyledon's main purpose in life is to absorb the starches and other nourishing things packed away in the grain, and not to digest crude sap, as most leaves do. It has, in most instances, no use for chlorophyll, and therefore it is seldom green.

We may find it near the roots of a young grass-plant, shrivelled away, now that its work is done, to a little horny, brownish scale.

122 Field, Forest, and Wayside Flowers

The second leaf of the young monocotyledon is developed later than the seed-leaf, and higher up on the stem, and the third comes later and higher still. So when the growing lily or wheat is a few



FIG. 24.—Parallel-veined leaves of the Indian shot (*Canna Indica*).
(From the *Vegetable World*.)

inches above ground we see that its leaves are scattered along the stem, each singly and alone.

When the plant is a little older this alternate arrangement may be abandoned for some more

complex plan. The leaves of some lilies are borne in circles, like spokes of a wheel, and those of some of the lilies' cousins are so ranged along the stem that a line drawn through the point of insertion of each will go winding upward in a beautifully symmetrical spiral.

One of the most marked characteristics of Monocyletons is the veining of the leaves.

By this alone we can generally tell almost at a glance whether a plant is to be classed with the lily or with the rose.

The foliage of the lily-kin generally has what botanists call parallel veins (Fig. 24).

A mathematician would take exception to the term, for parallel lines, as we all know, never meet, while parallel leaf-veins come together at the leaf's tip.

But the student of plant-life who called the veins of lily-leaves and grass-blades "parallel," was probably comparing them to the veins of dicotyledenous foliage, which twist and branch into a mesh-work as bewildering as it is beautiful (Fig. 25).

The leaves of lilies and their kin are almost always simple in outline,—arrow-shaped, heart-shaped, oval, or long and narrow, like blades of grass.

Branched leaves occur only rarely and exceptionally among the palms, and in a few of jack-in-the-pulpit's eccentric cousins. But the blade-like foliage (Fig 26) is borne by many plants among the lily's kin—the crocus, iris and spider-



FIG. 25.—Net-veined leaves of the lime-tree.
(From the *Vegetable World*.)

wort, the orange-colored lily of old-fashioned gardens, the blue-eyed grass, the cat-tail flags, and other familiar flower friends. Such leaves, like grass-blades, have no true stalks, but spring from sheaths which enfold the stem. These clasping



FIG. 26.—Blade-like leaves of the iris, with clasping bases.
(From the *Vegetable World*.)

bases and perfectly straight veins are characteristic of the narrow foliage of monocotyledonous plants. Whether narrow or broad, the leaves borne by the lily's kin have, as a rule, straight edges, plain and unadorned.

The leaves of the rose's kin are far more elaborate in effect. Sometimes, as in the case of the rose itself, each of them is "compound"—made up of a number of smaller leaves. Sometimes they are cut into delicate lace-work, as is the foliage of the yarrow and of the domestic carrot.

Sometimes, like the leaves of the rose-geranium, they are curiously slashed, and in many cases their edges are daintily cut into points, teeth, or scallops.

Their veins, as we have already observed, run "every-which way," and even when the larger veins parallel one another with copy-book precision, as in the chestnut-leaves, the veinlets wander here and there in graceful lawlessness.

It is in the tissue of the stem, and in its mode of growth, that the chief distinction between the two greatest groups of flowering-plants is to be found.

Next to the palmettos, which are not found in a wild state north of the Carolinas, the Indian corn is the largest of native monocotyledonous plants. If we cut a thin, cross-wise slice out of a corn-stalk

we need no microscope to show us its internal structure. We see that there is no separable bark, and that the woody substance is in delicate threads, which are scattered all through the pithy interior, but are most numerous toward the outside of the stalk. The palmetto trunk is built after the same plan, but its woody threads are so tough, and so closely massed together, that they make a material

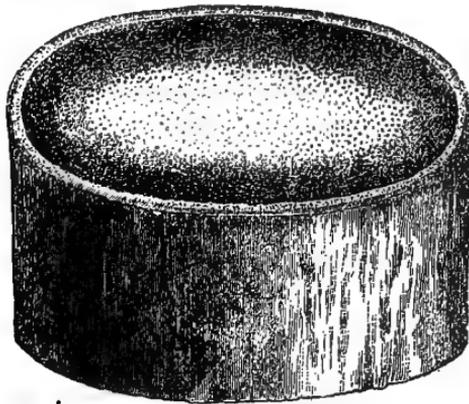


FIG. 27.—Crosswise section of a palmetto trunk.
(From the *Vegetable World*.)

hard enough to be useful to the cabinet-maker (Fig. 27).

If we could detach a single woody thread from the corn-stalk, cut a thin, crosswise slice of it, and examine it with a powerful microscope, we should see that it is a compact bundle of small filaments, and that each filament is a row of short tubes or

128 Field, Forest, and Wayside Flowers

vessels. Transverse partition-walls separate one vessel from another, and these walls are sometimes horizontal and sometimes aslant. An inquiry into the names and uses of all these vessels would take one far into the mazes of structural botany.

The student afield, with no equipment save a penknife and a pocket-lens, and with mayhap but a limited stock of patience, is content to know that this woody thread is a fibro-vascular bundle, and that its important parts are wood-vessels, bast-tubes, and tough fibres, which give strength and support to the whole affair. Further support is given to the fibro-vascular bundle of a monocotyledon or a fern by a bundle-sheath made of corky cells or of cells with very thick walls.

The kin of the rose, too, form fibro-vascular bundles, and tough ones at that. When, in ridding the lawn of an intrusive plantain, one gives a pull to the tuft of leaves they are apt to tear away, leaving whitish strings dangling from the broken surfaces. These are the fibro-vascular bundles of the leaf-stem, and so are the strings, which must be removed from imperfectly-frosted table-celery.

In the "wood" of a bundle are included all those vessels through which fluids ascend from the roots toward the leaves.

The walls of some of these are queerly pitted, and those of others are beautifully marked with raised rings or spirals.

When the plant is growing actively the largest vessels generally contain but a film of fluid covering their walls, while the rest of the space within them is filled with air.

The tubes, which are the most important part of the bast, have thin walls with delicate tracery, and are the route by which fluids descend from the leaves toward the roots.

The water which a growing plant absorbs from the soil holds in solution many mineral and chemical substances. This liquid is "crude sap," and it is the material upon which three magicians work together. The green coloring-matter in the leaves, the sunlight falling upon them, and the carbon dioxide in the air about them, are the efficient trio.

And the result of their subtle alchemy is "digested sap," which moves downward from the leaves into all the growing parts of the plant, travelling always through the bast.

When Nature is about to make a new fibro-vascular bundle, in lily-kin or in rose-kin, a little of the cellular substance of the growing stem experiences a change of character, and becomes set aside,

as it were, for new and higher uses. Each cell in such a cluster divides lengthwise into two, which again divide, each into two. This young tissue instinct with formative life is "procambium." After a little while the cells on one side of it lengthen, their walls grow thicker, and on them appear the annular and spiral markings characteristic of the first-formed wood-vessels. On the other side of the procambium, meantime, bast-tubes are taking shape and office.

In the palmetto-trunk, in the corn-stalk, and in the stems of most lilies the cells of the procambium soon cease to multiply, and they all become altered over into wood or bast before the close of the growing season.

Thus Nature comes to the end of her material, and the growth of the bundle ceases perforce. Fibro-vascular bundles of this nature, which can grow "just so much and no more," are called "closed," and are very general among monocotyledons. They are shut off from one another by masses of pith, and there is not, at any season, a continuous ring of young tissue running around the stem. So it is only in a few exceptional cases that the monocotyledonous stem grows steadily thicker with age.

The corn at six weeks old is more sturdy than when it first rises above ground, but this is mainly because the second joint of the stem is larger than the first, and the third larger than the second. So if we push away the earth from the base of growing corn we find that the portion closest to the ground is more slender than the portion above. But the increase in the diameter of the corn-stalk, lily-stem, or palmetto-trunk is entirely limited to the earliest period of growth. Some of the oldest palmettos in Florida are noticeably slender.

Among all the lily's many kin there is but one native plant which grows stouter as it grows old. This is the yucca or bear-grass of the Southern States, which is interesting to botanists as a connecting link between two great classes of plants, for it is a monocotyledon in everything except its mode of growth, and in that it resembles the dicotyledons. For the kin of the rose grow stouter and sturdier with every year of life.

The main stem and older branches of a rose-bush have a tough bark, which peels off readily in strips. If we examine this carefully we find that it consists of two portions. The outer layer is thin and colorless, and in an old rose-bush it is

132 Field, Forest, and Wayside Flowers

dry and apparently half dead. Inside this is a layer of green bark, full of sap and vitality.

Beneath this lies the wood—a hollow cylinder, enclosing a light porous substance—the pith. This marked division of the stem into concentric rings of bark, wood, and pith is found only in the dicotyledons.

In a very young plant of the rose's kin this distinction is not yet apparent.

Indeed, a cross-section of any very young flowering-plant shows a stem-tissue alike in every part. In the lily's kin it all behaves alike, for any cluster of cells anywhere in the young stalk may turn into procambium.

But when a young plant of the rose's kin is about to acquire fibro-vascular bundles the little clusters of cells which become instinct with constructive life lie just beneath the surface of the stem.

Next spring's bundles will develop in the spaces between those of last spring, and by time the stem is four or five years old it has a ring of bast running all around it and a ring of wood within. Between these, in spring, there is a circle of cells which are actively at work building up new tissue.

When we peel the bark off a spring bough we break these forming cells, and the jelly which fills them escapes, moistening the wood, and our destructive fingers also.

During this season of vigorous growth the fibro-vascular bundle of a dicotyledon consists, broadly speaking, of three parts—the wood, the bast, and the generative tissue, full of sap and vitality, which lies between them.

By the end of summer, however, a transverse section of the bundle in question will show no actively-dividing constructive cells. The formation of new substances is over for the season, and each fibro-vascular bundle now seems to consist of but two important elements, wood-vessels and bast-tubes.

But the work of tissue-building in this kind of a bundle is not finished. It is merely arrested. The constructive life at the core is "scotched, not killed," and after remaining dormant all winter it reawakens in spring. Then a zone of constructive or "cambium" cells, instinct with creative vigor, will come into being between wood and bast, and tissue-building will recommence.

So the fibro-vascular bundles of roses and their kin are capable of renewing their growth, year

after year, or, in technical language, they are "open."

In the country north of the Carolinas all native leaf-bearing trees are dicotyledons. In April, May, and June constructive tissue is present and active in them all. New wood is generated rapidly, and the vessels and cells which are formed are comparatively large. Later in the year, when life stirs less lustily in the vegetable creation, smaller vessels and cells will be formed. So the difference between "spring" and "summer" wood is often readily discernable even to the unaided eye, and always evident by aid of the pocket-lens.

We may see it on the upper surface of any casual stump. The spring wood often looks as if it had been used as a pincushion, because we see in it so many circular ends of now empty vessels and tubes. The summer wood is much more compact in its texture, and sometimes darker in color. So rings run around and around the stump, and by counting them we can tell the age of the tree—not accurately, but approximately. For it is quite possible that, if the season be moist, and the autumn late, more than one growth-ring will be formed in one year. If our stump were standing in Florida woods its rings would tell us little.

For these mild winters sometimes favor almost continuous growth, and cambium may be present, and new wood may be formed, during almost any month in the twelve. The rings of a tree (Fig. 28) are a trustworthy guide only in northern latitudes, where vegetation has a period of vigorous growth followed by a period of torpor.

In all dicotyledenous trunks the newest wood

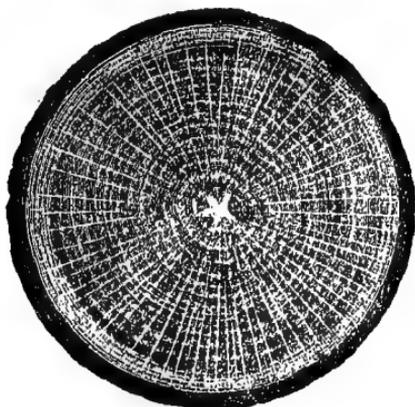


FIG. 28.—Crosswise section of the trunk of a young oak-tree, showing growth-rings.
(From the *Vegetable World*.)

lies just beneath the inner bark, and the older wood toward the centre. So a little is added to the girth by each year's growth, till the enormously thick trunks of some of our larger forest-trees are built.

The differences between the rose's kindred and the lily's kindred culminate in their flowers. The

136 Field, Forest, and Wayside Flowers

costly roses which droop in florist's windows are brought to an artificial state by arduous culture, and held in it by eternal vigilance. They are propagated mainly by cuttings. Left to themselves for a while their blossoms would dwindle and their pollen would intermix, till, in the course of time, the rose-garden would be filled with a generation of seedlings, showing what naturalists call "reversion to type." Jacqueminots, American Beauties, Bonsilenes and Catharine Mermels would be sought there in vain. In their stead we should find blossoms resembling some more, some less closely, the ancestral wild roses from which all sprang.

It is from the wild-rose, queen not yet come to her own (Fig. 29), that we shall best study the differences between the flowers of dicotyledons and those of monocotyledons.

The wild rose has five sepals and five petals. Its stamens are innumerable and the cells of the rose-hip are partially or entirely fused together. But the number five is more closely adhered to by other members of the rose tribe. The apple-blossom, for instance, has five sepals and five petals, and apple-seeds are stored in five horny pockets. The geranium tribe, the mallows, the



FIG. 29.—Wild roses.
137

numerous cousins of the pinks, the violets, almost every member of the immense buttercup connection, and many other blossoms of many tribes, follow the rule of five with more or less fidelity.

Other large families among the rose's kin bear blossoms, whose parts, like those of the garden-fuchsia, are in fours or in multiples of four.

Among the lily's kin the parts of the flower are in threes, or their structure shows that they once followed the rule of three, which they have now partially abandoned.

The lilies themselves have three sepals and three petals, generally much alike in color and texture (Fig. 30). Sometimes all six have grown together into a chalice, which is still bordered with six reminiscent scallops.

Within these are three stamens—or, it may be six—forming an outer and an inner trio. At the flower's heart there may be three pistils, or, as in the flowering rush, six. or one, which, when we slice it across, is found to contain three seed-pockets. Sometimes as the seed-vessel ripens these pockets break away from one another, so that the final result looks almost like three ripened pistils (Fig. 31).

The blossoms of grasses and sedges have de-

parted, sometimes widely, from the ancestral type, but even in them the “three-by-three” plan may be distinguished.

The palmettos of the Carolinas bear flowers much like those of grasses.



FIG. 30.—A lily-flower.
(From the *Vegetable World*.)



FIG. 31.—Seed-ves-
sel of the tulip.
(From the *Vegetable
World*.)

And so we come to these monocotyledons which, having diverged most widely from the primitive type, are most perplexing to the botanist,—the calla and her poor relations, and the cat-tail flags.

Incredible as it may sound, the calla is not a flower, and the snowy “spathe” which enfolds its



FIG. 32.—Sweet-flag (*Acorus Calamus*).

golden head is neither a petal nor a sisterhood of petals. It is a foliage-leaf, become big and beautiful in order to lure the marsh-flies of the calla's native haunts to visit and fertilize its flowers; for the real flowers are not one, but legion. They have lost everything which ever belonged to them except a few stamens, or a few stamens and a pistil, as the case may be. They completely cover the column or spadix, which stands up inside the enfolding leaf, and in the calla of commerce they are so massed together that it is difficult to distinguish them even with a lens.

The calla's past condition may be surmised from the present state of some of its humble cousins which are to be found around ponds and in bogs in the northern and central United States.

In the sweet-flag or calamus, for instance, the flowers which crowd the spadix are perfect and complete (Fig. 32).

Each has six flower-leaves, which are now reduced to half-transparent greenish scales, six stamens, and a three-celled ovary enclosing several seeds (Fig. 33).

By studying these flowers we see how a mass of perfect little lilies may have been altered into a mere club of stamens and pistils.

As the lilies are squeezed together their flower-leaves have no chance to reach a perfect develop-

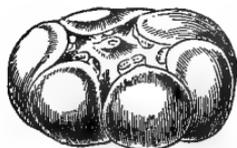


FIG. 33.—A single floret of the sweet-flag.

ment. So the spathe, at first a mere leafy sheath, begins to assume the duties which they have abandoned, and, by making a show in the world, helps to lure flying-insects to the blossom-colony.

The downward path is as easy in nature as it is in morals. Generation after generation the partially superseded flower-leaves pale and dwindle, till, as in the calla, they are wholly superseded, and the spathe completely usurps their office of insect-luring.

The cat-tail flag is like a calla, with its staminate and pistillate flowers separated, and with its creamy leaf torn away. It depends upon the wind for its pollen-carrying, and hence has no need of an insect-lure. Its flowers are reduced to the lowest possible terms, and may represent the last step in degeneration.

In early summer the cat-tail is a two-story arrangement (Fig. 34). The upper part is of golden-green and soft-like chenille, while the lower portion is darker in hue and more solid to the touch. The golden-green upper-story is a mass



FIG. 34.—June aspect of the cat-tail flags.

of stamens, or, to speak strictly, of reduced staminate flowers, inserted directly on the central stalk and mingled with long hairs. By latter July the stamens have shed their pollen and shrivelled, and they and their accompanying hairs have dropped off, leaving a bare stalk behind them. The darker and more substantial lower-story is a

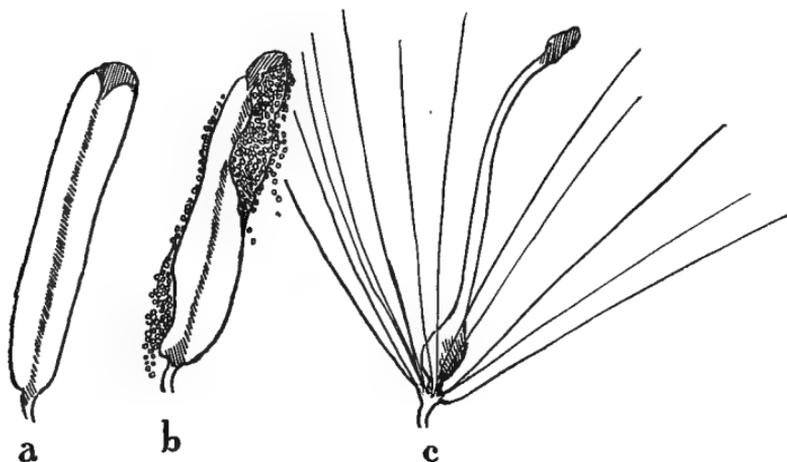


FIG. 35.—Single florets of the cat-tail flag.

a, Young staminate (or male) floret; *b*, older staminate (or male) floret; *c*, pistillate (or female) floret.

mass of blossoms, each reduced to a little stalk bearing one pistil and a few bristles. When the ovaries have ripened into minute fruits—not seeds, though we should incline to call them so—the bristles will buoy them up on the autumn winds and enable them to fly far in search of new homes (Fig. 35).

To the evolutionary botanist the little stalk

148 Field, Forest, and Wayside Flowers

which supports the cat-tail ovary suggests the stalk of a perhaps once perfect flower, and the bristles the flower-leaves that used to be.

So starting from the complete and perfect lily with six creamy flower-leaves, six stamens, a three-celled ovary, and a seed-vessel splitting into three, we can trace every step in a downward course till we come to the lowly estate of her distant poor relations, the cat-tail flags.

But in members of the lily's kin, of high or low degree, the fibro-vascular bundles of the stem are "closed," the leaves have parallel veins, the parts of the flower follow more or less closely the rule of three, the ripe seed contains abundant nourishment, packed around the germ, and the sprouting plant has one cotyledon.

And in the kindred of the rose, aristocratic or plebeian, the fibro-vascular bundles of the stem are "open," and the leaf-veins branch into complicated networks. The parts of the blossom are in fours or fives. The nourishment garnered for the germ is generally packed into the cotyledons, and those cotyledons are two and opposite.

So from the very first the great law of heredity asserts itself, and the type of the race is impressed upon the germ while it yet lies dormant in the seed.

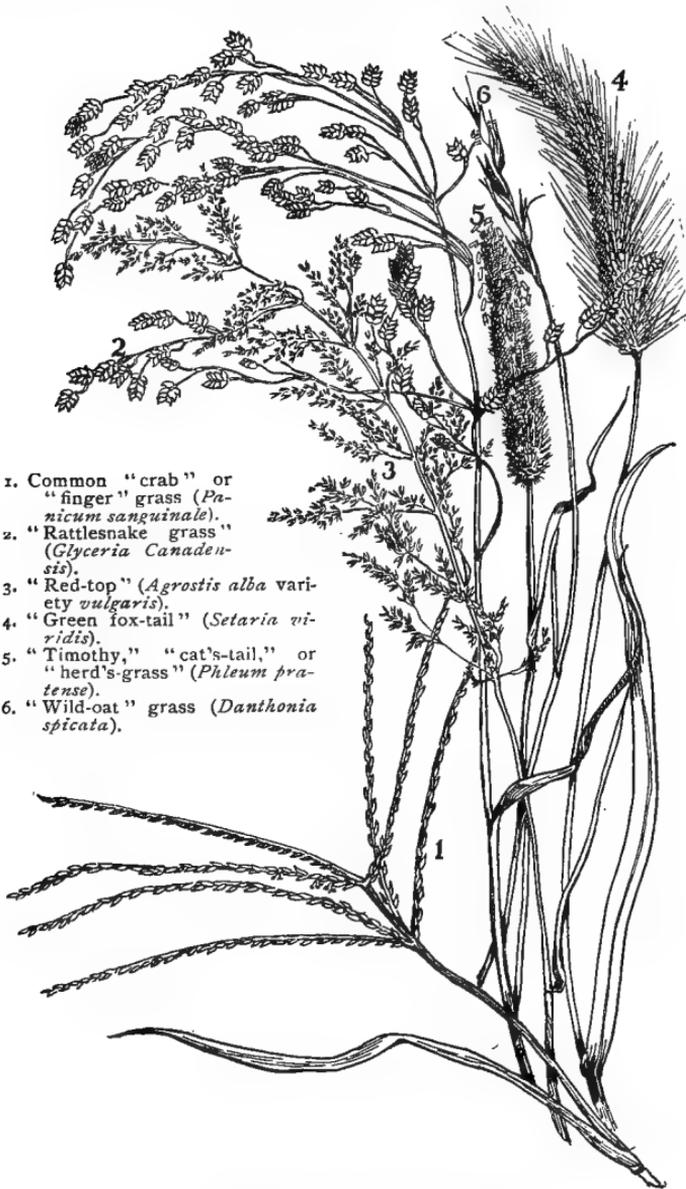
CHAPTER VII

GRASSES

"Praised be my Lord for our mother the earth, the which doth sustain us, and keep us, and bringeth forth divers fruits, and flowers of many colors and grass."—*Song of the Creatures*, by Francis of Assisi.

THE late Oliver Wendell Holmes, in one of the most exquisite passages of all his work, has suggested that homesick longings for earth may come over unreasonable human nature even in the courts of heaven itself, and that eyes may turn from all the glory and the glow, with reminiscent craving for the cool color and graceful billowing of blowing grass, starred with daisies and with dew.

To one who has seen a region, however beautiful, which lacked grass, the sentences in which the author has expressed his feeling come with peculiar force. For no splendor of semi-tropic sunshine, no blue of water and sky, no grace of palms, can compensate to the landscape for the



1. Common "crab" or "finger" grass (*Panicum sanguinale*).
2. "Rattlesnake grass" (*Glyceria Canadensis*).
3. "Red-top" (*Agrostis alba* variety *vulgaris*).
4. "Green fox-tail" (*Setaria viridis*).
5. "Timothy," "cat's-tail," or "herd's-grass" (*Phleum pratense*).
6. "Wild-oat" grass (*Danthonia spicata*).

FIG. 36.—Some familiar grasses.

loss of the humble plants, constantly trodden under foot of man, and chiefly valued for their utility as fodder.

In fact, as Mrs. Stowe wrote in one of her Florida letters, "You never realize what grass is—till you have to do without it."

But in temperate regions grasses give character to the whole landscape. They foster the wild life of the fields, forming sheltering bowers in which small animals hide from their enemies, and ground-nesting birds rear their broods.

Grasses are the basis of a large proportion of the higher life of the globe, for no family of plants equals them in usefulness as food for man and beast. They give us corn, oats, wheat, barley, rye, rice, and sugar. Our bread comes directly from grasses, and, as they feed the flocks and herds, our milk, cheese, butter, meat, and leather come from them indirectly.

So they enter into close business relations with the farmer, the stock-raiser, the miller, the baker, the shoemaker, the saddler, and the exporter. After the grain has been gathered, the stems which upbore it are peculiarly adapted for use in many industries. And, lastly, the grasses are doing, slowly and continuously, what the world's

152 Field, Forest, and Wayside Flowers

great soldiers have sometimes done in a single battle, for they are determining boundary lines.

Most grasses have a strong rootstock, often called a root—really an underground stem. It creeps horizontally beneath the surface of the soil, sending fibrous roots downward and leaves and stems upward. It survives severe winters and parching droughts, and young blades grow up from it in spring, or on the return of rainy weather.

To this family habit we owe, in great measure, the beauty of the fields and the life of grazing animals, for if all grasses grew from seed each year cattle would soon exterminate the very sorts which they like best.

And the subterranean rootstocks of grasses are extremely useful as soil and sand-binders for wave-beaten and wind-swept regions.

All down the sandy ocean coasts a war is waged, unceasingly, between the sea and the land. The robber-waves, like an attacking army, seem forever trying to overwhelm or to carry off the land. The land tries to withstand and repel them.

Each of the principal combatants has formed an alliance. The waves are helped by the wind,

The land has its assistants, too,—a humble host, —whose work is done quietly, and chiefly underground, but whose combined aid is invaluable. These are the coast-grasses, whose stems bend to the winds, but whose widely-penetrating roots bind the sands in a network of tough fibres, and defy the encroachments of the waves.

On the Atlantic seaboard, from Canada to Virginia, the coastwise sand-dunes are overgrown with the “marram-grass” or “sea sand-reed” (Fig. 37).

Its strong rootstocks often attain a length of twenty feet or more, and become closely interwoven, forming a netlike mass which is very resistant to the force of wind and sea. Further south the “little panic-grass” takes up the good work, and gives permanence to the coast-lines of Florida and the Gulf States. The running mesquit of Arizona and the alkali-grass of the plains help to hold in place the shifting soils of the great thirst-lands. Several species of mud-binding grasses give solidity to the shores of the great lakes and render the banks of the Mississippi and its tributaries more permanent than they would otherwise be.

The public services of such grasses as these have been acknowledged in high places. During the

reign of William the Third the English Parliament passed laws to preserve two species of grass which

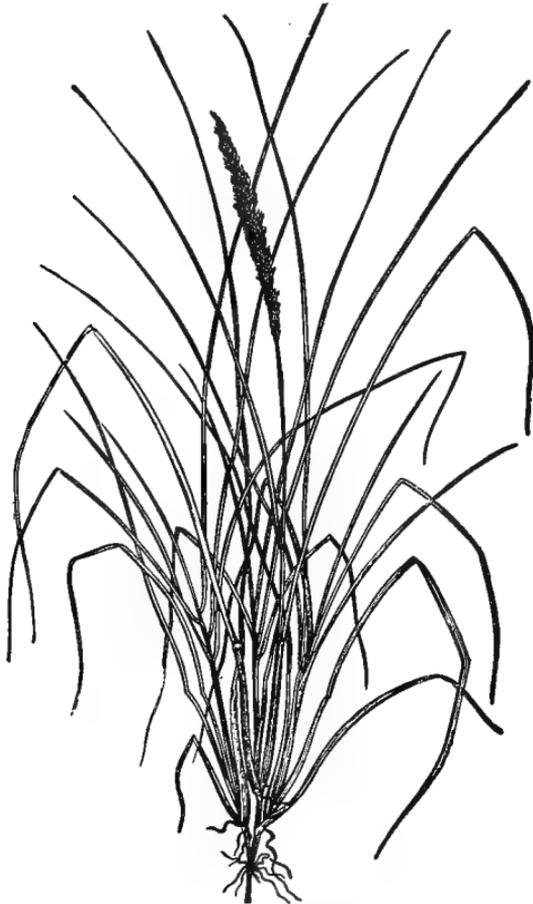


FIG. 37.—“Marram-grass,” “beach-grass,” or “sea-sand reed”
(*Ammophila arundinacea* of Gray).
(From Bulletin No. 7 of the U. S. Department of Agriculture, “American
Grasses.”)

act as sand-binders along the storm-beaten Scottish coast. Severe punishment was to be inflicted

upon whomsoever should destroy these good friends of the nation, and even the possession of any of their stalks, within eight miles of the coast, was a penal offence.

In Holland like laws protected the grasses which have made it possible for the little country to hold the lands so laboriously wrested from the North Sea.

Cape Cod folks, once upon a time, were legally compelled to turn out every April and plant marram grass,—much as the inhabitants of some rural districts must give a certain number of days' labor, each spring, to the work of road-mending. "Town and harbor of Provincetown owe their preservation to this grass," says Lamson-Scribner.

At one time Provincetown had a "beach grass committee," whose duty it was to enter any man's enclosure, summer or winter, and set out marram, or "beach-grass" as it was called, "if the sand were uncovered or movable."

Sand-storms, once the terror of the town, were thus entirely prevented.

We have now laws for the protection of forests, and it has been suggested that government might, with equal wisdom, concern itself in the preservation of those grasses which hold together mud-flats and sandy shores.

156 Field, Forest, and Wayside Flowers

For if such vegetable friends are wantonly removed, or are allowed to perish, valuable tracts of ground are buried under sand, or are altogether washed away, and harbors are rendered unsafe by accumulating shoals and bars of sand or mud, brought from other shores.

Some species of grass, in the course of many summers, convert marshes and half-submerged shores into firm land, and hence have been called "Nature's most valuable colonists."

They hold territory which has been wrested from the waters, and which, but for them, would speedily be retaken.

Thus they fix, if they do not change, the bounds of land and sea, and help to make geography for the boys and girls of coming generations.

To the evolutionary botanist the grasses are peculiarly interesting, for while many of their characteristics show the highest possible adaptation to the conditions of their lives, their flowers are conspicuous instances of degeneration.

They have reached, it seems, the last stage in a strange, eventful history. It is surmised that the first flowers ever born into the young world had stamens only, or a pistil only, as the case might be, had neither calyx nor corolla, and were wind-

fertilized. The cone-bearing trees have blossoms which still adhere to these most ancient of all floral customs.

Later came the insect-fertilized flowers, with pretty corollas developed especially to charm their winged friends.

The grasses, in their present form, seem the latest flowers of all. They have reached a third condition, and after acquiring calyx and corolla to please insects, have abandoned these little messengers,—or been abandoned by them,—and have reverted to the primitive ancestral habit of dependence upon the wind.

Though the wind and the grasses take opposite sides in the contest between earth and sea, they are, on the whole, close friends. For the wind is not only the agent for the cross-fertilization of the grasses. He is the master-artificer who has moulded and fashioned them in every part, from root to flower.

If we pick a spear of "red-top" we find that its stem is hollow. The hollow stems of the grasses, like those of the dandelion, have the utmost strength obtainable with economy of material, and both strength and economy are needed in the structure of a stalk which must uphold, in the

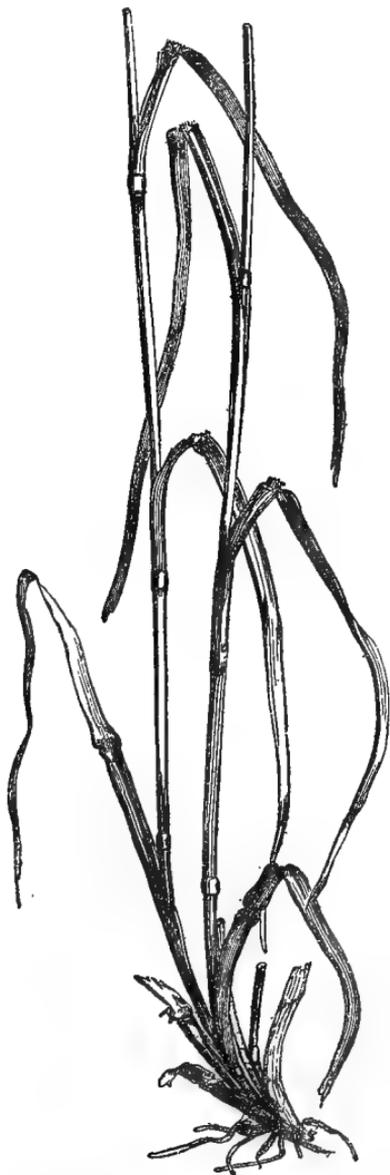


FIG. 38.—Stems of the rye, showing the knots or "nodes."
(From the *Vegetable World*.)

wind-swept fields, a proportionately large and heavy mass of bloom.

Fine whitish ribs run all down the length of the stem. These are woody and give it strength, and further reinforcements are lent by the bases of the leaves, which are wrapped around the stem, so as to enclose it in a series of sheaths.

Each of these sheaths has an opening all down its length, and is welded to the stem by its base only, and just at the point of junction the stem is solid and swells into a knot (Fig. 38).

These knots or "nodes," and the clasping leaf-bases also, are closest together near the ground.

And the lower part of the grass-stem, which Nature thus reënforces, is just the portion subjected to the greatest strains when winds sway the head of blossom above.

The Indian corn, the giant among native grasses, with its large leaves and long slender stalk, seems peculiarly likely to fall a victim to the wind. And its fibro-vascular bundles, which are water and food conduits, might, one would think, be squeezed or crushed by the swaying of the breeze-rocked stem. A beautiful provision is made against either of these mischances.

Each bundle, in the first place, is invested by a strong, tough bundle-sheath. And being thus well protected individually, the bundles are used, collectively, as a means to reënforce the stem. For the course of each from the ground to the leaf is a long arch, curving outward. So each bundle with its sheath acts as a strut, and if the bundles interweave, as they do most beautifully, in some grasses and rushes they resemble the network of girders in an iron bridge.

A like adaptation enables the palmetto to support its heavy crown, despite the winds which blow so lustily in southern latitudes.

The gales which bend but do not snap the

grass-stalk pass harmlessly over the long, narrow leaves, which have taken the form of pennants to meet a like necessity. For both grass-blade and yacht-pennant must expose the largest possible area to the light, and yet present no broad surface to be torn by winds.

These narrow leaves are born one by one along the hollow stem which botanists call a haulm. They are traversed by straight veins, which run lengthwise, almost parallel to one another. At the point where the leaf or "blade" bends away from its sheathing-base there is a little whitish, semi-transparent scale—the ligule or "shoe-latchet" (Fig. 39).

While "a grass" is speedily recognized by the merest tyro, the trained botanist is sometimes puzzled in the effort to identify his particular grass, and to differentiate it from near relations, which resemble it as confusingly as Dromio of Ephesus resembled Dromio of Syracuse. Under such circumstances the ligule sometimes gives the clue, for in one species it may be chopped off abruptly, in another drawn out into a delicate point, and in a third cut into a fringe.

Its purpose in the plant's domestic economy is not evident.

As grass-flowers send their pollen abroad only by the wind, they have no need to lure insect messengers, and hence have no striking colors, and, in most cases, no perfume. They are generally very small, and are massed together in compact groups,

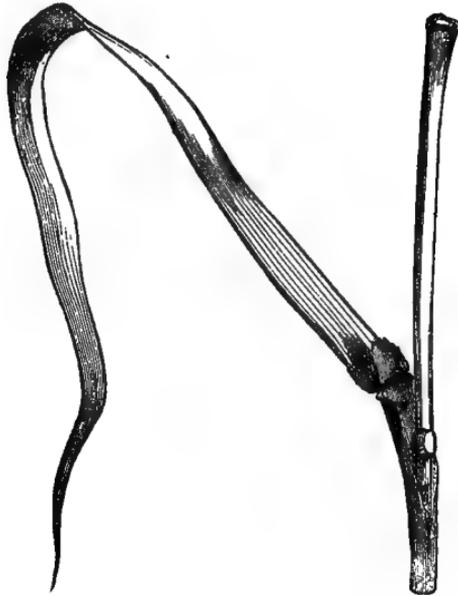


FIG. 39.—Ligula of millet-grass.
(From the *Vegetable World*.)

which live in close propinquity to other groups, forming large floral communities.

The oat of commerce is a typical grass, and from a study of its parts one can gain knowledge on the structure of grasses in general.

To a casual glance there is little difference be-

tween the oat-blossom and the grain ready for the harvest. The flower-cluster is green. The ripe oat-cluster or "fruit" is yellow. The non-botanist would find no other distinction between flower and fruit. Indeed, he probably would not recognize the flower as a flower nor the "fruit" as a fruit.

What looks like one grain in the oat-cluster is—little as one might think so—two flowers, and between them there is generally a little white affair, which is the last vestige of a third (Fig. 40, *a*).

The whole trio constitute a "spikelet." Most grass-flowers grow thus in spikelets, which are little floral households.

Outside the oat-spikelet there are two chaffy pointed green scales.

These are the "outer" or "empty" glumes. They correspond to the involucre, or circle of little green scales which surrounds the whole head of bloom in many clustered flowers (Fig. 40, *b*). All grass spikelets are thus partly or wholly enclosed in one or two, or sometimes more than two empty glumes. Sometimes they are so small that Nature seems in fair way to abolish them altogether.



FIG. 40.—Oats and yarrow.

a, A cluster or "spikelet" of oat-blossoms; *b*, a cluster or "head" of yarrow-blossoms; *c*, a single oat-blossom with its enfolding "glumes"; *d*, a single yarrow-blossom with its attendant "bracteole."

Sometimes, as in the oat-blossom, they are large enough to shut the whole spikelet in between them.

When we separate the empty glumes of the oat-spikelet we find the enclosed flowers (Fig. 40, *c*). Each is shut in between two green scales, which are like the "empty glumes," but smaller, and blossom and scales together look like a green oat-grain.

Scales similar to these enclose the blossoms of all typical grasses. They are generally two in number, and are sometimes called "flowering glumes" and sometimes "paleae," while Gray's "Manual" calls the lower and outer one the "flowering glume" and the upper and inner one the palea. However designated, they correspond to those scale-like leaves which stand beside the florets of many-clustered flowers, and are variously named by the technical botanist (Fig. 40, *d*).

At some fair future day we will have, let us hope, the same name for the same organ, whatever the organism in which it occurs. This plan will save the nature-student much tribulation, and will give him far clearer ideas of relationship and development than he can possibly get under the present system.

Meantime we call these little green affairs "bracteoles" when they stand beside the florets of the yarrow and "flowering glumes" and "paleae" when they enclose the tiny blossoms of the grasses.

But they occupy a similar post in the plant economy everywhere. They are humble attendants upon the true flowers, standing close by as if to guard and screen them.

We shall see the oat-blossom itself when the flowering glume has been removed. Its most conspicuous parts are a pistil and three stamens. The anthers are large, as in all the grasses, and they are balanced like see-saw boards, on the tips of slender filaments.

So they oscillate and sway at the faintest breath, shaking their pollen out to the wind. The filaments, which are as fine as gossamer, are also stirred by the faintest zephyr.

And, lastly, the spikelet itself dangles at the end of a delicate stalk, which forms part of an open, swaying flower-cluster. So the wind has its will with the oat-blossoms, and its force is used to the utmost in shaking the stamens and scattering the pollen. The pollen is light and dry, so that it can readily be detached from the anthers, and blown away

166 Field, Forest, and Wayside Flowers

And the pistil is especially fitted to catch the precious dust as it flies.

The stigma is proportionately long and large, and forks into two parts.

These spread widely asunder, as if welcoming the pollen with open arms; and they are hairy and somewhat glutinous, so that the golden grains which come to them may catch and cling.

But in the anatomy of grasses and of oats, among the rest we find hints that the coöperation between them and the wind has not always been so perfect as it is to-day.

For the flowers still have vestiges of petals, and hence we surmise that once upon a time they lured insects, and were fertilized by them.

When the wind became the pollen carrier for the grass-blossoms, their petals were no longer needed as insect lures. So they grew "small by degrees and beautifully less."

Some grasses have three of these mementoes of bygone glories, others have only two (Fig. 41). They are minute affairs, transparent or translucent, and very pretty under a low-power microscope even in their present degradation. When the stamens and pistil are matured these reminiscences of petals become succulent, and thus force

palet and flowering glume apart, so that the stamens can dangle out to the wind, and the pistil can reach abroad for pollen.

And by thus making themselves useful in a new capacity the superseded petals have saved their lives.

Had they been less versatile they might have shared the fate of some sedge petals, which have shrivelled and shrunk to the vanishing point.

When the pistil has been fertilized, the flowering glume and palet close together again and form a protective covering for the ripening fruit.

The ovary has but one ovule, so this fruit contains but one seed. It is wrapped in two coats, as seeds

generally are, and outside these are three more coats, which constitute the envelopes of the fruit.

The whole affair is known to botany as a "caryopsis," and to the general public as a grain (Fig. 42). The innermost integument clings tightly to the seed, and each succeeding one adheres to the one beneath it. They peel off with difficulty, still clinging together, so that the grain appears to have a single tough skin.



FIG. 41.—Single flower of a grass, showing two vestigial petals, three stamens, and ovary with two plume-like styles.

Just inside the innermost skin of the wheat-grain there is a layer of nitrogenous substance, far richer in nutriment than the starchy substances which lie beneath it. When the integuments of the wheat-grain are torn off, this nutritive "aleurone" layer is apt to come away with them. But any process of milling which can keep the aleurone with the starchy inner part of the grain will produce a flour highly nutritive in proportion to its bulk.

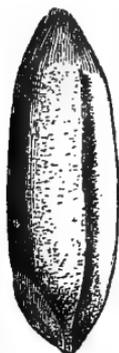


FIG. 42.—
Caryopsis of the
wheat.
(From the
*Vegetable
World*.)

The parts of the grasses are simple and few, but Nature can so vary their forms and their arrangement that botanists recognize about four thousand species, of which over two hundred and sixty grow east of the Rockies.

The number of flowers in each spikelet varies greatly in different species. Sometimes there are a dozen or more—sometimes there is but one, with rudiments and traces of others above it. The spikelets may be ranged down one side of a main axis in compact, straight rows; they may surround the axis, as they do in "timothy" grass, forming a cylinder of bloom, or they may dangle, as the oat-spikelets do, at the tips of slender branchlets, which form part of larger sprays.

Thus the whole mass of bloom may be loose and spreading, like that of the red-top, or it may be narrow and compressed.

Sometimes the empty glumes end in a long, bristle-like point, called an awn.

Often the flowering glume is provided with an awn, which may be straight, or curved, or twisted.

The problem of providing some mode of conveyance for the seed has been solved by Nature, for various grasses, in ways as various.

The "hedge-hog" or "sand-bur" grass, common in alluvial lands, has converted its outer glumes into thorny coverings for the fruit (Fig. 43).

These catch hold of everything and everybody, and succeed so well in spreading the species that it has become a most troublesome weed.

Uncle Sam warns farmers against it, and even the text-book, forgetful of scholastic calm, dubs it vile.

The squirrel-tail grass long ago bore three-flowered spikelets (Fig. 44). But now the side-blossoms of each trio have dwindled away, and the empty glumes below them have undergone a transformation to subserve the general good, and become long bristles, which enable the matured fruit to blow away.

As grass-pollen is carried about among the blossoms by the wind much of it is liable to be dropped and wasted.



FIG. 43.—Sand-bur grass (*Cenchrus tribuloides*).

a and *b*, the bur ready to travel; *c*, the pair of flowers, 1 staminate and 1 perfect. (From Bulletin No. 7 of the U. S. Department of Agriculture, "American Grasses.")

In some species Nature makes good this loss beforehand by furnishing a double supply of the life-giving grains.

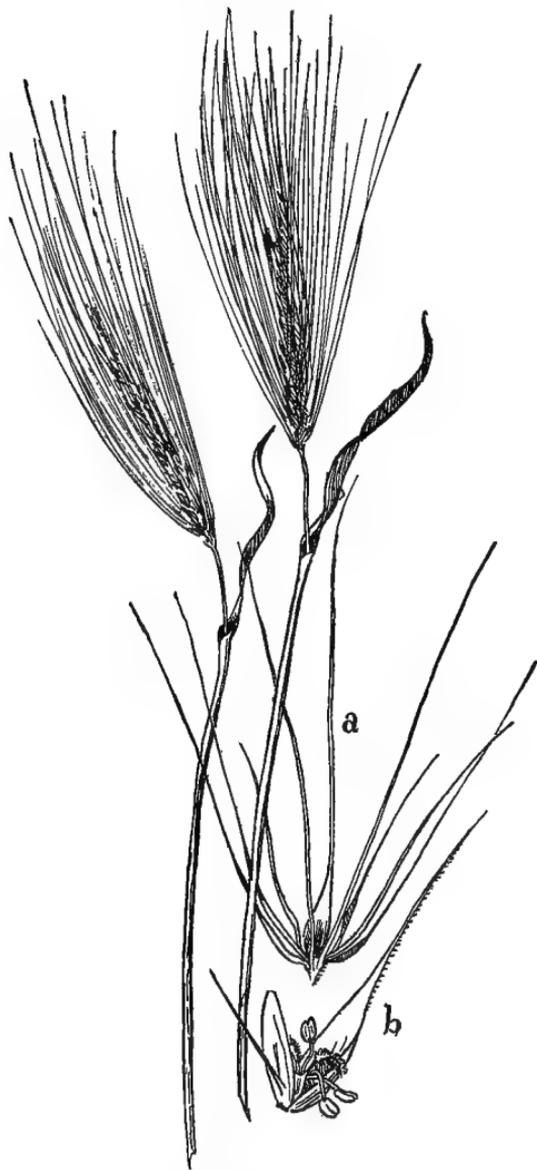


FIG. 44.—Squirrel-tail grass (*Hordeum jubatum*).
a, a magnified spikelet ; *b*, a magnified flower.

172 Field, Forest, and Wayside Flowers

The too familiar sand-bur, for instance, bears spikelets which are each a pair of flowers, one with both stamens and pistil, and one with stamens only. The blossom of the rice has six stamens, and a few grass-flowers have more than six.

But generally and typically there are three, for the grasses are distantly related to the lilies, and have no connection whatever with the rose and her kin.

The pistils of many grass-flowers do not mature till the stamens round about them are empty and shrivelled.

But the wind which has carried off the home-grown pollen will probably bring some to the waiting stigma from a neighboring plume of the same species of grass.

Unless the wind thus makes restitution for the goods he has snatched away, these grasses will bring no fruit to perfection. But if they form seed the young plants which spring from it will have the advantage which double parentage gives the seedling in its struggle for life.

The anthers and stigmas of the wheat mature together, but the flowers only expand partially, and remain open for but a quarter of an hour. The blossom appears from the glumes suddenly, scattering some—not all—of its pollen.

As the glumes close over the pistil so soon, the wind has little time in which to bring it pollen from other wheat-blossoms, and it is often obliged to use the remnant which the stamens have kept. With this it can produce good seed.

The flowering period of the whole spike of blossoms lasts four days, but since each flower blooms for but the quarter of an hour a very small proportion of them are expanded at any one time.

One of the marked characteristics of all grass-flowers is their evanescence; no blossoms are so short lived.

During their brief time of blooming a few species are visited by insects. The hospitality shown to these little guests is perhaps a last survival of an ancient family custom, a lingering memory of a time when the grasses habitually entertained a miscellaneous winged company, and the wind was by no means their only hope.

“I have often observed a small fly busy upon the anthers of various grasses,” says Müller, “and at least two species are visited by beetles.”

The giants of the tribe are the bamboos, which, in their tropic homes, attain a height of fifty or sixty feet, while even those which grow in Florida gardens cast their swaying shadows on the houses' eaves.

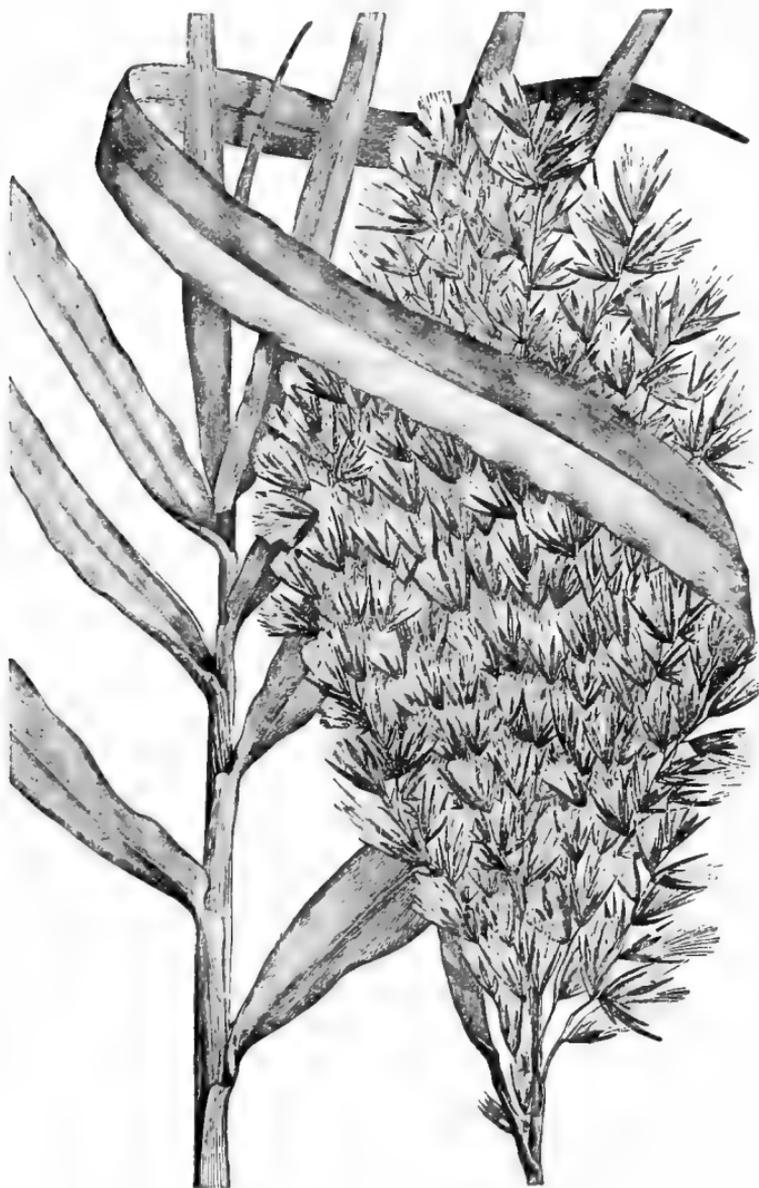


FIG. 45.—Common reed (*Phragmites communis*).
(From Farmers' Bulletin 86, U. S. Department of Agriculture.)

But these are naturalized foreigners. A great gap separates them from the tallest native grasses, the Indian corn, the wild rice, and the reeds (Fig. 45).

Few popular names are more loosely used than this term "reed." It is applied to large grasses of several species and to the cat-tail flags which are not grasses at all. But the true reed of classic story and of modern verse is the *phragmites communis*, whose spears of bloom, sometimes twelve feet tall, are conspicuous objects in latter summer, on the edges of ponds and streams. The plant looks, from a distance, like broom-corn.

Its many broad leaves and feathery head of blossom are swayed by the faintest breath, so that "there are not many things in Nature," says Stevenson, "more striking to man's eye than the shivering of the reeds. It is such an eloquent pantomime of terror; and to see such a number of terrified creatures in every nook along the shore is enough to infect a silly human with alarm."

Their dumb fear was noticed by the people of the classic world, who accounted for it by a legend.

There was a certain nymph called Syrinx, who was much beloved by the satyrs and the spirits of the wood.

She would have none of them, for she was a

176 Field, Forest, and Wayside Flowers

faithful worshipper of Diana and loved only the chase. In her hunting dress she looked like Diana's very self, save that her bow was of horn and Diana's was of silver.

One day, as she returned from the hunt, she was pursued by passionate Pan, who had long sighed for her.

Just as he overtook her she cried for help to her friends, the water nymphs.

They heard the prayer, and granted it, so that Pan, who had pursued a maiden, clasped only a tuft of reeds.

As he breathed a sigh the air sounded through the reeds and produced a plaintive melody. The god was charmed with the sweetness of the music. He bound together bits of reed of unequal length and made that primitive wind instrument which he called a "syrinx," in honor of the loved and lost Arcadian nymph.

But her fear dwells ever in the reeds, and so does the music of Pan. "He once played upon their foremother," says Stevenson, "and so, by the hand of his rivers, he still plays upon these later generations, and plays the same air, both sweet and shrill, to tell us of the beauty and the terror of the world."

CHAPTER VIII

RUSHES AND SEDGES

“When as the breezes pass
The gleaming rushes lean a thousand ways.”

—*Lowell.*

THE wind has many fosterlings in the outdoor world, but the grasses, rushes, and sedges are, in a peculiar sense, his own.

The grasses grow in prairies and open fields. The rushes are most abundant on roadsides and river-shores, and in bogs and moist meadows, and while some sedges live on the low-lying banks of brooks and ditches, others are found in marshes, on sea-beaches, and on mountain-tops, above the tree-line. So the grasses, rushes, and sedges generally prefer the breeziest situations which the countryside affords.

The wind is the author of their being, for their flowers, for untold generations, have been wind-fertilized.

And the wind has moulded them, for the



FIG. 46.—Five familiar water-rushes.

1, *Juncus bufonius*; 2, *Juncus tenuis*. 3, *Juncus Greenii*; 4, *Juncus effusus*,
or "soft-rush"; 5, *Juncus articulatus*.

rushes and sedges, like the grasses, have long, narrow leaves and swaying stems, so that gales can pass through and over them, leaving them unharmed.

The rushes were apparently the last of these three families to be adopted by the wind. Their flowers are small and humble, but the unlearned in botany would recognize them as flowers indeed, still showing a distinct likeness to their far-off cousins, the lilies. In the sedges the six leaves of the lily flower have become curiously changed or have been abolished altogether, and certain ancestral traits are wellnigh obliterated.

So the Nature-student will find the rushes the more approachable family of the two, and an acquaintance with them will prove the best means of introduction to the sedges, their distant cousins.

We somehow expect a rush to be a vegetable of imposing proportions. Perhaps this is because the name is often given to the stately cat-tail flags.

But the true rushes—in our latitudes, at least—are small affairs. The tallest are barely four feet high, and the least form a close mat upon the ground, in moist and sunny places.

They are broadly divided into two groups, the

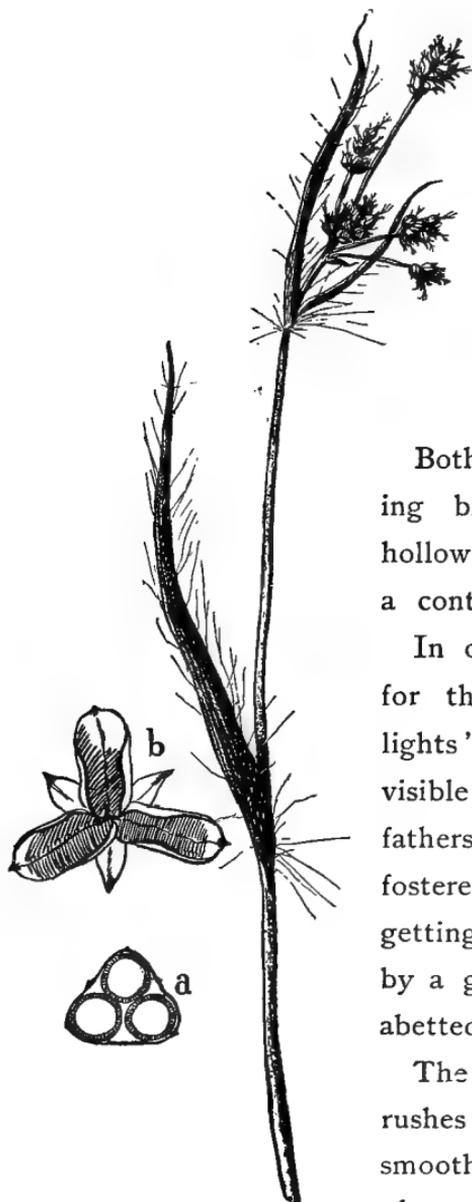


FIG. 47.—A wood-rush
(*Luzula campestris*).
a, Unripe seed-vessel cut across;
b, ripened and emptied seed-vessel.

“water-” and the “wood”-rushes, and a tyro can refer his particular specimen to its own group at a glance, for all the water-rushes are smooth and all the wood-rushes are hairy (Fig. 47).

Both sorts have round, tapering blossom-stems, sometimes hollow, but generally filled with a continuous fine, white pith.

In old times this pith served for the wicks of the “rush-lights” which made darkness visible to our great-grandfathers, and whose inadequacy fostered the habits of early getting to bed, now abandoned by a generation of night-owls, abetted by gas and electricity.

The leaves of the water-rushes are generally round, smooth, and glossy, and those of many species resemble the stems in all points,

save that they wear no crown of buds and flowers.

In some of our commonest water-rushes the leaves are reduced to sheaths, and they merely enfold the base of the flower-stalk, which has assumed all their duties in the vegetable economy, besides fulfilling its own. In the skin of this doubly-useful flower-stalk there are many stomata, and beneath the skin are cells filled with chlorophyll, so that the whole surface-tissue transpires and digests, as do the green parts of foliage leaves.

Though the flowering stems of most rushes are filled with pith, their tubular leaves are often hollow, and those of many species are kept in shape by an interesting little contrivance.

If you draw one of these leaves slowly between thumb and finger, compressing it closely meantime, you feel that there are little lumps or knots in its inner substance. And if you split it lengthwise with a penknife you find that there are green girders extending across the internal hollow and placed at regular distances apart (Fig. 48). The members of the family which bear such foliage as this are called "knotty-leaved rushes."

Their structure furnishes an answer to the mechanical problem "devise some economical means

to prevent a cylinder of delicate tissue from collapsing."

The same problem has occurred in the organization of some seaweeds, and has been solved by Nature in almost the same way.



There are no eccentricities or complications in the leaves of the wood-rushes, which are flat, hairy and grass-like.

The flowers of all the rushes are borne in a large, loose cluster.

This cluster generally tops the stem, and beside the flowers are a pair or trio or circle of slender, green spears, which

FIG. 48.—
Length-
wise sec-
tion of
the tubu-
lar leaf of
a "knot-
ty-leav-
ed" rush.

together constitute the "involucre."
In the common "soft-rush" the involucre consists of a single leaf.
This pokes up aggressively, prolonging the line of the stalk, so that the flower cluster is thrust from its place and dangles down sidewise. But, despite appearances to the contrary, the blossoms crown the stem, after the custom of the rushes, and all above them is a single "involucral leaf."

The flowers of the wood- and water-rushes are all of the same lily-like type. There are three

green sepals, with semi-transparent edges (Fig. 49) touched with brown or rose, and three petals, which are often chaffy and semi-transparent throughout. Some rushes have three stamens, some have six, and at the heart of the flower is the pistil with three feathery stigmas spread abroad like the lines in the letter Y. These are often rosy-red, and their little plumes glisten like spun-glass, so that the flowers are pretty, even now, when the colors have faded from their petals. They close, finally and in conclusion, soon after they are picked, so that one who would identify the species had better take his "key" into the fields.

One of the wood-rushes still shows remarkable approximation to the conditions of insect-fertilized flowers, and two of them are visited, now and then, by insects.

It seems probable that the little petals, now sere and translucent, were once soft in texture and lovely in hue.

In those days insects may have "visited around" among the rushes numerously and often.

But the petals and sepals which the flowers wear nowadays are ineffective for display or allure-ment,—and seem to be produced merely for "old sake's sake."



FIG. 49.—Flower cluster and flower analysis of a common water-rush (*Juncus articulatus*).

1, The blossom seen from above; 2, the blossom seen from one side; 3, the nearly ripe seed-vessel sectioned across; 4, the ripened and empty seed-vessel sectioned across.

The rush flowers are very dependent upon their present messenger, the wind, for the pistils, in most of the species, ripen first. So they are ready for pollen before the home-grown pollen is ready for them, and must use the life-giving dust which is blown to them from older flowers.

The ripe pollen is smooth and powdery, so that it may readily be detached by the wind and borne away, but the anthers do not sway at the lips of slender filaments, as they do in the thorough-going wind-fertilized blossoms of the grasses.

The seeds of the wood-rushes are matured by midsummer.

Those of the water-rushes are not ripe till August or September.

Both sorts are borne in dry capsules, which split into three valves, setting the seeds free.

But the wood-rush capsules have just three seeds apiece, while those of the water-rushes contain a large number.

It is not uncommon for water-loving plants to put a relatively enormous progeny forth upon the world, for seedlings which cannot thrive unless they keep their feet wet are peculiarly the victims of chance and change. Many will begin life in

dry ground, where they will speedily wither away because they lack moisture; and even those which have the luck to fall into water or mud find life full of uncertainties. The rivers which they love shift their courses, the brooks and ponds dry up, the swamps are drained.

Wood-rush seeds can settle and thrive in any piece of open wood- or meadow-land.

But in regulating the affairs of the water-rushes, cat-tail flags and pickerel-weed, Nature provides beforehand for an altogether probable slaughter of the innocents.

Under the microscope the seeds borne by several of the water-rushes show a delicate cross-bar pattern in high relief, and some are tipped with a queer little horn (Fig. 50).

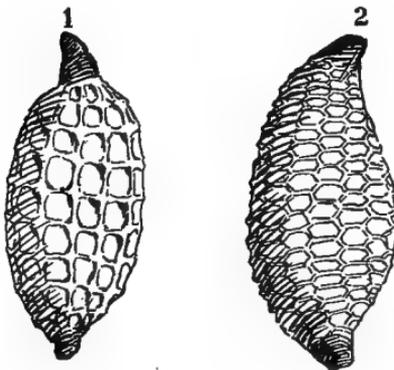


FIG. 50.—Rush-seeds.
1, *Juncus Greenii*; 2, *Juncus tenuis*.

In latter summer the cells which go to make up these cross-bars and horns become converted into mucilage. At first this mucilage is dry and

hard, but it can absorb a great quantity of water, and as it does so it becomes soft and swells

astonishingly. The first heavy autumnal rains give it an opportunity to exercise its capabilities.

In the moist atmosphere the ridges and horns dissolve, and the seeds become embedded in a mass of viscid jelly. The mass swells up, forces its way through the slits in the now opened capsule, and carries the seeds out with it. By exposure to air and sun the mucilage becomes brittle and powdery. Then the seeds are readily detached from it and carried off by autumn gales to seek their fortunes.

One would think that this method of seed distribution might be unique. But it has been adopted also by a little flower called "yellow-eyed-grass" (*Xyris flexuosa*), which often lives as neighbor to the water-rushes, and so must adapt itself to similar conditions. Yet the cousinship between these two plant families is of that remote degree which in human relations "counts for nothing" north of Mason and Dixon's line.

The seeds of both water-rushes and yellow-eyed-grass are small and light, so that they can be blown far afield in quest of an abiding place, and they are long and narrow, and hence expose a large proportionate surface to the wind.

The ripe seed-vessels of all the rushes are sur-

188 Field, Forest, and Wayside Flowers

rounded by the dry petals and sepals of the little flower, and by the same token we can always distinguish a rush from the wind's other fosterlings afield (Fig. 51).

The sedges can readily be recognized and known from the grasses, their next of kin, for grass-stems are usually hollow and always round, while those of the sedges are solid, and, at least toward their tips, triangular. Moreover, sedges grow in tussocks, and grasses form a close, continuous mat upon the ground.

The bases of sedge-leaves are not merely wrapped about the stem, after the fashion of the grasses, but they form seamless, tubular sheaths, which invest it closely.

In old England all sedges were included under the name of "shear-grass," a term applied to them on account of the sharp or scissor-like edges of their narrow leaves.

The same characteristic got them the name by which we know them, for "sedge" and "saw" are both derived from an old Teutonic word, which means "to cut."

The leaves are disposed along the stem in what is known as the "three-ranked arrangement," the fourth, as one counts upward, being directly



FIG. 51.—Some New England sedges.

- 1, *Eleocharis tuberculosa*, "spike-rush"; 2, *Eriophorum alpinum*, "cotton-grass"; 3, *Carex grisea*; 4, *Eriophorum polystachyon*, "cotton-grass"; 5, *Carex tribuloides*; 6, *Carex crinita*; 7, *Carex stipata*; 8, *Scirpus sylvaticus*, the true "bul-rush" (in fruit); 9, *Scirpus sylvaticus* (in flower); 10, *Carex lubulina*.

190 Field, Forest, and Wayside Flowers

above the first and the fifth above the second, so that if one should draw a line through the bases of the leaves it would intersect three in the course of one complete spiral turn.

The number three dominates the sedges throughout their organization. It occurs repeatedly, or is traced obscurely, in their flowers, for they are lily-kin. Inferentially the ancestors of all the sedges had three pistils, or a single pistil dividing into three stigmas, three stamens, or six, in two trios, three petals, and three sepals. They were, in many respects, like the rushes of today.

But their descendants have departed, more or less widely, from the ancient family traditions. For some species have but two stigmas, whole groups have two stamens, or manage to get along with one, and two tribes bear stamens in one flower and pistils in another.

Sedge-blossoms grow in spikes, clumps, or clusters, massed together so closely that their calyxes and corollas, when they possess any, are utterly ineffective.

But as the wind is their sole messenger, nowadays, there is no reason why they should allure and charm insects, as their ancestors may have

done in the days of old. The florets, like those of the cat-tail flags, have undergone a change of form in connection with changed circumstances. In those sedge-flowers which bear stamens only, the calyx and corolla, no longer needed for any purpose, have vanished utterly away.

But the sepals and petals of the perfect floret borne by many sedges have had another job offered them by Nature, and have saved themselves from extinction by acquiring usefulness in a new capacity. In process of time they have become adapted to aid in the great work of seed distribution.

One of the stateliest of native sedges is the so-miscalled "wool-grass," which is a conspicuous object in wet fields during the latter summer. The large and graceful tassel of bloom is composed of innumerable soft, brown lumps, not much larger than grains of barley. If we pick one of these apart, under a lens we shall find that it is a compact mass of overlapping scales (Fig. 52).

Under each scale is a single flower, with three stamens, and a long, slender pistil dividing into three stigmas.

By August the stamens have withered away,



FIG. 52.—From low-lying fields.

1, "Wool-grass" (*Eriphorum cyperinum*); 2, the fruit with surrounding hairs;
3, "beak-rush" (*Rhynchospora glomerata*); 4, a cluster of flowers and scales
of the "beak-rush"; 5, its ripe fruit with accompanying bristles.

after accomplishing their life-work. The pistil has done its work, too. It is now a fruit, ripe and ready to travel, for around it are six long hairs, which are the petals and sepals, altered over into a flying apparatus. In the "beak-rush," which we may find growing near the "wool-grass," calyx and corolla have undergone an equally great but wholly different adaptation.

They are converted into barbed bristles, which catch hold where and when they can, and thus help the seed along in the world.

The calyx and corolla of the pretty "cotton-grass" are changed, like those of the "wool-grass," into long streamers, which lengthen as the seed matures, and become a tuft of creamy filaments, an inch or two in length. They make this sedge a conspicuous and beautiful object in low-lying fields, when olive and bronze shades begin to replace the vivid greens of the earlier year (Fig. 51).

The true "bulrush" and the "spike-rush" (Fig. 51), which are both sedges, in spite of their misleading names, have adopted the beak-rush's plan, and changed their petals and sepals into toothed bristles, which look, through the microscope, like narrow saw-blades.

194 Field, Forest, and Wayside Flowers

Most of our native sedges³ belong to one great group, the genus *Carex*. Its various members generally grow in moist places and blossom in the spring, so that their seeds are set, and often ripened, too, by midsummer.

“A *Carex*” can be recognized afield by the tyro, but the correct identification of the particular *Carex* in question is quite another matter. For the species are so difficult to distinguish one from another, vary so perplexingly, and blend into one another so confusingly, that they can confound the experienced naturalist. In most *Carex*s the stamens and pistils are borne in separate flowers, which grow upon the same plant.

In one large section of them the two kinds of flowers grow on the same spike, which is staminate at its apex, and pistillate below, or, as Tweedledee was wont to remark, “contrariwise.”

In another large section the staminate flowers grow in a spike by themselves, at the tip-top of the sedge, while the pistillate blossoms, in modest groups, occupy lower places (Fig. 53).

Each flower of either sex is sheltered and almost concealed by a green scale. The staminate flowers have no calyces nor corollas at all, not even reminiscent ones of saw-blades or bristles.



FIG. 53.—A typical carex (*Carex hystrix*).
1, A staminate flower with its scale; 2, a pistillate flower with its scale; 3, cross-section of the *perigynium*, showing the fruit within. (All magnified.)

Each is reduced to its lowest terms, and is merely a trio of stamens.

Its flower-affinity consists of a pistil, borne on a short stalk, and partly or completely surrounded by a tiny green bract. The pistil forks at its tip into two or three long stigmas, which reach over the tiny bract close to them and the larger scale below and wait for the pollen messages which the wind will bring to them from other sedges. After the pollen has come, the stigmas, having served their purpose, wither away. At about the same time the tiny bract which has invested the pistil increases greatly in size, and by latter summer it becomes an inflated flask-shaped sac, enclosing the ripening fruit. This sac is known as the "perigynium," and is one of the distinguishing marks of the *Carex* family. Some botanists regard it as the sepals and petals of the sedge-flower, joined together, and altered out of knowledge.

Inside the perigynium there is a hard lens-shaped or triangular body, which we should incline to call a seed. But, small though it be, it is the ripened ovary, and hence a fruit.

The sedges, unlike the grasses, are a useless family. They are of small value to man, and their leaves and stems contain so little nutritious

matter that they are seldom eaten by grazing animals. Indeed, in the whole great family of two thousand species there are but three useful members.

The chufa, a native of the Mediterranean shores, is sometimes cultivated for the sake of its small, sweet tubers.

Another sedge, the *Cyperus textilis*, is used in India for making ropes and mats. It is nearly related to the most useful and celebrated of all the sedges—the *Cyperus papyrus*, or paper-reed of old Egypt. The Hebrew name for this plant occurs in the Old Testament account of the hiding of the infant Moses, and has been rendered “Bull-rush” in the English Bible.

This sedge provided cheap and convenient writing material for the ancient world. “Papyrus,” says an excellent authority, “was made of the inner cuticle of the stalk, which was separated into thin strips. These were laid side by side, with another layer of strips crossing them at right angles. The two layers, thus prepared, were soaked in water, then pressed together to make them adhere, and dried. For books the papyrus was formed into rolls, by cementing together a number of sheets.”

198 Field, Forest, and Wayside Flowers

The manufactured papyrus was called “papu” by the Egyptians, and hence our word paper. Herodotus calls it byblis, whence the Greek “book” and our “bible.”

So sedges, in their humble way, have helped to pass the treasures of thought and learning onward through the ages, and as the life, mental and spiritual, is more than meat, they have not been so far behind the grasses in real serviceableness after all.

CHAPTER IX

NIGHT FLOWERS

WHEN night finds us in quiet homes, with quiet minds and bodies pleasantly tired, there may come to us the thought of those to whom the evening is as a morning, and whose wakeful and busy time is just beginning.

In many fields of industry work gets fairly under way about the bedtime of the public at large. The newspaper offices are all alight and astir. On the railroads thousands of men are assuming those exacting duties which, for them, turn night into day. The night nurses in hospitals, the sentries in forts, the watch at sea, have all hours of vigilant wakefulness before them.

In the animal world the darkness which lulls one creature to repose rouses another into intensest life. Beasts of prey, which have drowsed through the sunlit hours, wake in the twilight to "seek their meat from God," and migrant birds

200 Field, Forest, and Wayside Flowers

stretch their wings for a flight which will end only with the dawn.

In the insect world innumerable creatures fly out of countless holes and hiding-places as dusk falls, seeking those flowers of darkness which hold continuous receptions for them through the dewy summer nights.

There is a popular but an erroneous impression that only two or three sorts of blossoms unfold at evening. The night-blooming cereus is so big and splendid that it occupies an undue place in the public mind as the flower of darkness, whose nocturnal habits are shared only by the moon-flower. But if we bethink us that moths draw most of their sustenance from flower-calices, we will realize that there must be a whole category of night-blooming flowers. For though many blossoms do not close at dusk, but keep open house day and night during their whole time of blooming, the buds of most species expand in the sunshine, and the chances are that their sweets will be extracted soon afterward by some diurnal rover.

How, then, does Nature feed the crepuscular moths, which flit abroad at sundown, and the nocturnal moths, which fly in darkness? We realize their numbers, to our cost, if we burn a lamp near

an open window on a sultry night. In a museum of natural history we may see them gathered according to their tribes, a mighty host, clad all in night's sombre livery. It would be a formidable undertaking to count the species, and as for the individuals, they must be numberless as the sands of the shore. For them the night-flowers blow, and as the guests are many, the banquet is abundant.

In our gardens and in the fields a number of blossoms expand in the twilight. Some of these close about sunrise, some wilt in the radiance of noon, and some remain open all through the day, and hence are never thought of as nocturnal flowers. But their first freshness and uttermost sweetness are given to the night-moths, and though we may see them blooming in the sunshine, they are really blossoms of the night.

Among garden-flowers the most familiar night-bloomer is the honeysuckle. Its buds open late in the afternoon or in the evening before dusk falls. On a very cloudy day I have seen them expanding as early as half-past three, and in the long June afterglow it may be eight o'clock before the last flowers unfold. They are slender vases filled to the brim with fragrance, which is

202 Field, Forest, and Wayside Flowers

shed upon the night air, a mute invitation to the vine's best friends, the "hawk" or "sphinx" moths.

Several sorts of these sphinxes visit the flowers during the earlier hours of the night. One, which begins his supper before daylight has faded, is rather larger than a bumble-bee. His body and upper wings are in dull shades of gray and brown, but on his under wings are patches of "sunset"-pink, which show that his habits are crepuscular rather than nocturnal. For the true night-moths, the "butterflies of the earth's shadow," are dun-colored, gray, or white. Nature, which never wastes, has withheld from them the colors which would be invisible to their mates, and has sent them abroad as sombrely clad as so many nuns and friars. This little visitor, with the bright colors on his wings, roves abroad in the evening and morning twilight when there is enough light to reveal his adornment to his lady-love.

Later in the night, when he has supped, the vine will be visited by larger sphinxes, dusky or sad-colored, as are all insects which fly in darkness. All these moths have long proboscises, which can reach down to the bases of deep and slender blossom-tubes, and which coil up like watchsprings when the insects are at rest.

They sip like humming-birds, poised above the flower on whirring wings, and hence are sometimes known as "humming-bird moths." They are called "hawk-moths," on account of the swiftness of their flight, and "sphinxes," because the caterpillars from which they develop have a curi-



Sphinx ligustri.

Sphinx convolvuli.

FIG. 54.—Nocturnal guests of the honeysuckle.

(From Figuiet's *Insect World*.)

ous habit of remaining motionless, with their heads and the forepart of their bodies raised in an attitude a little like that of the crouching-sphinxes of old Egypt. A few hawk-moths fly by day, but most species rove abroad during the morning and evening twilight, when they may be seen flitting with great swiftness from flower to flower (Fig. 54).

204 Field, Forest, and Wayside Flowers

The honeysuckles blow just at the time of year when these moths are most numerous, and they offer a rich feast to their chosen guests, for the freshly-opened flowers are filled to the middle of their slender tubes with nectar.

The pollen-grains of the honeysuckles are rounded, somewhat sticky, and are covered with small, sharp points (Fig. 55). They adhere to the hairy



FIG. 55.—Pollen of the honeysuckle. (Magnified.)

bodies of the night-moths, and thus are carried to the pistils of other flowers.

On warm, calm evenings the honeysuckles' visitors are so numerous that by morning all the flowers have had their pollen entirely removed.

But after cold and windy nights the anthers still retain much of their golden store.

This will be carried away in daylight hours by butterflies or humming-birds.

The white day or Japan lily (*Funkia japonica*) (Fig. 56) opens about sundown, giving forth an alluring sweetness. I have never seen a winged insect accept this seductive invitation, but as the



FIG. 56.—Day or "Japan" lilies (*Funkia Japonica*).

long blossom-tubes are sometimes followed by shining, green seed-vessels, it is evident that the day lily occasionally receives a visitor, who comes under cover of night. A flower-tube so long as this can be drained only by an insect with a very long proboscis. Such insects are large and conspicuous, and if they flew by day would be speedily " nabbed " by birds, collectors, or small boys. Like Léander, they must pay their addresses by night for life's sweet sake.

So the deepest-throated flowers are almost all nocturnal. The jasmine, the tuberose, and stephanotis, which keep their nectar in very long and slender tubes, blow at evening, and give their fragrance to the night. The *Yucca Filamentosa*, familiarly known as " Adam's needle and thread," is another familiar garden night-flower (Fig. 57).

By day its greenish-white flowers are bell-shaped and odorless; and if the twilight be cold or rainy its coming makes little difference in their aspect. But on a clear, sultry evening, soon after sunset, the yucca shows a marked change. Its blossoms open widely, spreading into great six-pointed stars, and breathe forth a very penetrating and characteristic odor.

As morning breaks the blossoms lose the star-

208 Field, Forest, and Wayside Flowers

like form, and sunshine finds them scentless bells once more, dangling in the lassitude consequent upon a night of alert, and probably futile, wakefulness.

For this yucca is brought to our gardens from the South, and is accustomed to have its pollen fetched and carried by subtropical night-rovers. Few native nocturnal moths are able to sip its sweets or transfer its pollen; and if, during its brief term of beauty, a spell of cold rain discourages insect-rovers, the whole creamy spire of flowers may bloom and fade without setting a single seed.

But in fine, warm summer evenings they are sometimes visited by the small moth which fertilizes the wild yuccas of the Georgia coast.

The mode of procedure of this little wanderer is peculiar. She is a mother moth, seeking shelter and maintenance for a young family, and she has no aim except the welfare of her future offspring.

But in attending to her own affairs, she, incidentally, takes charge of the yucca's affairs also. The coming family are to be housed in the seed-vessel of the plant, and nourished on its young seeds.

But the yucca's pistil and stamens are so situ-



FIG. 57.—“Adam's needle and thread” (*Yucca filamentosa*).

ated, with regard to each other, that pollen can scarcely reach the stigma without the aid of insect ministrations.

And the mother-moth seems to understand that unless the pistil is touched by pollen from the anthers there will be neither seed-vessel nor seed. She first bores the ovary in several places, and in each hole she deposits an egg. Then she collects load after load of pollen from the anthers, gathering it up by means of a long, coiling organ, which seems to have been given her for this special purpose. She thrusts most of this pollen into the holes with the eggs, so that it makes warm and dry beds for the grubs that are to be. And, guided by a marvellous instinct, she also places some of it on the stigma of the flower. So as the grubs develop in the ovary, the seeds which serve as their food develop also, and with them so many other seeds that the perpetuation of the yucca family is ensured.

“When the grub is full grown,” says Müller, “it bores a hole through the capsule, lowers itself to the ground by a thread, digs its way a few inches into the soil and spins a cocoon, in which it spends autumn, winter, and spring.”

In its native haunts it passes into the pupa

212 Field, Forest, and Wayside Flowers

stage about fourteen days before the Georgia yucca (*Yucca recurvifolia*) begins to bloom, and emerges from its temporary tomb as the flowers expand. But it is probable that our average winters are too severe for a transplanted southern family, and that most of the *Pronuba yuccasella* larvæ in our gardens freeze with the freezing soil, and thus perish untimely. Some few, however, survive the winter evidently and make use of the yucca blossoms as their mother did before them, for in most seasons we will find a few capsules full-grown and symmetrically formed, but with holes in them.

And so wounded and marred, the flowers have fulfilled the purpose of their lives, and attained a development which they might not otherwise have reached.

Occasionally one finds a perfectly-developed capsule which is not pierced, showing that the yucca receives visits, few and far between, from some nocturnal guest which fertilizes the blossoms without marring them. But in many seasons no efficient callers come to the flowers and no capsules form at all.

Many of the white Japan lilies are likewise disappointed, so large a proportion of them, in fact,

that one season, when my garden yielded twenty large heads of bloom, each bearing many flowers, only eight capsules formed.

But the night-flowers which blow in the fields, even when they are of foreign descent, have near kin among the aborigines of the soil. So each has its insect attendant, faithful to the family, time out of mind, and their sweetness is not wasted, nor does Nature's purpose for them fail.

The most familiar nocturnal wild-flower east of the Alleghanies is the evening primrose (*Cenothera biennis*) (Fig. 58). It is extremely common everywhere in the Northern Atlantic states—along roadsides, in fence corners, and around the edges of thickets. By day its appearance is uninteresting. A stalk from three to six feet tall bears a profusion of long, narrow, rather coarse leaves, and above them a spire of faded flowers and buds. In the afternoon the primrose has nothing to show but fading flowers and buds, and one is reminded of "jam yesterday and jam to-morrow—but never jam to-day," in "Alice in Wonderland." The faded blossoms bloomed the night before last, the wilting ones were beautiful last night, the large buds above them will expand this evening. About sunset or a little sooner, if the plant is in the

214 Field, Forest, and Wayside Flowers

shade, they begin to swell. The green calyx splits in four places, disclosing four lines of gold which widen under our eyes. Then, with a start and a jerk, one narrow sepal draws backward, and the yellow corella is revealed. Little thrills go through the bud, like the slight movement of an awakening child. A second sepal draws backward, and then a third, and with an impulse of fully-aroused life the flower bursts its last bond and opens wide, showing its heart of gold. A delicate perfume is shed abroad; and by this as well as by the gleam of yellow petals the moth is lured to the flower.

There is a garden evening-primrose which opens in a most impressive manner, with a sudden flare of golden petals, and a slight pop, like that made by withdrawing a small but stubborn cork. But the wild evening-primroses open slowly, with little pauses and delays, as if they were half afraid to venture into the untried life before them.

Along the Ohio valley and in the alluvial country westward (and in many places further east) the commonest night-flower is the Jamestown or jimson-weed (*Datura stramonium*) (Fig. 59). The vagabond habits of this dweller in waste ground, its rank, weedy aspect, and the disagreeable smell



FIG. 58.—A wild evening primrose (*Enothera biennis*).

of its leaves, spoil the impression which might be made by the beauty of the blossoms were they not



FIG. 59.—Jimson-weed (*Datura stramonium*).

so lowly born. Growing with the jimson-weed we may find its first cousin, the *Datura tatula*, a smaller plant bearing flowers strongly tinged with

218 Field, Forest, and Wayside Flowers

purple. The buds of both species expand late in the afternoon—from four to six o'clock, according to the weather. Both are immigrants from warmer lands, but it is evident that they have made friends among the native night-flying insects, for the thorny seed-vessels follow duly upon the fading of the flowers.

The night visitor of the jimson-weed is the

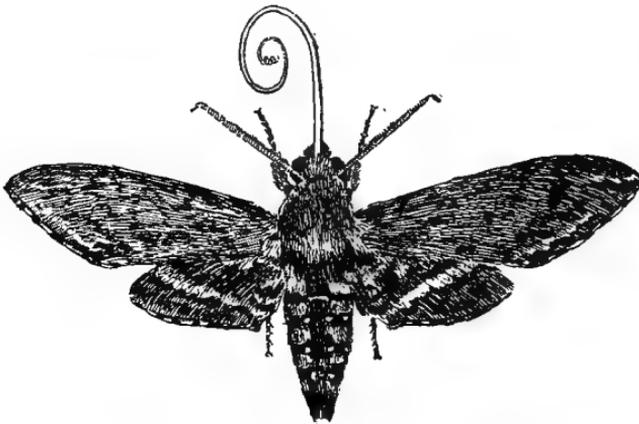


FIG. 60.—Night visitor to the jimson-weed (*Sphinx Carolina*).
(From Harris' *Insects Injurious to Vegetation*.)

Sphinx Carolina (Fig. 60), a large moth whose caterpillar has a great and evil reputation throughout the South, where it is known as the “tobacco-worm.” In our gardens these caterpillars live on the tomato-vines. They are large, but it is difficult to see them, notwithstanding, as their bodies are of exactly the same tint as the vine-



FIG. 61.—Hedge bind-weed (*Convolvulus sepium*).

stems. The full-grown moths appear in June, and on any warm, clear evening, from midsummer till frost, they may be seen, hovering like humming-birds above the blossoms of their choice.

“The flowers of the great convolvulus (Fig. 61) or hedge bind-weed close,” says Müller, “on cloudy evenings”—but on moonlight nights they are all wide awake, and watching for their best friend, the Sphinx convolvuli. In England, where this great night-moth is rare, the hedge bind-weed seldom produces seed, though it may be visited and fertilized in the morning hours by the sunshine-loving butterflies.

But in our warm summer twilights Sphinx convolvuli is not uncommon, and one may catch him, as he has been caught aforetime, by a naturalist who “stood by a moonlit hedge, overgrown with convolvulus, held thumb and finger over a flower, and closed its orifice when the moth had entered.”

The pretty roadside saponaria, familiarly known as “bouncing Bet,” expands about sundown, and in the twilight its sweets are sipped by sphinx-moths, which, doubtless, help to transfer its pollen. It remains open throughout the following day and entertains butterflies; but the strong fragrance of the flowers at evening shows that night-moths are

222 Field, Forest, and Wayside Flowers

the favorite guests. The stamens of the bouncing Bet are ten in number. Soon after the flower opens five of them thrust their heads out of the tube, and their anthers ripen and split. When they have shed their pollen, the other five emerge, mature, and open.

All this time the young pistil lies concealed in the flower-tube, but, after the second quintette of stamens have given away most of their store, it comes out of its seclusion, and the two long stigmas expand themselves. The butterfly guests by day and the moth visitors by night carry pollen from the stamens of younger flowers to the pistils of older ones.

Many members of the pink family, to which "bouncing Bet" belongs, have formed the habit of ripening two successive quintettes of stamens, and, last of all, the pistil. This arrangement makes sure that the flower will set seed only by aid of pollen brought from another, and that its seeds (if they are formed) will be endowed with great vitality. But the family is placed entirely at the mercy of flying insects, for without their ministrations no seed can be set at all. So the whole future of such flower families depends upon the success with which its members entice their winged friends.



FIG. 62.—Bouncing Bet (*Saponaria officinalis*).

Some of the pink family have adapted themselves so nearly to the requirements of their chosen guests that they have become unfitted for miscellaneous hospitality. Their blossom-tubes are too long and too narrow to be drained by most insects, and hence many diurnal flowers of the pink family are wholly dependent on butterflies, as some nocturnal species are upon night-moths.

The differences between day- and night-blossoms are beautifully shown by two nearly-related English wild-flowers which have recently come into our fields. They are known to English village children as red and white campion, and to botanists as "corn-cockle" and "evening-lychnis." The red campion (*Lychnis githago*) or corn-cockle is already resolving itself into a nuisance in the grain-fields of the Central and Western States. It is rosy-purple, blooms by day, and is fertilized by butterflies. As it is able to attract those insect friends by its bright color alone, it is scentless. A few clearly-drawn, dark lines, running from the edge of the blossom to its centre, are a floral signal-code, telling the butterflies where the nectar which they seek is stored for them, at the bottom of a tube so slender and deep that smaller insects cannot reach down to it. At evening, when

the corn-cockle's butterfly friends go to rest, it closes.

The evening-lychnis, which is still somewhat rare in this country, resembles the corn-cockle almost



FIG. 63.—Corn-cockle (*Lychnis githago*).
(From Annual Report of U. S. Department of
Agriculture for 1886.)

exactly in size, form, and foliage, but is adapted in several interesting ways to its chosen friends, the night-moths. It opens at evening, after remaining partially closed all day, and thus it saves its nectar for its nocturnal guests. That they may more readily see it in the dark fields it glimmers white, and as an additional help to them in finding it the flower is

fragrant. Lastly, the evening-lychnis has no lines to indicate the whereabouts of its nectar, for these

would be undistinguishable in the dark, and therefore useless.

Whoever tries to gather red currants or strawberries by twilight will find that the red of the fruit, so noticeable by day, now blends undistinguishably with the green of the leaves. Long before real darkness comes, the most conspicuous of daytime colors vanishes into the shadows. But a very small object, if it be white, can be seen in the darkest hours of a moonless night. This the night-flowers seem to have learned, for they are all white or pale-yellow.

Their distinguishing charm is their sweetness. Honeysuckle, tuberose, day-lily, stephanotis, night-blooming cereus—what scents for a Sybarite are here! The evening primroses have a delicious fragrance, and the diurnal primroses have none. There are two nocturnal species of silene, both sweet-scented, while the nine or ten diurnal species are all odorless. Even the despised jimsonweed blossom lures the moths by a delicate perfume which is lost directly we gather it, in the rank odor of the broken stem.

The closing time of these night-flowers, like the time of their expansion, is variable. It may depend partly upon the vigor of the plant, its age,

and its location. A flower which has been visited and fertilized by moths will probably wilt more quickly than one which has been neglected, and

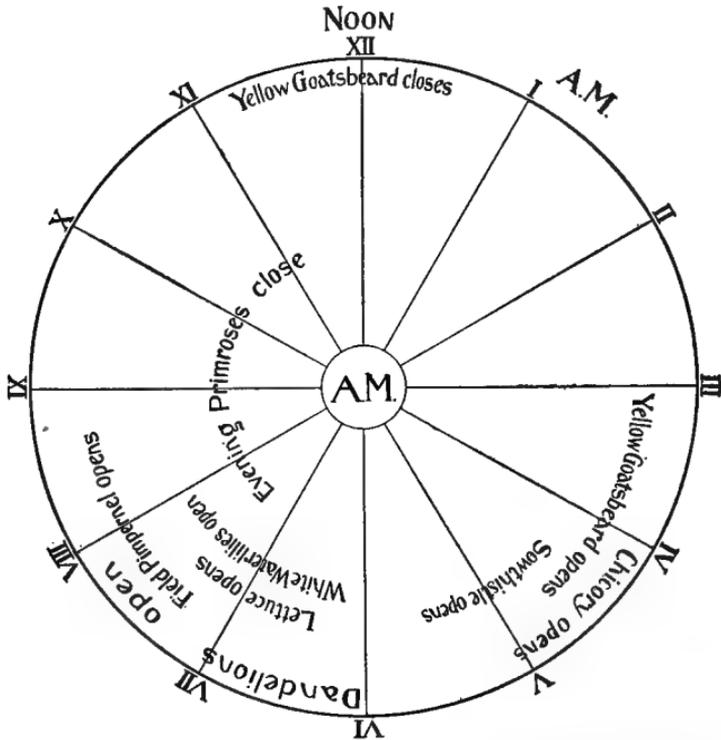


FIG. 64A.—A flower-clock—morning. (Tentatively submitted.)

Most of the morning hours and flowers are cited from a "clock" compiled for France by Lamarck. They may need some correction for the more southern latitudes of the United States.

the life of the blossom after daylight will be affected by the temperature and humidity of the morning. Honeysuckles generally keep their fresh looks all day, and with them a fragrance, fainter

than that which lured the sphinx-moth, but delicious still. But they do not survive a torrid and glaring noon. Evening-primroses, if the morning

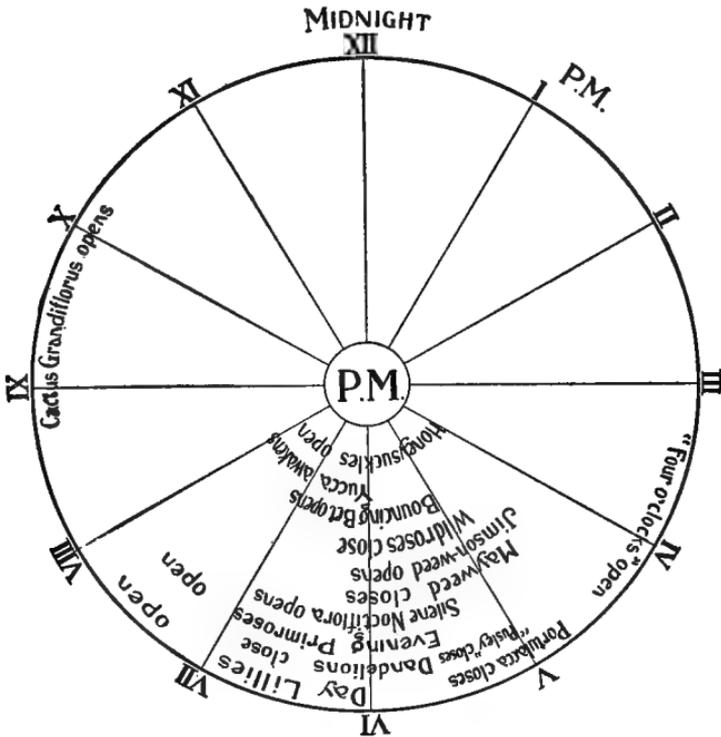


FIG. 64B.—A flower-clock—afternoon and evening.
(Tentatively submitted.)

The post-meridial half of the clock is compiled from the author's observations in garden and field in the states of Ohio and New York.

is cloudy, or if they grow in the shade, are pretty until midday, but if ardent sunshine reaches them they wilt much earlier, while the day-lilies remain crisp and fragrant till twilight falls again.

230 Field, Forest, and Wayside Flowers

All these flowers, if the moths have failed them, will perhaps be visited and fertilized by the sunshine-loving butterflies.

Linnæus had the pretty idea of a time-keeping garden, and he drew up for the latitude of Upsala, in Sweden, a list of plants, arranged according to the time at which their buds expand. This list is the famous "floral clock," "whose wheels," says Jean Paul Richter, "are the sun and earth and whose index figures are flowers."

De Candolle, the French botanist, arranged another floral clock for the vicinity of Paris.

The suggestion has charmed the popular fancy and excited the fertile inventiveness of the penny-a-liners. So every now and then a newspaper article appears, stating exact times for the opening and closing of familiar flowers, and it goes the rounds, giving unsuspecting people to understand that flowers are as punctual as express-trains. But blossoms are not accurate timekeepers. The honeysuckle, as we have seen, takes to itself a margin of four hours, and Linnæus's floral clock allows for variations of an hour or two in almost every plant. No clock of bloom would serve as a substitute for the mechanical clock of commerce, that soulless autocrat which tyrannizes over our

lives and regulates their every detail nowadays. The timekeeping garden, alack-a-day, is for the dwellers in "that sweet isle of rest which is called Avalon," or for the lotos-eaters who have no trains to "make," no board meetings to attend, and no engagements to keep, but who "pass their days in dreamful ease," and "no joy know but calm."

CHAPTER X

CLIMBING PLANTS

THE vine has served rhetoricians ever since the Dark Ages as a type of clinging helplessness and utter dependence. It has symbolized the condition of woman under the old régime, before she entered the learned professions and the business world, donned short skirts, mounted the bicycle, and wrote herself down Woman. Therefore, we learn, with some surprise, that the vine, like many a woman in unreconstructed societies, is only apparently relieved of the burdens of existence, and that it works as hard for its living as the "sturdy oak," to which it clings.

The charitable soul is now and then defrauded by a ne'er-do-well, who puts into his schemes for the avoidance of work an amount of astuteness, adroitness, and energy which would win success in some legitimate field of labor.

Vines, when one studies their habits, are some-

what suggestive of such characters, for they expend much vital energy in searching for something to support them, and in holding fast to the support when it is found. The "movements and habits of climbing plants" have been carefully studied by Darwin, whose book on the subject is the source of most of the facts here and now set forth. He divides climbing plants into four classes. Those of the first class twine spirally around a support, and have no other spontaneous movements. To this category beans and hops belong.

Vines of the second class ascend by means of special organs. Sometimes, as is the case with the clematis, the leaf-stalks do double duty, and not only uphold the leaves, but also embrace any slender thing within reach. And sometimes the plant bears tendrils, which reach out like the feelers of an octopus, seeking what they may clasp and hold. By this method sweet-peas get on in the world. But no sharp line of distinction can be drawn between "leaf-climbers" and "tendrill-bearers." They are closely connected, and are classified together.

Vines of the third class scramble upward by means of hooks, and this is the way some roses clamber. Many of these hook-climbers are natives

234 Field, Forest, and Wayside Flowers

of tropical forests, and they are most successful where masses of tangled vegetation uphold and “boost” them.

In the fourth class Darwin places the “root-



FIG. 65.—English ivy (*Hedera Helix*).
Climbing by means of aerial rootlets. (From the *Vegetable World*.)

climbers.” These produce roots both in earth and air. The ærial roots, or “rootlets,” are short, woody threads, which half cover the main stem and branches, and cling tightly to bare walls, naked

rocks, or the trunks of large trees. The English-ivy, the poison-ivy, and the climbing-fig all clamber by this expedient, and their grip upon their supports is amazingly tenacious.

Darwin observed that the rootlets of the climbing-fig, when they were a few days old, began to emit minute drops of a clear, viscid fluid. This fig is a first cousin to the plant which produces the india-rubber of commerce, and, like all members of the family, it abounds in caoutchouc. So the liquid which glues its rootlets to the wall is fluid india-rubber, and with time and exposure to the air this substance becomes converted into a brittle, resinous matter, very similar to shellac. "Whether other plants which climb by their rootlets emit any cement," says Darwin, "I do not know; but the rootlets of the ivy, placed against glass, barely adhered to it, yet secreted a little yellowish matter."

But hook- and root-climbers, however lovely and pleasant to the landscape-gardener, have little interest for the student of plant habits. His attention is given rather to the twiners and tendril-bearers, whose movements seem instinct with life, akin to that of the animal world; for every tender tip of every growing twiner sweeps around and

236 Field, Forest, and Wayside Flowers

around continuously. As the growth of the plant causes the ends of its main stem and branches to ascend, the motion of each vine is not a series of circles, but one close, continuous spiral. This revolving movement is quicker by day than it is by night. It is accelerated by the warmth of sunshiny summer noons, and retarded by overcast or chilly weather. It is most rapid, generally speaking, in June heats, when all plant-life reaches its uttermost fulness, and it slows down gradually with the waning of the year. But all summer long, in glad or in gloomy weather, this strange movement goes on in growing tips of twining and tendril-bearing vines.

Decrease in temperature always has the effect of retarding the revolution of a vine-tip. When twining plants grow in a window the sprays travel faster when in the sunlight, and their speed slackens as they twine into the shadow. Thus, a morning-glory, living in a sunny window, has been found to make a complete revolution in five hours and thirty minutes, but the half of its orbit which lay in the light was traversed in one hour, and all the rest of the time was spent in getting around the semi-circle which lay in shadow.

When a hop begins to grow, the two or three

first-formed joints, or "internodes," of the stem are straight, and stand erect and still. "But the next formed," says Darwin, "whilst very young, may be seen to bend to one side, and to travel slowly around toward all points of the compass, moving like the hands of a watch, with the sun." The movement very soon acquires its full ordinary velocity, and it continues as long as the plant continues to grow; but each separate internode, as it becomes old, ceases to move. The internodes travel slowly when they are very young, and accelerate their speed as they approach maturity.

So the tender tip and the lower and older part of the spray are moving in the same direction, but at varying rates; and this difference sometimes gives a serpentine twist to the shoots of vigorous twiners. The ends of many vine-sprays are bent over so as to form hooks, which are of great assistance to the plants in their efforts to rise in the world. For not only does the terminal hook lay hold of any support within reach, but it causes the tip of the shoot to embrace this support much more closely than it could otherwise do, and thus may prevent the stem from being blown aside in windy weather. It is very noticeable in the young sprays of the Virginia creeper (see Fig. 67).

“The first purpose of the spontaneous revolving movement,” says Darwin, “is to enable the shoot to find its support. This is admirably ef-



Bind-weed (*Convolvulus*).
Twining “against the sun.”



Hop-vine (*Humulus Lupulus*).
Twining “with the sun.”

FIG. 66.—Bind-weed and hop-vine.
(From the *Vegetable World*.)

fected by the revolutions carried on night and day, a wider and wider circle being swept as the shoot increases in length. This movement like-

wise explains how it is that plants twine." The hop and the honeysuckle always move in the same direction as the hands of a watch (Fig. 66). They follow the sun. The bean, jasmine, wistaria, and convolvulus turn always in the contrary direction to the hands of a watch, or against the sun. A few vines—notably the bittersweet—seem indifferent which way they twine, and one species studied by Darwin, the *Scypanthus elegans*, can revolve first one way and then the other; can, in fact, "reverse" like an expert waltzer.

But the great majority of those which have been studied twine always the same way, and as a rule plants near of kin wind about their supports in the same direction. The speed of the revolving movement varies greatly. The convolvulus and the bean sweep completely around the circle in less than two hours. On the other hand, some plants take twenty-four hours for a single revolution, and one sluggard was found which seemed unable to get around in less than forty-eight hours. The rate of speed seems to have little to do with the thickness of the vine, for the woody shoots of the wistaria are found to traverse the circle faster than do the slender herbaceous tips of the morning-glories.

In all the leaf-climbers and tendril-bearers whose habits have been investigated, the young internodes revolve, but these movements are less regular than those of the twiners.

The tender shoots of that familiar leaf-climber, the clematis, while growing vigorously in spring, make small oval revolutions, moving always in the same direction as the hands of a watch. Later in the season the vine-tips travel more fitfully and slowly through a very small circle, and by midsummer their movements have almost ceased.

But the leaf-stalks have acquired a high degree of sensitiveness, as if to make up for the failing powers of the shoots.

While the leaf is yet so young that its blade—or flat, green surface—has attained but one-sixth of its full size, its stalk is so well developed that the whole affair has somewhat the disproportioned and lanky appearance of a few-days'-old colt. At this stage of growth the sensitiveness of the leaf-stalk is at its highest, and the tender blade is bent downward, so that the whole leaf has a hook-like form (Fig. 67).

When the growth of the plant or an impulse from the wind brings the hook into such a position that it catches on a twig the sensitive stalk

feels the pressure and begins to curve. Darwin experimented upon one species of clematis with a

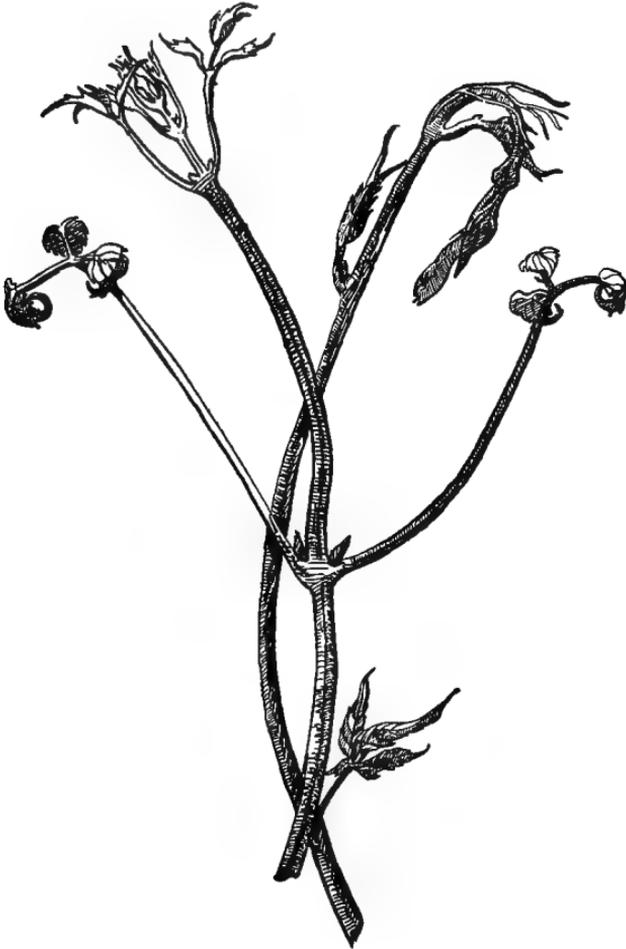


FIG. 67.—Scaling-hooks of the Virginia creeper (*Ampelopsis quinquefolia*) and of the wild clematis (*Clematis Virginiana*).

stick placed so as to press lightly against one of its young leaf-stalks. He found that the leaf-stalk

curled completely around the stick in the course of twelve hours, and though, after twenty-four hours, the stick was removed, the young stalk never subsequently straightened itself.

After the clasping leaf-stalk has made sure of its hold, it is subjected to some remarkable alterations. It literally "undergoes a change of heart," so that, though the stalk in its days of youth and freedom was flexible, and could be snapped easily, the clasping coil is wonderfully tough.

The purpose of this change evidently is to fit the leaf-stem to give the branch firm and durable support.

The ways of the tendril-bearing vines may be readily studied by observation of two among them which are familiar to all mankind—the grapevine and its graceful cousin, the Virginia creeper. Nature ages ago set an example of thrift akin to that which beats its swords into ploughshares when cruel war is done. She is wont to adapt the same organ in various ways, so that it can fulfil various tasks in various conditions. Thus vine tendrils are leaf-stalks, or flower-stalks, as the case may be, altered over into fitness for their new work of clasping and clinging. Those of the great majority of vines are transformed leaf-stalks, and now and then betray their true nature by bearing at their ex-

tremities partly-grown or imperfectly formed leaves. Those of the grape and the Virginia creeper are altered flower-stalks, and occasionally reveal their origin by developing into what are known as "flower-tendrils." These, like Bottom the weaver, undertake all rôles, bearing a bunch of flowers midway, and having coiling, sensitive tips. And among those borne by the grape the vine-dresser finds every gradation, from the tendril with a solitary blossom half-way along its length to the bunch of flowers or grapes ending in a tendril coil. But whether they are leaf-stems or flower-stems by nature the conduct of all tendrils is much the same. "Both kinds spontaneously revolve," says Darwin, "and at about the same rate. Both, when touched, bend quickly toward the touched side. And both kinds soon after grasping a support contract spirally, and then increase greatly in thickness and strength."

A vigorous grape-tendril is often several inches in length, and forks once or twice. Its branches move independently of one another, and in bright July days they traverse their circle in from two to three hours. After a tendril has revolved for a time it bends toward the dark, so that if a grapevine be planted against a wall the tendrils reach toward it, and in a vineyard they generally point

toward the north. "The tendrils of the Virginia creeper exhibit," says Darwin, "no marked or regular revolving movement, though they show a decided tendency to turn from the light toward the dark." But the vital force which they save by thus living in comparative quiet and ease seems expended in movements, few and slight, yet strangely like those of a reasoning creature. These tendrils have generally several branches, each instinct with vitality. When they meet with a flat surface they all turn toward it, spread themselves as far apart as possible, and bring their hooked tips into close contact with it. "In effecting this," says Darwin, "the several branches after touching the surface often rise up, place themselves in a new position, and again come down into contact with it. In the course of about two days after a tendril has arranged its branches so as to press upon any surface, its curved tips swell, become bright-red, and form on their under sides little disks, or cushions, with which they adhere firmly."

As these disks soon fasten themselves to smooth surfaces, naturalists believe that the vine secretes a little resinous vegetable cement, by means of which the tendril tip sticks fast to the spot which it has selected. After it has made sure of its hold, the

tendrils contract spirally, and by so doing it draws up the branch upon which it grows. Coiled thus, it is as elastic as a steel spring, and when the main stalk of the tendril is pulled the strain is distributed equally among all the attached disks. Withered branches of the Virginia creeper continue to cling to their supporting wall years after their death, despite the tugging winds of many winters and the softening influences of the rains of many springs. Darwin experimented upon a single lateral branchlet of a tendril supposed to be at least ten years old, and found that it supported a weight of two pounds. "The whole tendril had five disk-bearing branches, of equal thickness, and apparently of equal strength, so that, after having been exposed during ten years to the weather, it would probably have resisted a strain of ten pounds."

But a tendril which has found no support undergoes no further development. It was "adapted" to catch and cling, and as it has failed to fulfil its office there is no further use for it in the vine's economy. For, whatever society may do, Nature tolerates no shirks. The useless tendril, in the course of a week or two, shrivels into a slender thread, drops off, and drifts away like summer leaves in October.

CHAPTER XI

THE SPORING OF THE FERN

“We have the receipt of fern-seed
We walk invisible.”

—*King Henry the Fourth.*

WHEN Falstaff, of delightful—though not of blessed—memory, had perpetrated a number of lawless deeds, without either fear or reproach, he boasted that he and his cronies “had the receipt of fern-seed.”

The fine dust which borders the matured fronds of the common bracken was supposed to confer magic powers upon whomsoever should gather it with proper ceremonies, at the stroke of twelve, on midsummer’s night. Chief of these, and most useful to gentlemen like Falstaff, with great appetites and slender purses, was the power of becoming invisible at will.

The experience of four more centuries has taught us that uncriticised appropriation of other

men's goods comes never by aid of fern-seed, and only sometimes by bribing or hoodwinking the powers that be.

And modern science tells us that there is no such thing as fern-seed, for the tiny globular or oval bodies from which flowerless plants are perpetuated are not seeds, but spores.

The seed, as we have seen, consists generally of two coats, enclosing a tiny plant and a store of food for its sustenance during the first few days of its life above ground.

But the spore is much simpler in structure. Its morphological equivalent in the flowering-plant is not the ovary, nor even the ovule or young seed within the ovary, but it is a tiny vesicle or cell which formed inside the ovule when the flower first unfolded.

In the flowering-plant the jelly-like substance of this cell mingles with some of the jelly in the pollen-grain, and after this union is complete the cell begins to grow and shape itself into a tiny plant. This union of the contents of the pollen-grain with the vesicle in the ovule has been understood, though less fully than we understand it to-day, for two centuries or more. Hence, all the plants which bear flowers with stamens and pistils, and so have

248 Field, Forest, and Wayside Flowers

ovules and pollen, are called "phanerogams," the term being derived from two Greek words which mean a visible or apparent marriage.

It was long suspected that among flowerless plants also the new individual was born as the result of the union of two parent-cells, but with the imperfect microscopes of former times this union could not be seen in detail, and the facts concerning it could never be accurately learned.

So all the series of the flowerless plants, among which are numbered lichens, seaweeds, mosses, liverworts, horsetails, and ferns, were named "cryptogams," from two Greek terms, which mean a hidden marriage.

But little is hidden by mere minuteness from the modern compound-microscope, and though some of the smallest cryptogams—the microbes and bacteria—have "ways that are dark" still, the life-history of the mosses, liverworts, horsetails, and ferns is now accurately known.

The differences between these two great series of plants—the flowering and the flowerless—are sharply defined at the very beginning of their histories. In the ripe seed the little plant is already formed.

It lies snugly folded into the smallest possible

compass, and is very pale and tiny, but even a pocket-lens will show that it has a leaf, or two, as the case may be, a little stem, and at the end of this a knob, whence the first roots will spring.

And this little plant, in due time, will grow into the exact likeness of the parent-plant from which it sprang.

Judged by their exteriors, the little spores which dust the edges or dot the backs of fern-leaves are more elaborate than seeds, for the fern-spore has always two coats, and sometimes three, and the outermost coat is often as daintily wrought as if a fairy carver had expended his best skill upon it. But inside careful investigation with the most powerful of microscopes finds only a minute drop of jelly, containing a little starch, some oil, and many tiny floating grains of chlorophyll. No germ is contained within the spore of any cryptogam.

But the jelly, or protoplasm, in the spore is instinct with creative life. When growth begins, the outer coat of the spore breaks irregularly, and the inner coat, with part of its contents, protrudes through the fissure, forming a knob, which is soon cut off from the rest of the spore by a transverse wall. This outgrowth contains little or no chlorophyll, and it lengthens rapidly, plunges downward

into the soil, and serves all the purposes of the first rootlet in the sprouting seed-plant.

Meantime the larger and greener portion of the spore stretches out into a tube, and a little later partitions grow across the interior of this tube, cutting it up into a chain of cells. Later still the cell at the outermost end divides into two by a lengthwise partition. Then all the cells begin to divide lengthwise and crosswise by the growth of delicate walls within them, till there is formed a sheet or plate of tissue, with the general outline of a flattened heart. Toward the centre of this heart, on the side which lies undermost, rows of new cells are now produced by the growing and splitting of old ones, till a cushion of tissue is formed.

And the under surface of the little heart also gives rise to a number of long, slender tubes, as fine as hairs, which are called "root-hairs," because their office is the same as that of the roots of higher plants (Fig. 68).

They anchor the little heart to the spot where it grew, and they help to sustain its life by absorbing moisture from the soil.

The mass of cellular tissue resulting from the development of the spore is called a prothallium, or prothallus.

The adders'-tongues, next of kin to the ferns and the horsetails, or scouring-rushes, both shed spores, which develop into prothalli. So do the

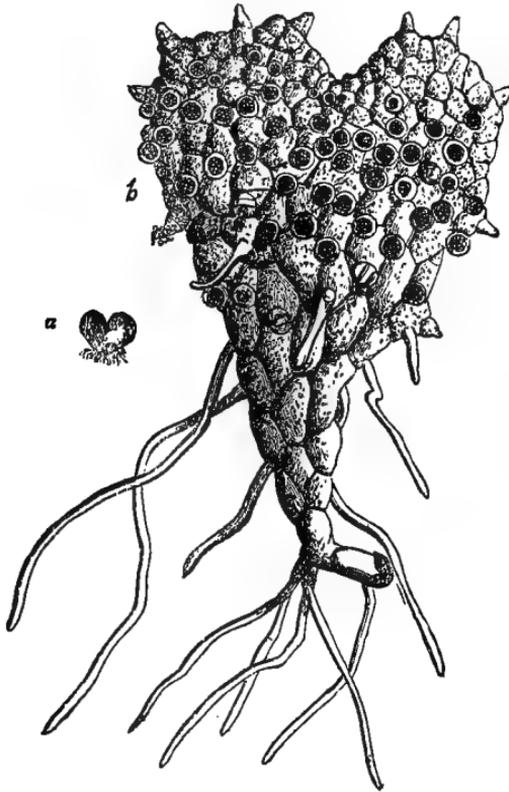


FIG. 68.—Prothallus of a southern fern (*Pteris serrulata*).
a, actual size; *b*, much magnified.

lycopodiums, which, under the names of “ground-pine,” “club-moss,” or “trailing-evergreen,” are familiar to almost every one who has summered in New England.

252 Field, Forest, and Wayside Flowers

The prothalli of the adders'-tongues and of the club-mosses are generally tuberous, and grow half buried in the soil, or beneath its surface. Those of the ferns and horsetails are green and leaf-like. But all are alike short-lived; all are quite destitute of woody tissue, and all are very small in comparison to the parent-plant.

The spores shed by the largest of our native ferns develop into prothalli less than half an inch wide in their widest part. They lie pressed close to the surface of the ground, or sometimes beneath it, and being so tiny and so retiring in their habits it is difficult to find them.

A pot in which a fern-plant has come to maturity and shed its spores, will probably contain some growing prothalli, and we may be able to find them by careful turning over of the surface-soil. But the details of their structure can be studied only by aid of a microscope of four or five hundred diameters.

By use of the lenses we have learned that after the prothallus has "got its growth," two sets of organs appear upon its under surface. These fill the same place in the history of the fern that stamens and pistils do in the history of the flowering plant. They are called antheridia and archegonia.

The first antheridia appear when the prothallus is three or four weeks old. They are most often formed toward the point of the heart, and are scattered over its lower surface, apparently without definite order.

Each antheridium is, at first, a single cell protruding slightly from the surface of the heart, and looking deceptively like a young root-hair.

Grown older, it is a little chamber, with a single layer of cells forming its encompassing wall, and with its interior packed quite full of tiny globes. When the antheridium has reached fullest maturity the cells, which wall in the little chamber, absorb water freely, swell, and burst open.

The minute globes, which have been cribbed, cabined, and confined, are now set free. Each globe is what botanists call a "mother-cell," and coiled up inside it lies something which looks like a strap, with a narrower and a broader end. This is an "antherozoid"

(Fig. 69). Soon after the mother-cell comes out



FIG. 69.—Antherozoids of *Pteris serrulata*.

(From the *Vegetable World*.)

of the antheridium it bursts, and the antherozoid, which has been lying in it, curled up and mo-

254 Field, Forest, and Wayside Flowers

tionless, finds itself thrust forth into the great world.

Being cast upon his own resources has had an energizing and awakening effect upon many a human idler or Jack-a-dreams. And the little antherozoid, turned loose, acts as if it had become instinct with conscious life.

Its coils draw apart, and we see that at the thicker end of the spiral is a tiny drop of jelly, which is all that now remains of the contents of the mother-cell, while at the thinner end there is a dense tuft of fine, curved filaments.

These tremble and sway like the fins of a fish, and by their aid the antherozoid can swim about, with a motion so like that of an aquatic animal that one who watches it is inclined to doubt that it is endowed only with the blind, unconscious life of the vegetable world. Hence, the tiny thing is sometimes called a spermatozoid, for the Greek suffix *zoid* signifies "like an animal," while *sperma* means "a germinal principle of life."

There is ample opportunity for the display of its natatorial powers, for to a swimmer so minute every drop of dew is a lake.

While Nature has been giving birth to these little navigators, there have been forming, on the cush-

ion of the prothallus, the archegonia, which are the reasons of their being. An archegonium also begins life as a single cell, on the under surface of the prothallus. A little later a crosswise partition appears, dividing the cell into an upper and a lower portion. More partitions are formed, making a cluster of cells, while the life of the prothallus moulds the plastic young tissue till the maturing archegonium takes the shape of a flask, with a proportionately very long and thick neck, curved over to one side (Fig. 70).

The curve is generally in such a direction that the mouth of the flask points toward an antheridium.

At first the flask's mouth is closed, and its neck is filled with a row of cells, called the "neck-canal cells." But a little later these dissolve into mucilage, and at the same time the lips of the flask draw apart. And from the flask's mouth, at this date in its history, there is discharged an acid

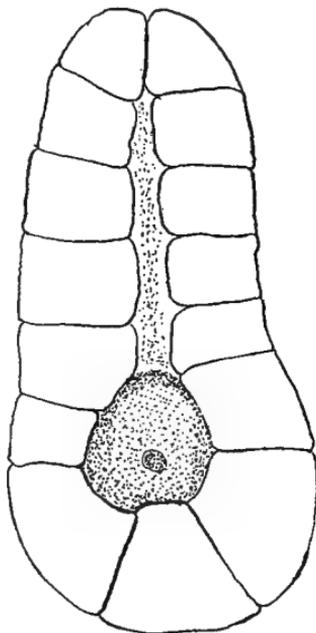


FIG. 70.—Young archegonium of a garden maidenhair (*Adiantum cuneatum*). (Much magnified.)

256 Field, Forest, and Wayside Flowers

which is attractive—but we do not yet know just how or why—to the spermatozoids.

Some rainy day or dewy night, when the under surface of the prothallus is wet, the active little swimmers approach the open neck of the archegonium, and are lured into it. And down in the rounded part of the flask they find the “affinity” which they have been unconsciously seeking, a naked globe of colorless jelly known as the “oosphere.” One spermatozoid enters the oosphere, and mingles with it, and with this act of fusion the life-purpose of the prothallus is accomplished.

The now fertilized oosphere surrounds itself with a delicate membrane, and becomes the “oospore.”

So again in the life-history of the fern we have come around to the single “cell” or globe of protoplasm from which we can trace the development of every living organism.

From the first globe—the fern-spore—creative Nature made the tiny heart-shaped prothallus. From the second globe,—the oospore,—she will make the perfect fern.

A prothallus may form a number of archegonia before a spermatozoid finds its way into any one of them. But as soon as an archegonium is fertilized no new ones appear, and the remaining life

of the prothallus is expended in nourishing the oospore. Sometimes it so happens that several sister oospores are ready to grow at the same time. But generally in this case one dominates the rest in the great struggle for life, and draws into itself all the nutriment which the prothallus can bestow. And so a prothallus seldom gives rise to more than one little fern.

If a prothallus is insufficiently nourished it may bear antheridia only, and no archegonia at all. Such "male" prothalli are apt to develop after an eccentric fashion of their own. They are often long and narrow, sometimes almost filamentous in form and grow into irregular projections. In fact, they are sometimes "all bubukles, whelks, and knobs," like Bardolph's countenance.

They are relatively small, and may even be reduced to a single vegetative cell, an antheridium, and a few root-hairs.

Several common native ferns, notably the great *Osmundas*, always give origin to a number of starveling "male" prothalli, in addition to the larger and more symmetrical ones which bear both antheridia and archegonia.

And in a few flowerless aquatic plants, closely akin to ferns, all the prothalli are either male or

female. In a few fern-allies the prothallus—male or female as the case may be—is minute and colorless, and remains throughout its brief life partially enclosed within the spore from which it grew. From such plants as this there is but a short upward step to the cone-bearing trees.

But all our familiar ferns of wood, rock, and roadside, the “*Filices*” of the working botanist become parents of prothalli which escape from the spore in their earliest youth, and live thereafter as independent plants, growing on the surface of the earth, and getting their own honest living by aid of a working-outfit of chlorophyll and root-hairs.

So there is in ferns a true alternation of generations. The fern gives birth to a prothallus, and the prothallus gives birth to a fern. In this curious genealogy there is no resemblance between parent and offspring, but the offspring is a young copy of its grandparent.

The fern prothallus corresponds to a small fraction of the blossom in a flowering-plant. To prove this it would be necessary to plunge so deeply into structural botany that the reader might find the comparison, like many another, odious.

The life-story of the prothallus resembles that of the flower in these respects, that it lives to accom-

plish one purpose,—that this purpose is the fusion of two reproductive cells, one male and the other female,—and that when this life-work is finished it dies. And as the unfertilized flower lives long past its normal time of blooming, still waiting for breeze or insect to bring it pollen wherewith to set its seed, the unfertilized prothallus may continue to grow for several months, or even, in the case of the *Osmunda*, for years.

But as soon as spermatozoids have entered the archegonia, and one or two oospores have been formed, the prothallus begins to wither.

The oospore is soon cut into two parts by a vertical partition, and then into four by a horizontal one. Three of these divisions become the stem, leaf and first root of the young fern. The fourth becomes an organ termed “the foot” by means of which the fern draws its support from the parent prothallus till it is old enough to shift for itself. By that time the prothallus is quite depleted and exhausted.

After the fern has passed its earliest youth the first-formed or “primary” root withers away.

In most native species the main stem lies horizontally along the surface of the earth, or just beneath it. The leaves or “fronds” spring from

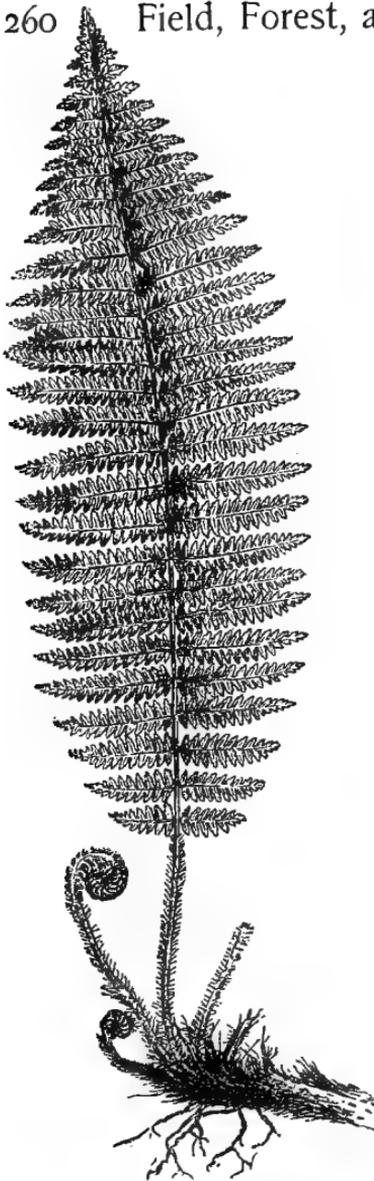


FIG. 71.—“Male-fern” (*Aspidium felix-maas*), showing the prostrate root-stock and the downward roll and scaly covering of the young fronds.

(From the *Vegetable World*.)

its upper side, and a number of small, branching rootlets arise, without regularity or system, from its lower surface. Sometimes the half-buried main stem, or “rootstock,” is many inches long, and at one end of it there is a large actively-dividing cell—the growing point. But in the tropical tree-ferns the main stem stands erect, and the “growing point” is at its tip-top.

When our native ferns appear above ground in spring, their leaves, or fronds, are rolled downward from the tips like croziers, and by this token we can distinguish them from their near kindred, the adder’s-tongues

(Ophioglossaceæ), which enter the world upright.

The roly-poly ferns of

early spring are generally hairy or scaly (Fig. 71), with brown transparent outgrowths which help to protect the tender frond from cold snaps and bitter winds. Later in the season hairs and chaffy scales may still be seen clinging to the fern-stalk and sometimes almost covering its lower portion. Under the microscope these scales are seen to consist each of a single layer of cells, with thickened brown walls, through which a mucilaginous or resinous liquid oozes. Gold and silver ferns have their under surfaces covered with hairs which exude resinous and waxy substances.

But the trick of developing hairs is best understood by the tree-ferns, whose young leaves are completely buried in a brown mass of vegetable fur, sometimes utilized by robber man for stuffing mattresses.

By latter July most native ferns have attained maturity, and on the backs of the fronds, in many species, we can see dots and dashes of silver-green, dark-green, or brown. These are "sori," and their general plan can be readily seen with a pocket-lens.

Typically each sorus consists of a little scale or lid, covering a group, or perhaps two groups, of stalked sporangia, and each sporangium is a little

round or watch-shaped box filled with spores (Fig. 72). The sporangia of many ferns are nearly surrounded by an incomplete ring of large cells, whose brownish walls are of a substance akin to cork. As

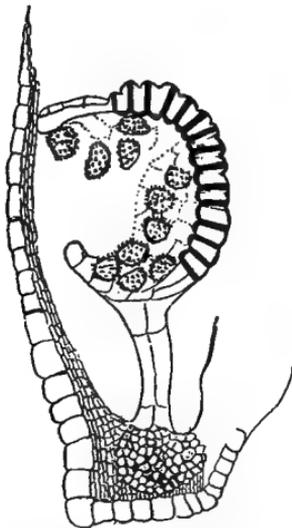


FIG. 72.—Opening sporangium of a Florida fern (*Pteris cretica*). (Much magnified.)

the sporangium grows older the outer walls of these cells dry and shrink; and as this shrinking proceeds, the incomplete ring begins to straighten itself out. By so doing it pulls upon the surrounding tissue and ruptures the sporangium, scattering the dust-like spores to the four winds. The sporangia of the great Osmundas have no encompassing ring, but they are split by the action of a little group of corky cells,

which shrink together as they grow old, and thus first strain and then rend the neighboring tissue.

The spores of native outdoor-ferns remain dormant through the winter and grow into prothalli in the spring.

The Hartford climbing-fern, the common sensitive-fern (Fig. 73), and a few others have instituted a division of labor by which some fronds



FIG. 73.—Vegetative and spore-bearing fronds of the sensitive fern
(*Onoclea sensibilis*).

fulfil all the offices of foliage, while others, which are curiously contracted, produce sporangia and do nothing else. The spore-bearing fronds of the sensitive-fern, browned and desiccated by the winter storms, are conspicuous amid the tender greenery of low-lying fields in early spring. The royal *Osmunda*, called "flowering-fern" also practices division of labor, but practices it less completely, for the lower part of the great frond is green and leaf-like, while the upper portion is a plummy mass of densely-crowded sporangia.

The development of these sporangia begins in early spring, before the fronds unroll, and they attain their full growth by the first of June. So the royal *Osmunda* takes more than a month's precedence of less methodical ferns, which make all fronds serve both purposes.

The sporangium in all the true ferns is formed from a single superficial cell. This cell grows so as to project above the general surface of the frond, and when it is hemispherical it is cut in two by a crosswise partition.

The inner section will become the stalk of the sporangium, and the rounded outer portion will eventually be fashioned into the sporangium itself.

But in the adder's-tongues and some other fern-

266 Field, Forest, and Wayside Flowers

allies the sporangia are developed each from a little cluster of superficial cells.

Upon this difference botany divides the ferns and their nearest of kin into two great groups.

The adder's-tongues (*Ophioglossaceæ*) belong to the smaller and older of these groups—the *Eusporangiateæ*. They are feeble descendants of a very ancient and once powerful and numerous family and are distantly related to the great ferns of the coal measures, which were also *Eusporangiateæ*.

But the majority of our native ferns are not, as is so often asserted, the depauperate progeny of a doughty race. They are "*Leptosporangiateæ*," and form their sporangia each from a single cell. This is the more modern method, and is followed by the younger branch of the fern family (*Filicinæ*).

The great majority of our native ferns belong to a younger branch of this younger branch, the *Polyodiaceæ*, which, as we know from the testimony of the rocks, did not make their appearance till within comparatively recent times. They have multiplied and have taken possession of the land, setting aside the law of primogeniture as Jacob did of old.

The disinherited *Eusporangiateæ* are represented in our country only by the moonworts and the adder's-tongue (*Ophioglossum vulgatum*). There

are but seven species in all, and their largest and most important member is barely two feet tall, while sixty-five species of the Leptosporangiateæ are found north of the southern boundary of Virginia, and even in Canadian forest-clearings some of them grow breast-high.

As we go southward the Leptosporangiateæ increase in number and in size, till in tropical woods the tall shafts of the tree-ferns rise like the columns of a great cathedral and the long fronds curve upward from their tops like springing gothic arches. One who has seen these truly "cathedral woods" is quite disabused of the prevalent but mistaken notion that the fern family as a whole has "fallen on evil days" (Fig. 74).

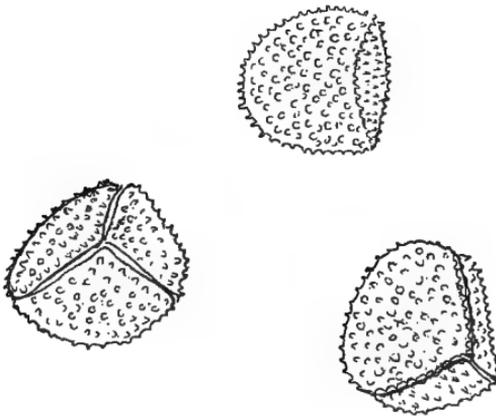


FIG. 74.—Spores of a club-moss (*Lycopodium complanatum*).
(Much magnified.)

CHAPTER XII

THE SENIORS OF THE FOREST

“Cedars blossom, though few people know it,
And look all dipped in sunshine like a poet.”

—*Lowell.*

THE evergreen woods have a character distinctively their own. This is most evident in winter, when they stand robed in living green while the deciduous trees are etched in soft grays against the sky, but it is noticeable at all seasons.

They may almost be said to have a flora of their own, for some blossoms blow beneath the evergreens which are not found elsewhere, and others thrive best on the mat of fallen needles which covers the ground under pines and hemlocks.

First and sweetest of these is the trailing-arbutus or May-flower. It fades as spring advances, and is followed by a number of the smaller and humbler orchids, little cousins of the stemless lady-slipper, which appears in June, and which is the last and almost the only showy blossom of the evergreen woods.

In July pine-roots give a home and a maintenance to some curious parasitic plants—"pine-drops," "pine-sap," and "Indian-pipe," or "ghost-flower." In latter summer the only bits of color on the ground are fungi,—white, yellow, orange, and red,—which come pushing through the mat of fallen pine-needles on which they live and feed.

There are few bees in the evergreen woods, and fewer butterflies. The birds seen in the shadowy aisles are the little warblers, which converse in low trills and twitterings. The joyous ringing bird-strains will be heard in copse or swale, in orchard, or meadow,—not in the far withdrawing vistas which lead between these pillared trunks to deeper solitudes.

The brooding silence of the evergreen woods is broken only by the occasional chatter of a squirrel, by wind passing through the boughs with a sound like the wash of waves on far-off shingle, and, perhaps, by the tremulous whistle of the pine-linnet, or the bell-like notes of the hermit-thrush.

Here and there, under the trees, are those cousins of the ferns which look so confusingly like evergreens that they have received the names of "ground-pine" and "trailing-hemlock."

They are fitting companions to the pine-trees, for both represent the vegetable life of the elder

270 Field, Forest, and Wayside Flowers

world. The group of the cone-bearers to which the hemlock, cedar, pine, spruce, and fir, as well as the arbor-vitæ and the larch, belong, were the first-born of flowering-plants. They are the link, connecting ferns and their allies with the kindred of the lily and of the rose.

All native cone-bearers belong to one botanic group, the Pine family, and this divides itself into two very unequal branches, the true pine connection (Pinaceæ) and the yews (Taxaceæ).

All our wild evergreens, except the yews, are numbered among the pinaceæ, and so are the larch and the "bald"-cypress of the Southern States, which are not evergreen. The Taxaceæ are represented in this country by a couple of small garden-shrubs, by the European yew, and the gingko or "maiden-hair tree" of cultivated grounds, and by the wild yew or ground-hemlock which straggles over barren northern hillsides.

The sprouting yew, like the baby-bean or maple, appears above ground with two seed-leaves and so do the seedling juniper, cedar, and arbor-vitæ. But the pine, spruce, fir, and hemlock begin at once to show some characteristics which prove their pedigree, and distinguish them from the kin of the lily or of the rose.

For these seedlings enter the world with what children call "a great plenty" of first leaves, from three to sixteen of them, arranged like the spokes of a wheel (Fig. 75).

These are needle-shaped, and the leaves which follow them are also needle-shaped or scale-like, and differ markedly from the broad, flat foliage borne by the beeches, oaks, and maples.

Thus our native cone-bearers are fitted to cope with the rather trying circumstances in which their lives are spent. For hemlocks, spruces, pines, firs, and red cedars inhabit coasts, mountains, and high latitudes.

All down the Atlantic shore from Maine to southern

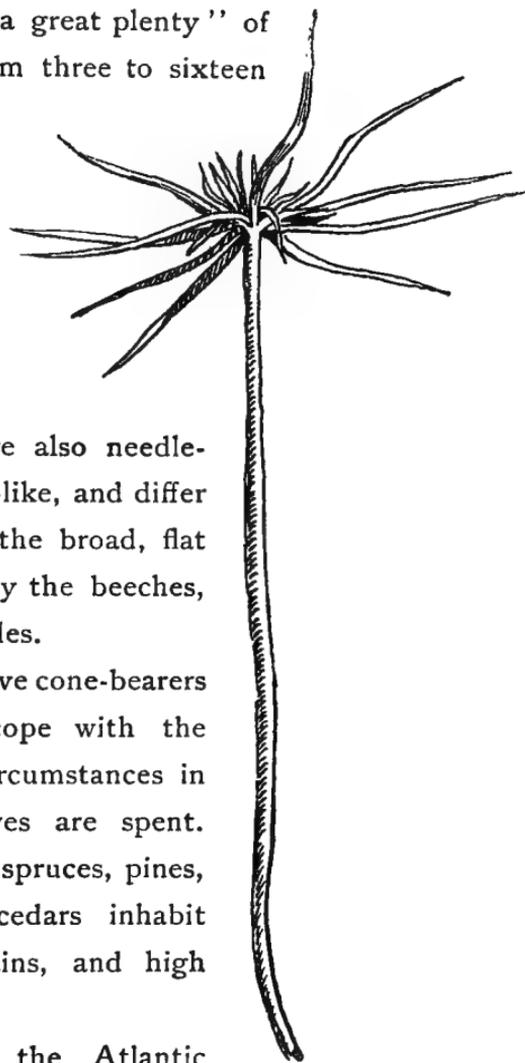


FIG. 75.—A seedling pine.

Florida pines, cedars, and junipers form a natural

272 Field, Forest, and Wayside Flowers

wind-break, sheltering the deciduous trees which grow further inland from the first keenness of ocean blasts; and in many places evergreen woods border on the great lakes, and bear the brunt of their gales.

As one ascends high mountains the broad-leaved trees grow fewer, till at last, all the rough slopes are clothed with the sombre green of spruces and pines. Indeed the word "pine" is derived from the Celtic "pin," a crag, which is preserved in the names of some Scotch and Welsh mountains—"Ben Lomond," "Ben Nevis," and "Penmaen-Mawr."

The forests of Maine and Canada are largely evergreen, and as one travels northward deciduous trees are left behind, till, at last, all the land is in possession of the spire-shaped spruces and the pines.

Coast and mountain evergreens must brave rough winds, and evergreens of high latitudes must be enabled to shed the snows of northern winters.

So Nature has fitted them for their circumstances by giving them the stiff, slender leaves which are popularly called "needles," or, as in the case of the arbor-vitæ, scale-like foliage, which invests the branches as tiles cover a roof. However fierce

the gale, such leaves cannot be torn as spreading foliage would probably be if it grew in similar situations and the slippery needles of northern evergreens shed snow masses which would break broad-leaved trees to pieces.

Some years ago southern Ohio was visited by a moderately heavy snow-storm in mid-May, when all the summer leaves were out. Their broad surfaces caught and held the flakes, and the boughs were soon over-weighted. All hands turned out with poles, rakes, and broomsticks to beat the snow off cherished trees, but, despite much zealous exertion, aided by a May-time sun, many branches crashed down in a few hours. The experience showed the probable effect of northern snows upon evergreens if they bore broad leaves.

But the needles of pines, hemlocks, and firs shed the flakes from their curved and shining surfaces and allow them to fall through the feathery branches toward the ground. Snow occasionally gathers upon the trees in masses sufficient to form a beautiful contrast to their sombre green, but its hold on the slippery needles is so insecure that the least puff of wind suffices to dislodge it.

The broad-leaved evergreens, laurel, laurestinas, holly, bay, and live-oak are native to climates

274 Field, Forest, and Wayside Flowers

where snow seldom falls heavily, and never lies in unwieldy masses.

The little needle-shaped or scale-like leaves of northern evergreens make up in number what they lack in size.

But though the trees are evergreen their leaves are not. One by one they fade and fall, till, in the course of a few years the entire foliage has been shed. Thus the spruce drops all its needles in the course of six or seven years. The yew-leaves fall after they have weathered the gales of about eight winters, and the leaves of the silver-fir drop to the ground when they have reached the ripe old age of twelve years. The discoloration of ageing leaves is not noticed amid the general greenness of their surroundings, and the void made by their fall is soon filled by fresh individuals.

The larch in the North and the "bald-cypress" in the South have departed widely from the family custom of the cone-bearers. Like the broad-leaved trees they drop their foliage each autumn, and they appear in spring clothed in complete new suits of tender green.

The true evergreens which retain their needles throughout, assume a sombre tint with the coming of the first heavy frosts. This is because the

chlorophyll-bodies which give the foliage its hue lose their vivid color in the autumn and change to a brownish-green.

The pines and hemlocks are most noticeable in winter, when there is no other green in the landscape and when they are contrasted with the snow; but in reality their color is more intense in summer. For in the first warm days of spring the chlorophyll bodies in the needle-shaped leaves resume their characteristic color, and with it their "activity of toil."

New-born pine-leaves issue in pairs, trios, or fives, from little brown buds, which are covered with delicate semi-transparent scales. These are regarded as altered "needles," just as the scales which protect the winter-buds of many broad-leaved trees are altered leaves.

The new needles of the white pine (Fig. 76) come into the world in fives. Those of the Jersey or scrub-pine are twins, and those of the pitch-pine grow in clusters of three. Each of our twenty-two native pines is faithful to some old family custom in this respect, so that if we count



FIG. 76.—Leaf cluster and bud scales of the white pine (*Pinus strobus*).

the needles issuing from the bud we have observed one of the characteristics by which we may determine its species.

After the leaf-cluster is mature the little brown bud-scales which sheltered its youth drop away and fall. A slow, gentle shower of them drips earthward in the pine-woods all through the latter year, and adds largely to that soft, mouldering carpet which covers the ground beneath the trees.

In the balsam-fir and in the yew-tree each needle has its own guardian scale-leaf, and the foliage is distributed evenly over the surface of the bough (Fig. 77).

Within the needle-like leaves of the pines and their cousins there is no delicate network of branching-veins such as we see in the foliage of oaks and maples. Instead, there is one compact bundle of vessels and tubes, through which plant-fluids creep out toward the sunlight to be digested, and then back again to growing roots and shoots. This bundle lies at the very centre of the leaf, and is sheathed, and in a measure protected from cold by an enclosing tube of thick cells with corky walls. Outside this corky tube lies the green substance of the leaf, composed of delicate cells containing chlorophyll.



FIG. 77.—A spray of the balsam-fir (*Abies balsamea*).

This tissue, like the bundle of vessels, is guarded by Nature against frosts and winds, for outside the delicate green cells there is a tough encompassing layer, or, it may be, several layers, of fibrous cells with very thick walls. These strengthen the leaf, rendering it less liable to be broken by gales, and they also serve, in a measure, to protect the inner tissues from sudden changes of temperature and from the drying effect of high winds. Then, outside all, is the leaf-skin or epidermis, which is also thick and fibrous.

The stomata are distributed evenly over the surfaces of these needle-shaped leaves. They pierce through the epidermis, and through the fibrous tissue beneath it, to the delicate green cells which may have superfluous moisture to breathe away. But as the cone-bearers often live on stony ground and in wind-swept situations, it is desirable that their leaves shall not part too readily with their vegetable juices. So each stoma opens at the base of a depression in the leaf-surface, where it is somewhat sheltered from the direct sunlight.

Even in New England there are a number of birds which do not join the great southward migration, but stay to brave winter and rough weather. During latter autumn this remnant is reënforced

by the arrival of birds from the North, to whom our latitudes are what Florida is to shivery people of elegant leisure. In the vicinity of Norfolk and of Cincinnati the bird-life of the leafless woods is almost as full and intense as that of the summer. But when the wind swoops down from the North, and deciduous trees afford no protection, the evergreens offer the birds a refuge in the time of trouble. Here they find both shelter and food, for after the "hips and the haws are all gone," and snow has covered the earth, a living can still be eked out, thanks to the juniper berries and the seeds of the cone-bearing trees.

Cedars and junipers make an especially effective wind-screen, and on the eve of a bitter night little birds gather in numbers on the branches of these trees, close to the trunk.

The habit of growth of the cone-bearers is similar to that of the oaks and maples and other kindred of the rose. The ascending stream of water from the roots passes through the younger wood, while the descending stream of sap from the leaves moves through the inner bark. The tree grows thicker as it grows older, and between bark and wood, each growing season, there is a ring of actively-dividing cells which are building up new

tissue. The oldest wood is at the centre of the trunk, and the newest is just beneath the bark (Fig. 78).

But in many cone-bearers and notably in the white pine, the heart-wood undergoes little altera-



FIG. 78.—Crosswise section of the trunk of a fir-tree, showing growth-rings.

(From the *Vegetable World*.)

tion as the tree matures, and it can resume the industry of former years, if necessary, and conduct water upward toward the thirsty leaves. Indeed so great is its versatility that it can make shift to fill, after a fashion, the offices of young wood and of bark, so that plant-fluids still ascend and descend slowly even in a girdled pine.

282 Field, Forest, and Wayside Flowers

In addition to this capacity of their wood for meeting an emergency, the cone-bearers have another peculiarity which helps them to survive misfortune.

For in all our native evergreens except the yew, the wood contains a quantity of resin. In the living tree this resin is held in solution in oil of turpentine, and the two together make a clear, sticky fluid known as "balsam." In the larch, pine, and fir there are little wells of it in the trunk and branches, and sometimes even in the leaves. The balsam of the fir is so abundant and adhesive that the Canadians and Indians made use of it for tightening the seams of their canoes.

"Give me of your balm, O fir-tree,"

cries Hiawatha,

"Of your balsam and your resin,
So to close the seams together,
That the water may not enter.
And the fir-tree, tall and sombre,
Sobbed through all its robes of darkness,
Take my balm, O Hiawatha."

The balsam pours out wherever the wood is wounded, and, by exposure to air and sun, it stiffens and forms a plaster for the torn tissues. This preserves the life of the wood, which, if left unprotected, would soon have all its vital juices dried away.

So girdled cone-bearers have been known to exist for forty years. Indeed a pine has "as many lives as a cat." We realize this when we see the pitch-pines at home, in the "turpentine country" of Georgia. Deeply wounded, or even girdled, and all bare save for a tuft or two at the top, they still live, and remind one of Charles the Second who was "such an unconscionable time a-dying."

Were it not for these peculiarities of structure, girdled pines would share the fate of girdled-oaks and maples, which seldom survive their injuries for more than three or four years. In these trees the heart-wood, which has retired from active service, can never resume its conductive duties, and there is no balsam which can be converted into surgeons'-plaster in time of need.

So the wood which is laid bare dries out more and more, and as soon as the drying has penetrated the outer or vital part of the trunk plant-fluids can no longer move between leaves and roots, circulation stops, and the tree dies.

Though the cross-section of a pine-tree is much like that of an oak, their woody tissues have a different aspect under the microscope.

The wood of the cone-bearers is almost entirely composed of "tracheids," which are little tubes

tapering to a point at either end (Fig. 79). Most of these run lengthwise of trunk or boughs, and in

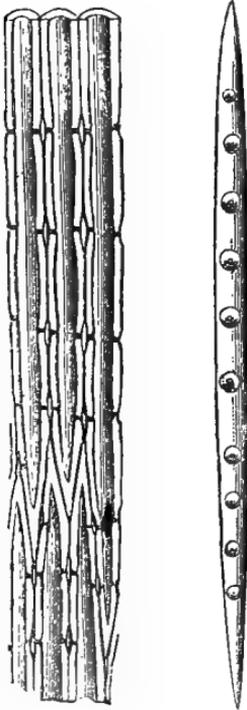


FIG. 79.—Tracheids of the fir-tree. (Magnified.)

their walls there are circles or ovals at regular distances apart. Each of these is a little plate of very thin tissue, set into the partition between two tracheids, and framed on both sides by a ring-shaped bulge in the tracheid-wall. The whole affair looks like a tiny circle surrounded by a halo. When the tracheids were young and full of protoplasm, plant-fluids were drawn through the thin spots, and thus a vital communication was kept up through all the maturing tissue. But by the time the tracheid is fully developed the protoplasm which has filled it disappears, and the mature wood of a cone bearer contains little else but a film of water on the tracheid-walls. So most of the "bordered pits" are no longer useful in the vegetable economy.

The Coniferæ combine the utmost grandure of

form with the greatest simplicity of floral structure. They are among the earliest terrestrial plants known to us. They are "the seniors of the forest,"—surviving types from a younger world. They were many and prosperous in the geologic "Age of Reptiles," when animal life swam and crawled but had scarcely yet begun to run or fly.

The first flowers the young world saw were borne by the Coniferæ, and as there were no winged insects in those days, the trees had to send pollen to one another by the wind. Now, when the summer air is full of possible pollen-carriers ready for errands, and when less conservative flower-families have learned to rely altogether upon their ministrations, the Coniferæ depend, as of old, upon the wind alone. They are like the people of some unprogressive communities, who cling to old methods of work, and look askance on modern machinery and labor-saving devices.

As the Coniferæ can carry on their affairs without the aid of flying messengers, they are able to perpetuate themselves abundantly in cold regions, while gay blossoms, which cannot set their seed without the ministrations of insects, are practically restricted to latitudes where the climate is favorable to the life of their winged friends.

Darwin has pointed out that in parts of the world where the summers are short and chill the land belongs to wind-fertilized plants, rushes, grasses, sedges, and cone-bearers.

And so the plants which entrust their future to the wind have, on the whole, a wider geographical range. But in pollen-sending, as in some other undertakings, newer methods make for economy, and the old way of doing things is wasteful. The Coniferæ have to produce so much pollen that there shall still be enough for all needs after a great quantity of the precious dust has been carried wide of its destination by vagrant winds.

So when the cone-bearing trees blossom, in May or June, their blown pollen is everywhere. It covers the surfaces of still waters, in the neighborhood of evergreen woods. Whole bucketfuls of it have been swept off the decks of vessels sailing close to the coast of North America. One observer has seen the ground near St. Louis covered with pollen, as if sprinkled with sulphur, and there was good reason to believe that it had been transported from pine forests, 400 miles to the south. "Kerner has seen the snow-fields of the higher Alps similarly dusted," says Darwin, "and another naturalist found numerous pollen-grains of Coniferæ

adhering to sticky slides which had been sent to a height of over five hundred feet by means of kites. Curiously enough more was found in the higher levels of the atmosphere."

The pollen of the Coniferæ is enabled to fly thus adventurously abroad because each grain is provided with two bladderly wings, so that its outline suggests one kind of a Chinese kite (Fig. 80).

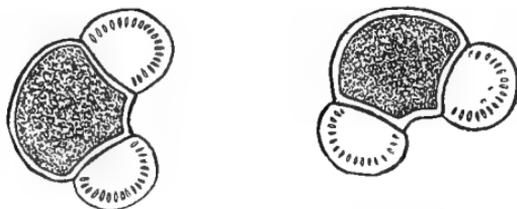


FIG. 80.—Winged pollen of the fir.

This winged pollen comes out of little sacs, which grow sometimes in pairs, sometimes in clusters, on the lower surfaces of shield-shaped scales, which have been called "staminal leaves." They are regarded as foliage leaves, set aside and altered over for new and higher uses.

Coöperation which brings about great results in the physical as well as in the industrial world enables the staminal leaves of the pine to make a brave show. They grow in long, close tufts, each of which is regarded as a very simple and primitive staminate flower (Fig. 81).

These flowers in their turn are massed in clusters, which are borne near the tips of boughs and twigs, where the wind can have its will with them. By latter May they are golden and conspicuous, and their abundant pollen flies from them in light clouds.

The staminal leaf-clusters, or staminate flowers,

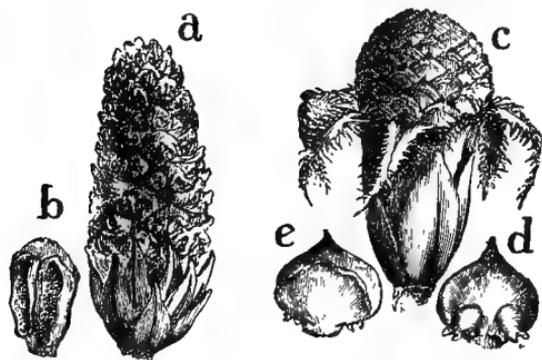


FIG. 81.—Flowers of the Scotch pine (*Pinus sylvestris*).

a, Staminate flower; *b*, a single "staminal leaf"; *c*, pistillate flower; *d*, upper surface of a carpel showing the two attached ovules; *e*, lower surface of a carpel. (From the *Vegetable World*.)

of the hemlock are more difficult to find, for they are not much larger than grains of rice, and they grow on the under surfaces of the branches.

Those of the junipers and red cedars make their presence evident by giving a yellow tinge to the boughs which bear them, but they are so tiny and so hidden among the leaves that one wonders how even the wind is able to find them out.

By time these humble flowers are prepared to

give their pollen to the breezes the pistillate blossoms are ready to turn it to good account.

The staminal leaf is a rudimentary affair, but its affinity is, if possible, more rudimentary still. In the heart of a freshly-opened pea-blossom there is already an extremely small, but perfectly formed, pod. Suppose we pluck away from the pea-flower its calyx, corolla, and stamens, till nothing but this tiny pod is left. Now if we split it we shall find within it a number of minute peas. If we pick off all these except two, the remnant, a naked and opened pod with two peas, will be equivalent to the "carpel" of most native cone-bearers.

The young cone is a community of carpels, each having its pair of attached ovules, and all arranged spirally about a woody axis. The very young "berry" of a red cedar or a juniper is a close ring of carpels enclosing a few ovules. And in both these cases the entire cluster is regarded as a single pistillate flower.

The ovule of the yew lives alone and is a "pistillate flower" all by itself. It is partly enveloped by small scales, and a little ring-shaped disk closely invests its base.

Among the red cedars, junipers, and yews some individuals bear pistillate flowers only, while others

290 Field, Forest, and Wayside Flowers

devote all their energies to the production of staminal leaves and pollen. But all other native evergreens produce both sorts of flower on the same tree, and they may frequently be seen on the self-same branch.

The ovule of a flower akin to the lily or the rose generally wears two coats. But the ovule of a cone-bearer has but a single coat, and at one point it presents a naked surface to the pollen.

Because their ovules are not enclosed in pistils the cone-bearers and their kin are known to systematic botany as "gymnosperms" (naked seeds). They are a last link in the chain which connects the flowerless and the flowering plants.

Naturalists assign the highest rank among flowerless plants to the club-mosses, and the selaginellas their nearest of kin.

Two sorts of selaginella are cultivated under the name of "lycopodium," and may be seen draping the stages in greenhouses, or making a moss-like mat all over the floor in florists' windows. These plants bear spores of two sorts and sizes, which ripen at about the same time, and fall to the ground together (Fig. 82). Then the substance contained in each of the smaller spores develops into a tiny "male" prothallus, consisting of one

vegetative cell, and beside it, a little chamber full of spermatozoids. And in the larger spore meantime there is formed a "female" prothallus, which soon grows big enough to rupture the spore-wall and protrudes through the fissure it has made.

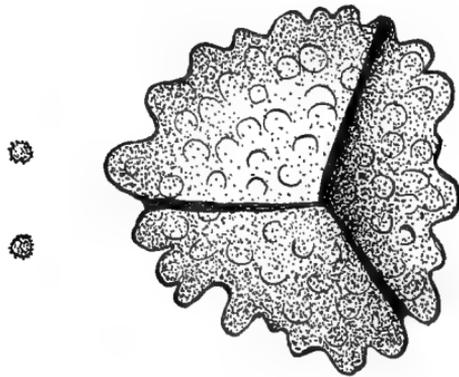


FIG. 82.—A larger ("macro") and two smaller ("micro") spores of *Selaginella martensii* (the *Lycopodium stoloniferum* of florists). All magnified alike to show actual comparative size.

In this protruding part, archegonia, like those of the fern-prothallus, are formed, and at about the same time the spermatozoids in the smaller spore are ready to seek their affinities, and the spore-wall bursts, setting them free. They are provided with little cilia, which quiver and vibrate like the cilia on the fern-spermatozoid, and by means of these they swim actively over the dewy- or rain-soaked ground, till they find the larger spore and in it the archegonium they have been seeking.

So the prothalli of the selaginella are male and female, and they spend their brief lives attached to their respective spores, and almost completely enclosed by them.

The gymnosperm represents the next phase of plant-history. For the sturdy pine-tree, like the little moss-like selaginella, has two prothallus parents, both tiny and short-lived. The selaginella prothallus which lives in the smaller or "micro"-spore is minute, though the one which develops in the larger or "macro"-spore comes a little way out into the world, and in some species grows large enough to be seen with a pocket-lens. But neither of the prothallus parents of the pine can be seen without the aid of a high-power microscope, and they never leave the spores in which their lives begin.

The larger or female prothallus is completely enclosed by the macrospore, and the macrospore is developed inside the ovule, and stays there during its entire life. This prothallus is only a little mass of cell-tissue, almost colorless, because it lives in the dark. After it has "got its growth" tiny archegonia are formed in it, and these stand in such a position that their flask-mouths open toward that spot in the ovule which is not

covered by the seed-coat. From three to five of these little flasks are prepared for pollen in each of the pine-ovules.

At the season when the winds are freighted with the pollen of the cone-bearers the scales of the pistillate flower draw apart, so that the precious dust can slip down between them to the ovule. And just at this stage of affairs a tiny drop of fluid exudes from the opening in the ovule's coat. The golden grains brought by the breezes are caught and held in this, and as the fluid evaporates, or is absorbed, they are gradually drawn down to the ovule's surface.

The ripe pollen-grain of the pine is not a mere bag of jelly, as is the pollen-grain of the crocus. It has two compartments or "cells" like the smaller spore of the selaginella. One of these is merely vegetative, and one, a little later, develops into the pollen-tube. The tube put forth by the crocus pollen-grain contains one globule of vitalizing protoplasm, the "generative cell." But the perfected pollen-tube of the pine contains two generative cells.

The tube penetrates the tissue of the ovule for a very short distance, and then there is a pause, while the little archegonia down below are coming

to maturity. After this interval of rest, the tube makes its way to the macrospore, pierces its delicate wall, and enters the neck of an archegonium. Here it finds a little globule of protoplasm, similar to that which is contained by the archegonium of a fern. One of the generative cells from the pollen-tube fuses with this globule, and after their union is complete creative life begins to mould their combined substance into a little cone-bearer.

The second "generative cell" of the pine-pollen seems to be a mere understudy. It comes down the pollen-tube into the ovule, but the most recent investigators agree that it does not enter an archegonium, and that, after a brief interval it melts away, as it were, and disappears. It may be a reminiscence of a now obsolete method of fertilization practiced by the pine's ancestors.

Fern, selaginella, pine, and rose seem to represent successive stages in the dwindling of the prothallus. That of the fern is a perfect plant, with green leafy surface and serviceable root-hairs. It comes out into the great world, supports itself independently there, and reaches, sometimes, the ripe age of two years. That of the selaginella is minute, and spends its brief life almost encompassed by the spore. That of the pine is highly

microscopic, and never leaves the spore, but continues utterly dependent upon the parent-tree so long as it lives. And careful investigation and comparison show in the highest flowering plants the last vestiges of the prothallus, here almost obliterated, but still distinct enough to show the far-off kinship of fern and rose.

A few years ago naturalists believed that the ovule of the flowering plants was quickened by union with a globule of protoplasm from the pollen-tube, while the female cell of the higher flowerless plant developed at the vitalizing contact of a spermatozoid, and that here lay the great difference between the patricians and the plebeians of the vegetable world.

But recently Mr. Herbert Webber has studied the whole process of fertilization in a subtropical gymnosperm, the coontie or arrow-root of southern Florida (*Zamia integrifolia*).

His investigation has proved that the kinship between the flowering and the flowerless plants is far closer than has been hitherto supposed. For what goes down through the pollen-tube of the coontie-blossom is not a mere globule of jelly, as in the crocus, or two globules of jelly, as in the pine, but two peg-top-shaped spermatozoids,

a-quiver with cilia, and spinning around as if instinct with conscious life. And two Japanese botanists have found spermatozoids in the pollen-tubes of two other cousins of the pines, the graceful cycad and the gingko-tree.

Once it was thought that a great gulf was fixed between the flowerless and the flowering plants. But further study has shown that this gulf is bridged, and that the two piers which support the bridge are the Lycopodineæ (club-mosses and selaginellas) and the gymnosperms.

After the pollen of a cone-bearer has found its way to the ovule the carpels close over and protect the developing seed. Those of the red cedars and junipers become succulent, and unite so as to form a globe with the seed inside. Those of the pine, spruce, hemlock, fir, and larch alter still more. The ovule of any of these trees is fastened to a little protruding disk in the carpel-wall (Fig. 83). After the ovule has been quickened this disk begins to develop surprisingly on its own account. It expands at top and sides, and soon completely outgrows the carpel to which it was once but an humble annex. So the carpel eventually loses its individuality and becomes two scales. The uppermost of these is the developed

disk which has the seeds attached to it, and hence is called the "semeniferous," or seed-bearing, scale. The outstripped remainder of the carpel forms a "bract-scale," and both become woody and, in many cones, are glued together with resin.

The ovule of the yew has no carpel, but after the vitalizing touch of the pollen upon it the ring-shaped disk about its base begins to grow, and forms a cup around the developing seed.

Though three or four of its little archegonia may have been fertilized, the seed of a native gymnosperm contains but one baby-tree. All the others were supplanted by the growth of this one, which has become sole heir, and will take to itself all the nourishment in the ripe seed. This inheritance is no mean one.

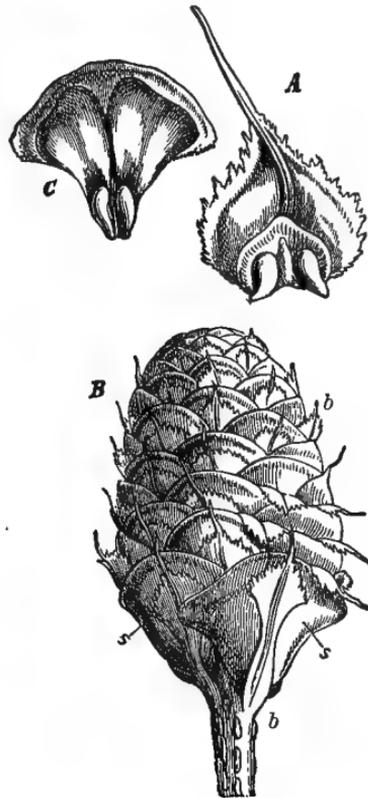


FIG. 83.—Common silver fir (*Abies pectinata*).

A, A young carpel, showing the protruding disk and the two ovules; B, a part of a mature cone showing the seed-bearing scales (s) and the bract scales (b); C, a ripe seed-bearing scale with the winged seeds. (After Sachs.)

298 Field, Forest, and Wayside Flowers

It has been laid away in the prothallus, whose cells are packed full of food for its nursling—albumen, starches, and fats.

And now the seed which has been so well guarded and nourished during its immaturity is to be sent out to get its own living. The red cedars, junipers, and yews employ the birds as sowers. When the cedar- and juniper-seeds are ripe the succulent globes which enclose them become purple, and show vividly against the sombre green of the boughs. At the season when there is little provender in the snow-clad fields these pretty berries tempt the birds, which devour them, and scatter their seeds broadcast. The fleshy cup which has grown up about the yew-seed becomes juicy and soft and turns bright-red. But though this cup is "pleasant to the eye and good for food," from a bird's point of view, the seed contained in it is poisonous. Instinct warns the birds of this, and after they have devoured the juicy cups they spit up the seeds, perhaps in a place far from the tree whence they were gathered.

The other cone bearers (with the exception of the "bald"-cypress) send their offspring away by their tried old messenger, the wind. The ripe seeds are winged, and when they are ready to

travel the cone-scales, which have hitherto been pressed together, draw apart, setting their wards free. The scales of the firs drop away altogether, leaving nothing of the cone but a woody axis.

The cones of the hemlocks, pines, and spruces gradually assume a pendant position while they are maturing, so that when their scales separate the ripe seeds are at once given to the winds. Thus the cone-bearers, like good parents, do their utmost "in protection of their tender ones."

But alas! In the vegetable world, no less than in the worlds of mice and men, the best-laid schemes "gang aft alee."

For often, in latter summer, one may see a squirrel perched upon a pine-branch, holding a nearly-ripe cone between his fore-paws. With attitudes and actions like those of a little monkey he tears away the scales and flings them earthward, and meantime he feasts eagerly upon the seeds whose stores of nutriment were prepared and laid away with no foreboding of his sharp claws and nibbling teeth thrust impertinently between Nature's plans and their fulfilment.

CHAPTER XIII

DOGBANE AND MILKWEED

“They lay wait as he that setteth snares.”

—*Jeremiah* v. 26.

THE story of the trap-setting and insect-eating plants is a more than twice-told tale. The pitcher-plant, which beguiles the hapless fly to his drowning in its vase-shaped leaves, baited on the outside with nectar-bearing glands, and filled with water; the Venus's fly-trap, which shuts up on him and crushes him; the sundew (*Drosera*), which chokes him in a sticky secretion, are all known, at least by pictures and descriptions, to the tyro in botanic study. And we have learned that they all have good and sufficient reasons for thus dealing with the hapless flies. For, as Darwin has pointed out, these plants usually grow rooted in moss, or in very sandy and barren soil. Insect-eating leaves are probably a device to supply the plant with nitrogen by means of the foliage, in circumstances where the roots prove powerless for the purpose.



FIG. 84.—Spreading dogbane (*Apocynum androsaemifolium*).

The insect slaughter which they carry on has the same excuse as the animal slaughter of the abattoir. It is killing for food, and the insects which these plants catch are honestly eaten and digested. But in the infinite analogy of the vegetable world we find what seems a curious parallel to killing for sport. There are a few native flowers which entrap insects simply and solely, it appears, for the deed's own sake. The prisoners serve no apparent use in the plant's economy, nor do their poor little corpses nourish the plant's life. A botanist who let his imagination run away with him might accuse the guileless-looking flowers of that savage joy in another creature's pain which drew our forefathers in crowds to the badger-drawings and bear-baitings of bygone times.

One of these flower tormentors is the spreading dogbane (*Apocynum androsæmifolium*) (Fig. 84), which is common all summer, along shady roadsides and around the borders of thickets, in the Northern and Eastern states. The plant is about three feet high, erect and branching. The flowers are nearly as large as single blossoms of the lily of the valley, and when closely examined are seen to be very beautiful.

The corolla is bell-shaped, and cleft at the edge

into five slender points. Its deep pink-veining suggests nectar, and the insect visitor is not disappointed, for at its base are five nectar-bearing glands. These stand in a ring around the pistil, and in a larger circle, outside the ring of honey-glands, are the five stamens. The anthers stand erect, and in shape are like arrow- or spear-heads (Fig. 85). Corresponding to the two points at the base of a spear-head there are, at the base of each anther, two little hard horns, and the stamens ring so closely about the pistil that horn is beside horn all around the circle.

On the inside of the corolla, near its base, are five triangular callosities, with their points up. These are placed in such a way as to alternate, with the stamens, and stand a little below them, so that the two hard points at the bases of two neighboring anthers, and the hard tip of the callosity—three little horns—come together like the teeth of a trap. There are no fewer than five places inside the flower's cup where these traps are set, and inside the circle of traps are the glands which contain nectar (Fig. 85).

The blossom is visited by bees and flies, but its favorite guests, says Müller, are butterflies. It cements its pollen to their tongues, and thus com-

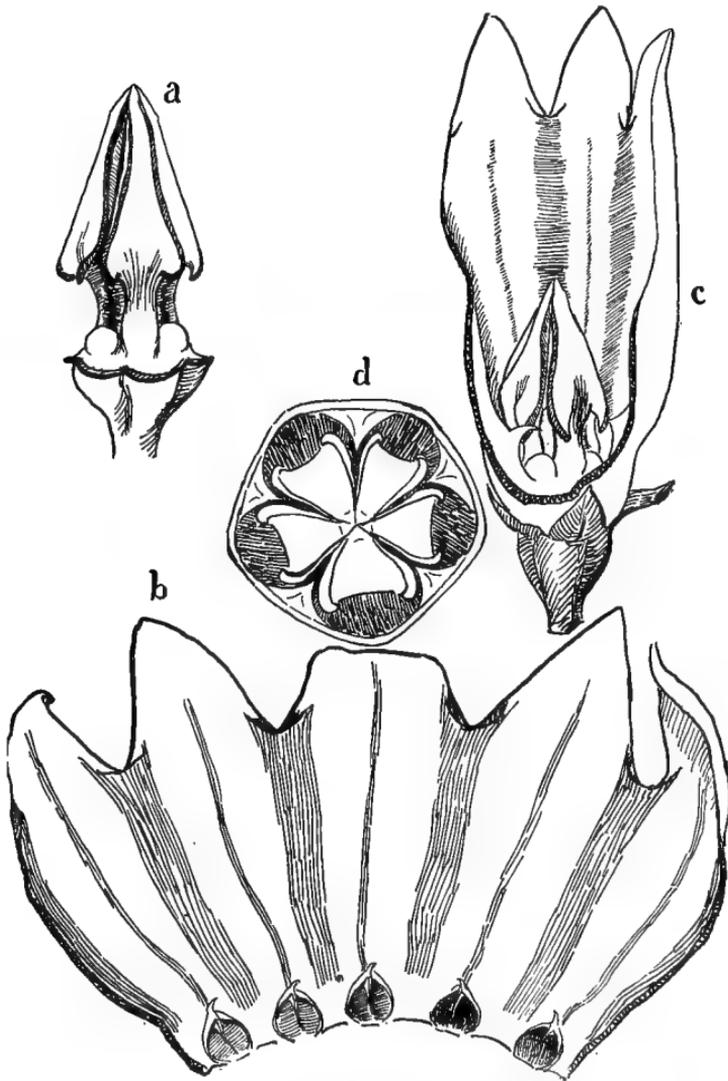


FIG. 85.—Trap of the spreading dogbane.

a, the flower with its calyx and corolla removed, showing the stamens and honey-glands; *b*, the opened corolla, showing the callosities; *c*, a trap seen from the side; *d*, the circle of traps, seen from above.

pels them to carry it away with them to other dogbane flowers.

The fly-caller seems unable to sip the nectar except by running his proboscis in between the long anthers, and just above the horny excrescences on the corolla. When he attempts to withdraw, after drinking his fill, the three points lock together, like the jaws of a trap, holding the tip of his proboscis in durance vile. If the winged captive is big and strong, he gets free with a long and a vigorous pull. But small flies are often held prisoners till they die, probably from starvation. Sometimes one may see three or four of these hapless victims on one full-blooming plant of spreading dogbane.

Among the prisoners one may often see a little summer-fly of dudish aspect, with body ringed with alternate bands of bronze and gold and wings of gauze shot with opaline colors. To what end is this bright little fellow sacrificed? Held as he is by the tip of his proboscis, his body does not come into contact with the plant, and hence it cannot be digested by the vegetable juices, as are the corpses of the sundew's victims. The only possible justification the dogbane can furnish for his taking off is that he has trespassed upon the



FIG. 86.—Common milkweed (*Asclepias cornuti*).

butterfly's preserves. For this intrusion he is dealt with as severely as poachers were under the forest-laws of feudal England.

There is another variety of dogbane, the Indian-hemp, or *Apocynum cannabinum*, which bears smaller blossoms than the *androsæmifolium*, blooms somewhat later, and is more widely distributed over the country. This flower has no callosities in its corolla, sets no snares for insect victims, and is apparently quite innocent of the crimes which one is inclined to lay to the charge of its first cousin.

The common milkweed (*Asclepias cornuti*) (Fig. 86) also imprisons insects, which sometimes die in captivity, and do no apparent good to the plant by their deaths. They have, however, invited misfortune, for though the milkweed is rich in honey and is visited by a large and miscellaneous company, it can be fertilized, apparently only by bees, and perhaps by a few large flies.

The milkweed is a peculiarly-constructed and very highly-organized flower. The sepals and the petals, each five in number, fold back as soon as the flower opens and press closely against the flower-stalk (Fig. 87, *a*). Inside them, standing upright in a ring, are five honey-jars or nectaries

of peculiar form (Fig. 87). Each nectary is hooded, and inside each is an incurved horn (Fig. 87, *b*). Within the circle of honey-jars are the five stamens, which are fixed to the base of the corolla, and stand in contact with each other, sur-

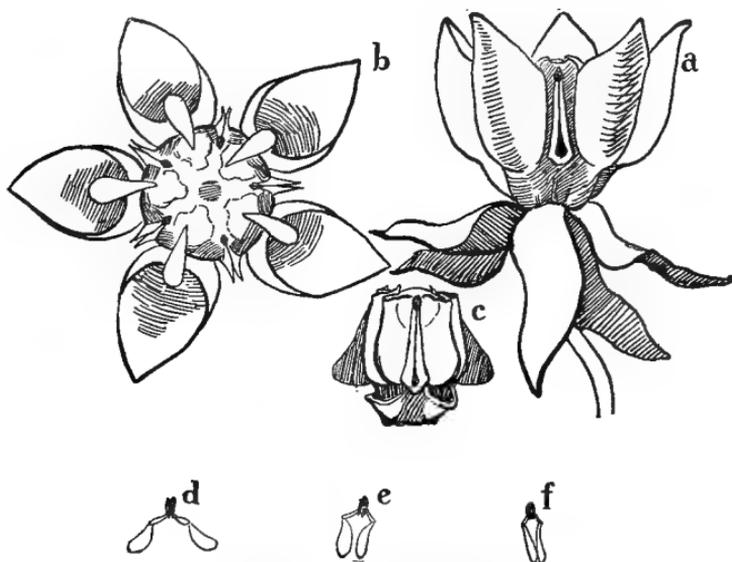


FIG. 87.—Trap of the milkweed

a, single blossom seen from the side, showing the corolla turned backward and the ring of upright nectaries; *b*, single blossom seen from above; *c*, the stamen ring, showing one of the openings between the stamens, and the disk at its upper end; *d*, a freshly removed disk, with its attached pollen masses; *e* and *f*, positions taken by the drying pollen masses as they are carried through the air by insects.

rounding and enclosing the pistil (Fig. 87, *c*). On top of the ring of stamens is a large five-sided disk, which keeps the pollen from being wet with rain or dew. The whole stamen system is like a little tub or firkin, standing in the midst of the

flower, upside down. Inside this firkin are two green pistils, which may become two green pods. Half the pollen of each anther is collected into a nine-pin-shaped mass, which is fastened to a similar mass formed by half the pollen of the next anther. Thus two connected pollen-masses belong to two separate stamens.

They are united by a tiny black disk, which is seen, on closer examination to be thin, hard, and horny (Fig. 87, *d*). "Its sides are bent forward for its whole length," says Müller, "so that their edges lie close together, and in the middle of its lower border is a wedge-shaped notch." The disk is set just above an opening between the stamens which runs "clear through" to the pistils inside the firkin. This opening is a mere slit at its widest part, but it is distinctly narrower at its upper end. The fly or bee stands on the outside of the firkin, and slips and slides on the smooth surface till one of her feet enters the lower and wider end of one of the slits.

The winged captive draws her leg upward in the effort to escape, and her foot catches in the notch on the lower side of the little black disk. Then, determined to be free, she pulls out, if she is strong enough, the whole affair, disk and attached

312 Field, Forest, and Wayside Flowers

pollen-masses. A bee will gather several of these at once, and I have seen one buzzing away from a head of milkweed loaded with no fewer than nine. Thus encumbered she was for a moment held prisoner by the flower, unable to pull herself loose. Following the ancient custom of the bees, she carried the pollen-masses at once to another milkweed plant, and perched upon one of its flowers, in the same position in which she had stood when visiting the first. This brought some of the pollen-masses on her feet exactly opposite the slits running through the stamen-ring to the pistil.

The pollen-masses, when they are first extracted, stand wide apart. But as the insect flies through the air with them they dry somewhat, and in drying they droop so close together that they can both be introduced into the lower and wider part of the stamen-slit of another flower (Figs. 87, *e* and *f*). When the insect literally tears itself away from this second flower it snaps the cords which binds the pollen-masses to the little black disk. The disk still clings to the insect's foot as a souvenir of its visit to the first milkweed blossom, but the pollen-masses are left behind pressed close to the little green pistils of milkweed blossom number two.

The bee seems the favorite guest of the milkweed. The pollen-masses come out at once to her tread, and are carried directly to the pistil of another flower.

Wasps visit the milkweed for its honey, but I have never seen them withdraw the pollen-masses. Flies seldom do, though the flower is visited by flies of many species. Indeed, it is a general favorite, standing in the midst of a winged throng till dark, for twilight brings to it a number of small, sad-colored moths with very long proboscides.

But not all these visitors are permitted to go in peace. A small fly with his legs stuck to the black disks is frequently unable to pull himself loose after he has drunk his fill.

In a bunch of twenty-five blossoms I have counted five flies thus held in captivity—three dead and two dying—and the same bunch had captured a long-legged, lace-winged caperer, whose struggles to free himself were as desperate as futile. On any large bunch of these flowers one can see mementoes of past tribulations. Here and there a blossom still holds a little black leg, the price of the liberty of some insect who has gone off free, but a cripple.

A flower so highly organized as the milkweed

314 Field, Forest, and Wayside Flowers

seldom receives and nourishes all comers. In one peculiarity of structure the milkweeds are like the orchids, that royal family of plants, for many orchids also send their pollen abroad massed into two clusters, which are united by a disk. But each orchid has its own very select and small circle of guests, and some among them endeavor to please one butterfly or moth friend, him and him alone. They are, in evolutionary language, "highly specialized."

On the other hand, a flower which keeps open house to all comers is generally primitive in color and structure. Such blossoms are apt to be yellow or white, with flat, open corollas, and without spurs, honey-jars, or covering to protect the pollen. So the milkweed is something of a problem to the evolutionary botanist.

And there is another puzzle for him in the inadequacy of Nature's very elaborate contrivances to ensure the fertilization of the milkweed. Flowers far simpler in structure and far less attractive to insects bring a larger proportionate number of fruits to perfection.

The great blossom-clusters which crown the milkweed in July and August are made up of from twenty-five to fifty flowers. But in September the

same stalk will support only from two to six seed-pods, and a pair of pods represents a single flower.

So most of the flowers die leaving no memorial behind them, and the flies which they have victimized are avenged.

In the language of some elegiac poetry we pause to breathe a sigh over the fate of the hapless flies which, like Haman of old, come to a feast and thereat are captured and slain.

However, these unfortunates are but a small proportion of the milkweed's fly visitors. The great majority make off, after taking their fill of nectar, without carrying away any portion of the pollen which the flower is endeavoring to send to its neighbors. This waste of nectar is bad for the milkweed, which would be better off with fewer fly visitors. So the flower would profit by any



FIG. 88.—A dogbane flower and its captive.

device which would dis-

316 Field, Forest, and Wayside Flowers

courage these many flies, without deterring those useful and desired visitors, the bees. Will flies learn after a while to shun the milkweed's dangerous sweets, so that they may all be left for worthier and more welcome guests? And how many generations will it take this proverbially foolish insect to lay the lesson to heart? (Fig. 88).

CHAPTER XIV

THISTLES AND NETTLES

"And the thorns which make us think
Of the thornless river brink
Where the ransomed tread."

—*Mrs. Browning.*

THE Book of Genesis teaches that thorns and thistles grew out of the cursed ground, in punishment for our first parents' sin. Modern science, harmonizing with ancient theology, holds that thistles and nettles, as we know them to-day, are younger children in the great family of plants. They are "highly specialized."

The larger thistles are suited in color and structure to the tastes and needs of the bumble-bees, which are among the latest born of insects. The nettles employ the wind as their pollen-carrier, and are wondrously adapted to make the best use of this capricious servant, which outdoes the most exacting of trades unions in its determination to "lay off" when it pleases and to regulate its own holidays and the length of its working-day. And



FIG. 89.—Nettle and Canada thistle (*Urtica dioica* and *Cnicus arvensis*).

both thistles and nettles are guarded, with Nature's utmost care, against pollen-thieves and grazing foes.

Both have juicy stalks, and leaves toothsome to vegetarian rovers. Both grow in uncultivated fields, along roadsides, and in waste open spots where grass is scarce, and where hungry cows and holiday-keeping horses are wont to wander, seeking what they may devour.

The thistle is saved from those who would eat it up by a bristling armor of prickles, dismaying to all animals except the donkey. That proverbially determined quadruped will not be turned from his gastronomic purpose by little things like these. Indeed, he seems to relish them as a pungent addition, giving zest to his repast, much as cayenne pepper and Chili sauce improve the dinner of the human gourmet. But to most animals the prickles of the thistle and the stings of the nettle are hurtful and repellent. "Weeds or shrubs with juicy, tender leaves," says Grant Allen, "are very apt to be eaten down by rabbits, cows, and other wandering herbivores. But if any individuals among such plants develop any peculiarities which prevent animals from browsing upon them, then those particular plants will be spared, while their neighbors are eaten. They will live

to produce offspring inheriting the habits of their parents, and of these offspring the more tender and defenceless will be eaten, while the thorniest, stringiest, or bitterest individuals will be spared, to produce offspring thorny, stringy, and bitter, like themselves. So, in the course of generations, Nature brings into being a number of plant-families, each protected from browsing animals by some well-marked peculiarity."

The common mullein, a plant of the roadsides and pastures, is rendered unappetizing by the down which covers its leaves, and which, it seems, is doubly useful. For "hairs," says Vines, "often serve to diminish transpiration and radiation, and to screen chlorophyll from too intense light, and a clothing of hairs is characteristic of plants which habitually grow in dry soils and in sunny situations." But in this case the fuzz which clothes the mullein-leaves makes them as "dry eating" as so much flannel.

The great cool leaves of the burdock are bitter and sour exceedingly (Fig. 90). So efficient are these devices of Nature for the protection of thistles, mullein, and burdock, that they are generally spared, even in close-cropped pastures. The dandelion and wild lettuce-leaves contain a bitter juice.



FIG. 90.—Burdock (*Arctium Lappa*).

In the hawthorne, the locust, and the wild orange-tree some of the lower branches develop into sharp spines which prick the noses of would-be assailants.

In the bramble those hairs which clothe the stem of most plants have thickened into pointed prickles. In the holly the angles of the leaves have grown into needle-like points, which deter animals from browsing upon them, and it is noticeable that when the holly develops into a tree its foliage, carried up into comparative safety, becomes almost smooth.

On the Irish gorse, a native of commons where cattle wander, and of mountain-slopes where half-starved sheep run wild, all the leaves are thorns. The green color of these thorns shows that they contain chlorophyll, and they fulfill the office of the foliage, which they have entirely supplanted. The whole gorse-bush, from its root to its crown of honey-sweet golden flowers, is one bristling defiance.

The teasel (Fig. 91) is evolving its armor, which is already disconcerting to a browsing vegetarian, and which may become positively deterrent in times to come. Its leaves are supported by strong, mid-ribs, each of which bristles all down its length, with saw-teeth. The side-veins are studded with smaller teeth, and, while the lower sides of the leaves are



FIG. 92.—Common wild teasel (*Dipsacus sylvestris*).

thus effectually protected, their upper sides are not always left unguarded. About one teasel in three has its upper leaf-surfaces dotted over with prickles, not very sharp to the fingers, but probably well able to hurt the lips and tongue of a browsing animal, and these prickles, by the bye, are interesting to the botanist, because they grow out of the leaf-surface, and not, after the usual habit of prickles, from the veins. A hungry rabbit, feeding among the teasels, would be likely to satisfy his appetite with those leaves having their upper surfaces soft and smooth, and to spare the more bristly individuals. So these well-guarded plants survive to set their seed, and become progenitors of young plants, which will inherit the parental habit of bearing leaves with prickles on both surfaces.

The botanist draws a distinction between a prickle and a thorn. A prickle can be removed with ease from the stem or leaf on which it grows. It is not incorporated with the wood, but merely, and often very lightly, attached to the bark or to the surface or edge of the leaf.

A thorn is, on the contrary, a fixture. The woody fibre of the plant runs up into it, and it cannot be detached without considerable difficulty.

The gorse (Fig. 92), the hawthorne, and the orange-tree are guarded by thorns indeed. But the so-called "thorns" which mar our delight in the queen of flowers are in reality prickles, and so are the natural defences of the blackberry and the thistle.

Further south, where life teems, under a semi-tropic sun, and the struggle for existence is keen in proportion to the number of the organisms engaged in it, many plants are provided with defensive and even offensive weapons, which make them formidable to all who venture too near. The cactus, for instance, is a succulent plant, growing on sandy plains, glaring rocks, or shining beaches, where such juicy stalks would be peculiarly grateful to parched throats; and it is dotted all over its surface with dense clusters of small but very penetrating and poisonous prickles. The pineapple, another refreshing thing native to thirsty lands, has foliage like the cheval-de-frieze of mediæval warfare. The fruit "sits," as its southern cultivators might say, in the midst of a ring of erect sword-shaped leaves, every one of which is bordered, for its entire length, along both edges, with sharp thorns. The pineapple gatherers are obliged to work in leathern boots reaching to their hips, and



FIG 92.—Irish gorse, furze, or whin
(*Ulex Europæus*).

without this defence the toothed leaves would rend clothing to ribbons, and cruelly tear the flesh beneath. In the saw-palmetto of the Florida "flat-woods," every leaf-stem is protected on both sides with curving points like the teeth of a saw.

The stings of our nettles are decidedly unpleasant, but they are not to be compared for a moment to the sufferings which can be inflicted by some tropical species. Listen, for instance, to De La Tour's experiences with an East Indian nettle. "One of the leaves," he says, "slightly touched my hand. At the time I experienced a slight pricking. The pain increased. In an hour it had become intolerable, as if some one was rubbing my hand with a red-hot iron. The pain spread rapidly along my arm as far as the armpit. I did not finally lose the pain for nine days."

Even our comparatively innocent nettle has one of the most highly developed of all the devices by which familiar plants guard themselves against the attacks of animals. Its sting is a tiny hollow cone, with the point upward. At the base of this are a number of cells filled with an irritating fluid containing formic acid, the same poison which gives virulence to the bites of the ant and the spider. And at the tip of the cone is a small round disk

330 Field, Forest, and Wayside Flowers

set on slantwise. When the sharp point of the cone is touched, however gently, it pierces the skin. Then the disk breaks off, and the poison which is in the cells at the base of the sting is pressed up through the hollow cone and into the wound. If a browsing cow thrusts her tender nostrils into a nettle-clump the points pierce her skin, the poison enters her veins, and she receives a sharp warning to let nettles alone in future.

We have several varieties of nettle, all immigrants from the old world. ^{Plants survive to Sitka, Alaska} Their flowers are modest little green affairs, so inconspicuous that most people do not believe nettles ever bloom at all. These tiny blossoms are borne on short branched spikes, which grow out almost at right angles to the leaf-stalks, and are often half hidden by the leaves. Each spike is made up of separate green blossoms, with four tiny flower-leaves apiece.

Some of the wee flowers bear stamens only, some bear pistils only, and, as a rule, both sorts of flower grow on one plant, though not unfrequently we come across a nettle whose blossoms are all of one kind. The stamen-heads explode when the bud expands, scattering the pollen, which is borne from flower to flower, or from plant to plant, by the wind. As the nettles have hence no need

to attract insects, the little blossoms have no petals whatever, only four small greenish sepals.

The florets which bear stamens only have in their midst a little green affair which is the reminiscence of a pistil. But the pistil now in use has a whole flower to itself, and is surrounded by two pairs of sepals (Fig. 93), the outer couple small



FIG. 93.—Single blossoms of the nettle.

a, Staminate flower just expanding; *b*, fully opened staminate flower; *c*, pistillate flower.

and spreading, the inner broader and upright. At the tip of the pistil there is a scattered tuft of hairs, to catch any chance pollen blowing by.

The nettle is connected with much wonder-lore, folk-lore, and tradition. Moreover, the family in times gone by has been not only famous, but useful. Its name is derived from the passive participle of a verb common to most Indo-European lan-

332 Field, Forest, and Wayside Flowers

guages which means "to sew." Closely allied words are "needle," "net," and "knit." Nettle would seem to mean "that with which we sew," and indicates that this plant supplied the thread used in former times by the German and Scandinavian nations. "We know this to have been a fact," says Moncure D. Conway, "in the Scotland of the last century. Scotch cloth is only the housewifery of the nettle; and a fabric made from the fibres of the plant was also used till a recent period in Friesland." Flax and hemp bear southern names, and when they were brought into the north of Europe the nettle's career of usefulness was ended. Like handicraftsmen on the introduction of machinery, it was thrown out of honorable employment. Then it became a vagabond and took to roadsides and wastes. Nettles are said to have been introduced into England by Roman soldiers who sowed the seed in Kent for their own use "to rubbe and chafe their limbs when through extreme cold they should be stiffe and benumbed," having been told that the climate of Britain was so cold that it was not to be endured without some friction to warm their blood.

We are all familiar with the oft-quoted lines:
"Tender-handed stroke a nettle and it stings you

for your pains," etc. They were written by Aaron Hill on a window in Scotland. Their thought is more tersely expressed in the old Devonshire saying: "He that handles a nettle tenderly is soonest stung," meaning that politeness is wasted on some people. For the physical sting of the vegetable nettle the dock-leaf is a remedy, whence the old adage, "Nettle out, dock in, dock remove the nettle sting." In old-folk medicine nettle-tea was a remedy for nettle-rash, a kind of foreshadowing of the coming doctrine that "*similia similibus curantur.*" Carried about on the person, the nettle was supposed to drive away fear, and on this account it was frequently worn in time of danger. "In the Tyrol, during a thunder-storm," says Thistle-ton Dyer, "the mountaineers throw nettles on the fire to protect themselves from lightning, and the same safeguard is practised in Italy." Well might this be a potent weed, for it is own cousin to the famous and fatal upas tree of Eastern story.

The thistle, companion of the nettle in vagabondage and in public execration (Fig. 94), is likewise deserving of a better fate and of a higher place in popular estimation. For it has been renowned in legend and wonder-lore, and has moreover played no mean part in authentic history.

334 Field, Forest, and Wayside Flowers

The old world knew it as a potent herb in charm-working and in folk-medicine. It was famed in the heraldry of the Middle Ages. And modern science recognizes it as one of the most highly organized of wild flowers, wondrously fitted to fight its own battles and to make friends for itself in the insect world.

Long, long ago the thistle was sacred to Thor, the Norse god of war and thunder. It must be gathered in silence, and its blossom was supposed to be colored by the lightning from which it defended. In English folk-medicine the weed continues to play a creditable part.

The blessed thistle is so called because it was an antidote to venom. The melancholy thistle, a recently arrived immigrant from the Old World, was a sure cure for that vague but distressful malady, "the blues." In rural England the thistle was—perhaps it still is—used in love divination. "When anxious to ascertain who loved her most," says Thistleton Dyer, "a young woman would take three or four heads of thistles, cut off their points, and assign to each thistle the name of an admirer, laying them under her pillow. On the following morning the thistle which has put forth a fresh sprout will denote the man who loves her most.



FIG. 94.—Common thistle (*Cnicus lanceolatus*).

As the geese once saved Rome, so the thistle saved Great Britain, by causing a midnight alarm and scaring off a midnight foe. A thousand years ago the inhabitants of England and Scotland were much harassed by the Danes, who sailed far up the rivers in flat-bottomed boats, attacked the villages, destroyed the crops, seized the movables, drove off the cattle, and were back in their boats and away before the astonished British could collect their thoughts and their forces, and punish the marauders as they deserved. But sea-robbers as the Danes were, they had a code of honor which forbade them to attack a sleeping foe. On one occasion, however, they were false to this tradition, and landed on the shores of a Scottish river in moonlight and silence, intending to surprise a sleeping village. But as they crept stealthily upon this evil errand one of them trod, with naked foot, upon a thistle. He very naturally cried out, and his clamor wakened the villagers, who flew to arms, and drove the sea-robbers away. Thereafter the thistle was honored in Scotland as the goose was in Rome. It was adopted as the national flower. It blooms with the rose of England and the shamrock of Ireland in the floral emblem of Great Britain, and many noble Scottish families

338 Field, Forest, and Wayside Flowers

have portrayed this wayside weed on their escutcheons.

The thistle is a member of the great composite family and its bloom is a mass of flowers set very close together. They are purple to please the bees, for purple and blue are the colors which those busy little insects love best, and they are rich in nectar. In most sorts the tube of each floret is so long and narrow that crawlers find it difficult to get in after the nectar, and winged insects with short proboscides cannot reach it either. Nature means to save it, if she can, for the butterflies and bees.

But the little Canada thistle has flower-tubes shorter than those of other species, and hence its nectar can be drained by insects of many varieties. The honey rises into the throat of the flower, so as to be accessible even to insects with very short tongues, and hence it is visited by a large number of species. Müller records no fewer than eighty-eight.

The mechanism of the florets is like that in the dandelion. The long anthers are united into a tube, which closely surrounds the pistil, and the pollen is shed into this tube. The pollen-grains are covered with little points, so that they cling together, and the whole mass of them is pushed

out at the top of the anther cylinder by the lengthening of the pistil. The pistil divides, at its tip, into two little arms, which are thickly clothed on their outsides with small pointed hairs. So, when the top of the pistil emerges from the anther-ring it is thickly covered, all over the outer surface, with pollen. In most instances this is soon removed, for the points on the pollen-grains cling to the hairy bodies of visiting insects. A little later the tips of the pistil separate so as to expose the sticky or stigmatic surfaces, and in this position it waits, open-armed, for a pollen-freighted friend.

But if no insects visit the flower the arms of the pistil curve over, as do those of the dandelion, and fertilize themselves with home-made pollen. However, Canada thistles are rarely thus thrown upon their own resources, for they are immensely popular and entertain guests from dawn till dusk. As soon as pollen has reached its stigma, or when it begins to wither, the blossom bends downward and outward. Having had its day and its opportunity, it retires into the background to give a better chance to its younger sisters. The florets of the white clover (Fig. 95) have learned a like habit for the family good, and toward midsummer one may find a white-clover head with a single blossom

standing straight up while all the rest are folded



FIG. 95.—Gathered in latter summer.

back against the stalk. Those which bend downward are fertilized florets enfolding the ripening seed, or unfertilized florets which have begun to wither. The one erect flower is a solitary watcher, still in alert expectation of the hoped-for bee.

The swamp-thistle, with flower-tubes longer than those of its Canadian cousin, has a smaller circle of insect friends, and the common thistle, with still deeper florets, is more exclusive still. But all varieties are forced to receive unbidden guests, for ants dearly love nectar, and they are enterprising, persevering, and

chronically hungry. If they can get into the pur-

ple tubes they will gormandize the sweets there, so that the robbed florets will have no inducement to offer to butterfly or bee, and it is extremely unlikely that an ant will pay for her refreshments by carrying the pollen where it ought to go, to another flower of the same species.

So there has been a warfare, summer after summer, for no one knows how many years, between the ants, which want to get into the purple tubes, and the thistle-plants which want to keep them out.

The devices of the thistle to this end are many and wonderful. Beginning at the ground (as the ant does), we find that the stem of the plant is clothed all the way up with fuzz or hairs. This makes things unpleasant for the crawler, for "nothing," says Sir John Lubbock, "bothers ants like hairs." In some varieties of thistle the stem looks as if it had been wound around and around with spider-webs, and often these are gummy, and likely to catch the crawling insect as it tries to work its way up.

Along the stem, here and there, are leaves. These in many varieties have horny edges which roll backward, making a barrier which the ant finds it very difficult to surmount. The under

sides of these leaves are often thickly clothed with long, cobwebby hairs, nets to snare the little clam-berer and hold her.

A persevering insect which labors to the top of the stem past the deterrent leaves finds herself before an armed body-guard which surrounds the flowers, a close frill of small leaves, often with recurving margins and thickly set with thorns. And in some kinds of thistle a crawler which has worried through all these obstacles meets and succumbs to a still greater difficulty at last. The many flowers which compose the thistle-head grow all together in a deep-green cup. This cup is made up of overlapping scales, and around it, in many varieties of thistle, more cobweb is wound.

In the common swamp- and pasture-thistles (Fig. 96) each scale of the cup has in its centre a whitish streak, which is very glutinous. Here the luckless crawler comes utterly and finally to grief, after all her struggles and in full view of her goal. She is held fast on the gummy streaks, and her frantic struggles to free herself only result in bogging her more hopelessly. The gum after a while stops up the little holes in her sides through which she breathes, and she is thus smothered to death.

Her fate is not only tragic but perplexing—for



FIG. 96.—Pasture-thistles (*Cnicus pumilis*).

here is the higher being sacrificed to the lower, and the more sentient to the less sentient.

One can scarcely think of a plant so fertile in defensive devices as an insensate thing, and is half inclined to fancy that the thistle continues to practice in modern times those savage modes of warfare once used by the Highland chieftains who carried it on their standards.

Nature is full of problems, and one of the most difficult is to reconcile some of its doings with the Divine Law of love. For we know that "the Lord our God is One" in Nature and in Revelation, and that "if Nature is the garment of God it is woven throughout, without seam"; its loveliness, its terror, its tenderness, its seeming cruelty are all parts of one beneficent and majestic whole. Yet Nature seems to us with our imperfect knowledge a blending of irreconcilable things.

The solution of one question is but the suggestion of another, and the ultimate questions remain wrapped in mystery as deep as that which enfolded them when God spake out of the whirlwind and propounded problems which neither Job nor his friends could solve.

Meantime a wood-thrush close by is asking over and over again that wistful question which the

wood thrushes ask each other: a question expressed in a rising cadence, which passes into silence before we can fully enjoy the exquisite timbre of its individual tones.

And after the question has been many times repeated, there comes at last, from far across the sunlit fields, that falling cadence which is the sweet and satisfying answer to it.

Is he prophet as well as poet, this wood-thrush, with his work-a-day brown jacket and spotted vest? After our many questionings will we get our answer too,—altogether satisfying and utterly sweet? The thrush seems appalled at such grave questionings, and flits off to his friends in the tree-tops who have not learned to “look before and after.” And as we see the last flicker of his wings we thank him not only for his song, but also for its suggested parable.

CHAPTER XV

A HANDFUL OF WEEDS

“All the idle weeds that grow
In our sustaining corn.”—*King Lear*.

OLD Noah Webster defines a “weed” as “a useless and troublesome plant,” i.e., a vegetable vagabond, not only idle, but mischievous. However worthless a plant may be from a utilitarian point of view, it is hence not a “weed” till it becomes so thoroughly at home in the land as to harass the gardener and the farmer; so it is merely a question of locality whether a plant is a weed or not. It may be quite without honor in its own country, where even beauty is no excuse for its being, yet under alien skies it may find itself the pet of the horticulturist. The little pink-tipped English daisy, so tenderly reared in New England gardens, is in its own country a troublesome lawn weed, while our homely mullein, that vagabond of the pastures, is—or used to be—cherished in Irish greenhouses under the name of “American flannel-plant.” I have even heard that there are



FIG. 97.—Amaranth and sow-thistle (*Amaranthus retroflexus* and *Sonchus asper*).

places west of the Mississippi where wild-carrot, despised intruder on Eastern lawns, is cosseted and extolled under the appropriate alias of "lace-flower." It is a pity that we, in the Eastern States, have become blind to the beauty of its feathery leaves and its wheels of delicate bloom, which in later August fill every field and roadside with unloved loveliness.

Indeed, all weeds are much in evidence in late summer and autumn. The flowers of most sorts are inconspicuous, but the seeds which follow compel attention by sheer force of numbers and ubiquity. They are here to-day to fight the farmers because they practised, ages ago, what the farmers have learned only within much more recent times.

Nature has taken extraordinary care that the seeds do not drop at the roots of the parent-plant into an exhausted soil. The weeds sow themselves broadcast each autumn. Some are provided with feathery plumes, and thus made so buoyant that the lightest breeze will bear them fast and far. Every autumn gust is freighted with a mixed company of these little flyaways. Thistle, sow-thistle, dandelion, milkweed, and golden-rod seeds all fly on feathery wings, and thus the respective families are kept up, and are spread over the country.

Some weeds lay hold on the passer-by, quadruped or biped, and force him, will he, nill he, to sow their seeds abroad. To bring this result about, the seeds or fruits are barbed, and they claw the unwary traveller and cling to him with exasperating constancy. When the "stickers" are at last picked or rubbed off, they fall to the ground, probably many rods from the spot where they grew, and thus Nature's purpose with regard to them is achieved. This is the way the ragweed travels. The thorny seed-vessels of the cockle-bur and the burdock also obtain free transportation in return for their close attachment to some wayfarer, quadruped or biped. So successful have been these schemes that the weeds which put them into practice have travelled half around the globe. Like an invading army they push further and further on, despite all the resistance of the owners of the soil.

Many, indeed most, of the dooryard weeds come from the Old World, and have already travelled across this continent to the newly-cultivated lands of the far West. Some varieties seem unable to live far from human habitations, and persistently follow us up in the teeth of all opposition. Like the mediæval Highlanders they have become sturdy and resourceful in the stern training-school of con-

tinuous war. We can almost say that the worse nuisance a weed is from the agricultural standpoint, the more highly is it adapted to the conditions of its life, the more is it a triumph of reproductive Nature.

It is common just because it has been able to travel, to endure, to survive, to live down and crowd out a host of things, prettier perhaps, but less able to battle for existence.

Some weeds have timed themselves with wonderful accuracy to the operations of the farmer. That bugbear of English wheat-growers, the scarlet-poppy, has acquired the habit of ripening its seed-vessels at the precise time when the wheat is ready for the sickle.

In our land and latitude, after wheat is reaped, the fields are taken possession of by weeds which regulate their affairs with such nicety that they grow, blow, mature their seed-vessels, and scatter their seed, all between the ingathering of the harvest and the coming of the frost.

“They blow,” we say, for all weeds bear flowers. Most sorts belong to that immense and successful botanical family, the *Compositæ*, which produce a very great number of very minute flowers, often so grouped as to resemble single larger flowers. To

the unbotanical public the most familiar is the daisy. Its yellow centre or disk is an assemblage of little trumpet-shaped blossoms, set as close together as possible. In a ring around this disk we see what botanists call the "ray-flowers," and what non-botanists call the "white leaves" of the daisy. On close examination these will be found to be tiny florets with a pistil apiece, but with no stamens, and with their white corollas split open all down one side. So the daisy, which looks like one flower, is really a close mass of very tiny blossoms. The cockle-bur, ragweed, sneezeweed, burdock, and sow-thistle are all Compositæ. So are the groundsel and the bur-marigold. So is that enemy to the western farmer and darling of the patriotic Scot, the thistle.

Each of the minute flower-clusters which are massed together in a tuft of golden-rod is made up after the daisy pattern, and proves, on examination, to be a head of disk-flowers surrounded by an aureole of ray-flowers. Asters are clearly seen to be arranged on the daisy plan. So is the brown and yellow "cone-flower" or "black-eyed Susan," and so are the sun-shaped things with names beginning with "heli" which run riot over the August landscape, as if earth had grown enam-

ored of the sun and copied his dear image, again and again in her flowers.

But other members of the *Compositæ* family have no outflashing rays, but are made up entirely of trumpet-shaped florets like those in the yellow centre of the daisy. These are called "*Tubulifloræ*," tube-flowers, and in this category the burdock and the thistle are found.

The florets which make up the blossom-heads of the chicory, salsify, dandelion, and sow-thistle are also alike in form and color; but these are all strap-shaped like the white rays on the outside of the daisy.

Those members of the *Compositæ* family which bear such blossom-heads as these are called *Ligulifloræ* "*strap-flowers*."

But each and every one of the strap-shaped florets borne by the sow-thistle and its allies has both stamens and pistil, and all the *Compositæ* of this particular persuasion have a milky juice.

About all the "*dooryard-weeds*," which have followed mankind for ages, there has gathered a wealth of legend, folk-lore, and literary association.

Amaranth (Fig. 97), "*the flower of death*," for instance, is almost as common as death itself. It grows in waste places near towns, and is a

coarse weed, topped with a feathery greenish or purplish plume.

Some species of amaranth are cultivated in old-fashioned gardens, and called "cockscomb," "love-lies-bleeding," and "prince's-feather." The gardener knows and hates another variety under the name of "pigweed." All varieties bear blossoms no bigger around than a hair, and these minute flowers grow in compact clusters, each cluster surrounded by a close circle of chaffy leaves, very slow to wither. The familiar "immortelles," though they are not related to the amaranth, are on the same botanical plan, and their white chaffy leaves (a botanist would call them the involucre) being pretty as well as durable, have brought the little blossoms into general favor. The unwithering amaranth was looked upon by the ancients as the flower of immortality. The phrase in the First Epistle of St. Peter, "a crown of glory that fadeth not away," is in the original, "the amarantine crown of glory." The purple flowers of the amaranth retain their color always, and regain their shape when wetted, and were used by the ancients for winter chaplets. As the flower of immortality amaranth was strewed over the graves of old Greece, and Homer relates that the Thessalonians wore

crowns of it at the burial of Achilles. Wreaths of it are still worn, and are hung over doors and windows by Swiss peasants on Ascension Day. Milton speaks of

“Immortal amaranth, a flower which once
In Paradise, fast by the Tree of Life,
Began to bloom; but soon for man’s offence,
To heaven removed, where first it grew, there grows
And flowers aloft shading the Fount of Life.”

And his angels are

“Crowned with amaranth and gold.”

From being the flower of immortality, amaranth became, by a natural association of ideas, the flower of death. In a beautiful poem by Longfellow, “The Two Angels,” it crowns the brows of Azrael, the Death Angel, while the Angel of Life wears a wreath of asphodels or daffodils, the flowers of life. Because perhaps death is as strong as love, amaranth is an antidote for the love-philtre. Yet who would expect to find the flower hymned of many poets on the coarse crouching weed which invades the bean-patch, or disfigures the gravel-paths once our pride?

When the signal-service was still far in the unknown future country people used to forecast the weather by the doings of some common and familiar plants, which are now superseded by modern science

and are no longer consulted as oracles or revered as prophets. "Chickweed, for instance," says Thistleton Dyer, "expands its leaves fully when fine weather is to follow, but if they are half closed, then the traveller is to put on his great-coat"; and, according to the "Shepherd's Calendar," thistle-down or dandelion-down "whisking about and turning around foreshadows tempestuous winds." "If the down flieth off dandelion and thistles when there is no wind," says another old collection of flower-lore, "it is a sign of rain."

The sow-thistle (*Sonchus oleraceus*) (Fig. 97), though it is an immigrant from the Old World, is already common enough in some sections of the country to fall under the ban of the farmer. In rural England one of its popular names is "hare's-palace," because, according to the "Grete Herbale," "if the hare come under it he is sure that no beast can touch him."

In Italy at Christmas-tide mangers are decorated in honor of the Christ-Child with mosses, branches of cypress and holly, and the yellow flowers of the sow-thistle. Why this dooryard-weed appears in such an honorable situation we cannot tell. Perhaps for the very practical reason that it is one of the few flowers to be found blooming out of doors

in mild December weather. Or perhaps its out-flashing golden petals suggested the sun, and so the rising of the Sun of Righteousness, much as the radiant aspect of some white and golden June flowers, caused them to be associated with Baldur, the Norse god of the summer sunshine.

The plantain or ribwort (*Plantago major*), that persistent intruder upon our lawns, was once highly esteemed as a healer of wounds, and hence, in some parts of England it was known as "wound-weed." One would almost as soon associate legend and fantasy with a cabbage as with this coarse-leaved herb (Fig. 98) whose aspect is matter of fact to the last degree. Yet in rural parts of the Old World it was—perhaps it still is—the favorite midsummer-dream plant. For just one hour on just one day of the year there may be found, beneath its leaves, a rare and magic coal; and with this under the pillow one will learn one's fate in a dream.

"When Aubrey happened to be walking behind Montague House," says Thistleton Dyer, "at twelve o'clock on Midsummer's Day, he saw about twenty young women, all, apparently, very busy weeding. On making inquiries he was told that they were looking for a coal under the root of a



FIG. 98.—“Ribwort” and “ripple-grass.”
a, *Plantago major*; *b*, *Plantago lanceolata*; *c*, young floret magnified; *d*, older floret magnified.

plantain, to put beneath their heads that night, when they would surely dream of their future husbands." Some matter-of-fact person long ago discovered that the "coal" is only a blackened root, which may be found whenever it is looked for.

From long-cherished faith in its potency it has come about perhaps that in the north of England the flower-spikes of the closely allied ripple-grass (*Plantago lanceolata*) were used as love-charms. But no magic which the plantain may have wrought as an inspirer of dreams or fetterer of maiden fancy is more wonderful than the story of its past as told by modern science.

"Our fields are full," says Grant Allen, "of degenerate flowers," and this is one of them. When we look closely at its green spikes we see that they are made up of numerous little four-rayed blossoms, whose pale and faded petals are tucked away out of sight, flat against the calyx. Yet their shape and arrangement distinctly recall the beautiful blue veronica, and it has been surmised that the two are very distant cousins. But the plantain flowers gave up devoting themselves to insects and became adapted for fertilization by the wind instead. Then the petals were no longer needed as a lure, and Nature withdrew their bright blue pig-

360 Field, Forest, and Wayside Flowers

ment, till they became the whitish, papery little affairs we see to-day.

Each plantain blossom has both stamens and pistils, but the pistils mature first. In the commonest varieties they project between the folded petals while the little flowers are still in bud, and are fertilized by pollen blown to them from some neighboring spike. Their feathery tips are wonderfully fitted to catch and hold any stray grains which happen to come their way. After the little plumes of the pistil have withered away, the stamens ripen and dangle out on cobwebby filaments, so as to scatter all their pollen to the four winds.

Let us notice that the lower flowerets of the spike are the first to open; and so if we pick a half-blown spike we find that all the pistils are ripe above while the stamens are ripe below. If the upper flowerets opened first the pollen would fall from their stamens to the lower flowerets of the same spike; but as the pistils below have always been fertilized before the stamens are ripe above, there is no chance of such an accident, and the seeds of each spike are set by aid of pollen brought from another.

So the plantain is wholly adapted to wind fertilization and has lost the bright color which once

upon a time served as a lure to the insects whose services are now dispensed with.

This "degeneration," as it is regarded by naturalists, is a sad result to follow upon untold years spent in our society. For the plantain is a "weed of civilization" which, from time out of mind, has sought human society and that of the best. So persistently does it haunt the track of man that one of its old popular names is "waybread."

This fondness of the plant for the edges of paths and roads has given rise to a German story that it was once a maiden, who, while watching by the wayside for her lover, was transformed into a weed by cruel magic; yet constant through all changes, she watches by the wayside still.

The North American Indians call the plantain "the print of the white man's foot." Longfellow alludes to this in those lines of "Hiawatha" which describe the coming of Europeans into the wild lands of the western world:

"Where so'ere they tread, beneath them
Springs a flower unknown among us,
Springs the 'White Man's Foot' in blossom."

Has it followed us westward and ever westward out of that mysterious land of the morning where human life began? Its origin, like that of its sister

362 Field, Forest, and Wayside Flowers

weeds, is wrapped in mystery, and its ways are past finding out. But one thing is sad and sure: individual weeds come and go, but the weed crop will never fail so long as the world endures.

CHAPTER XVI

THE SLEEPING OF THE FIELDS

“A Sabbath of rest unto the land.”

—*Leviticus* xxv. 4.

UNLESS one is blessed with a contented mind, a well-filled purse, and a good digestion, it is sometimes difficult to fight off depression in these autumn days, when we think we see all about us in the outdoor world the work of the great reaper, Death. The woodland paths are littered with fallen leaves, the hardiest garden-flowers have lost their brightness, and even the wild asters have doffed their queenly splendors of purple and gold and are gray and sombre, like Guinevere, grown old and turned nun.

Now, on stormy nights, the wind sounds a different note from any that we have heard in summer, and goes by with a low howl like that of some strong, savage thing into whose power the poor earth is soon to fall helpless. Yet the reign of the Frost King is beneficent. Difficult though it may be to convince ourselves of this truth, in wet November

weather, when yellow leaves shower down under dark skies, it is truth, not only cheering but scientific.

In those myths which were the nursery tales of the world's childhood men were told, ages ago, and over and over again, that winter is the sleep, not the death of the fields. The winter world is Brunehild pricked by Odin's sleep thorn. She is wrapped in slumber which seems as deep as that of death, yet she will wake at once to the kiss of Sigurd—the summer sunshine.

The beautiful summer is Proserpine carried off in the flower of her loveliness by the grim Lord of Hell and mourned for by her mother, Ceres, the bountiful earth. And in the story of Alcestis the myth occurs again. In both cases despair is turned to joy. Proserpine, still young and fair, is restored to her mother's arms, and Alcestis is brought in triumph to home, husband, and children, and her return is celebrated with feast and song. They are both stories of the sure return of spring—poetic ways of saying that winter seems to rob and slay, but in reality does neither.

To one who goes into the autumn fields with eyes opened by Nature-study, they are "happy autumn fields" indeed. The idea of death, which

is their superficial suggestion, is merged and lost in the far more deeply pervading thoughts of rest and resurrection. The brown meadows, in which the work of the reapers is done, have borne and nourished the crops of the year, the food of millions. Their summer's task completed, they lie at rest, gathering from air and sun, from autumn rain and winter snow, the constituents which will help to feed the crops of another year. The lilies, which neither toil nor spin, have yet made just and due provision for another summer's need. In bulbs, protected from frost and damp by a coat of papery, scales, the young foliage, and in some cases even the flowers of an other season, sleep, and packed in with them is a store of gums and starches gathered for the needs of next spring by this summer's leaves and roots.

The orchard-trees have been putting their vitality first into a wealth of bloom, and then into the fruit "pleasant to the eyes and good for food." Now their duties are done, and as a tired worker removes the clothing of the day before lying down to rest, they strip themselves of the green robes which they have worn all summer. The forest-trees by September have formed and ripened their seed. And all have laid away be-

neath their bark a store of nourishment which will feed the tender foliage of spring when it first begins to grow.

The leaves now fading have not been suddenly slain by ruthless frost. For weeks they have been bringing to a peaceful and fitting close a life which reached its fulness in the dog-days. While as yet summer was at high tide nature began to form across each leaf-stalk, just at the point where it joined the main stem, a very thin layer of cork. The manufacture of cork is not a trust in possession of the Spanish branch of the oak family. Cork is a constituent in the bark of most native flowering-shrubs and trees. It is also used by vegetation in repairing its rents and healing its wounds, and sometimes a layer of it is interposed to isolate diseased or dying tissues and, as it were, quarantine them from healthy and growing ones. The "wound-cork" which the trees use in lieu of court-plaster may be covered by the subsequent growth of trunk or branch, so that eventually it lies deep in the woody tissues.

But wherever it is met with cork can be readily recognized under the microscope by the forms of the cells composing it. They are square or brick-shaped, with clear-cut angles, and they lie as

bricks do in a house-wall, pressed closely together in horizontal rows (Fig. 99a). Sometimes they contain a brownish, granular substance, but oftener they are, in the expressive phrase once used by a daughter of Erin, "full of emptiness," and in this case they may be much bent and crinkled.

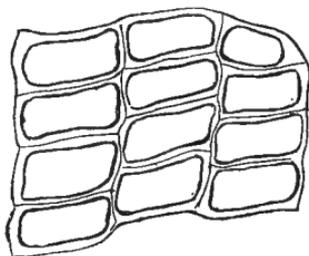


FIG. 99a.—Cork cells.
(From the leaf-scar of the horse-chestnut much magnified.)

The cork layer which severs the leaf from the bough does its work gently. At first it is not an unbroken sheet of cells, but a thin, incomplete, and porous plate, which intersects the softer tissues of the leaf-stalk but does not cut across the bundles of fibres and vessels which are the vital connection between bough and leaf.

At about the same time, or a little later in the season, another change takes place in the tissues of the leaf-stem. Now just outside the forming cork-plate there is a narrow band of rounded cells, which lie loosely together with many empty spaces among them. This is the "absciss" or "cutting-off" layer, and just here the stem-tissue is very easily ruptured.

By October the corky scale at the base of each leaf-stalk has gained its full thickness, and severs

almost completely the union between leaf and branch. Then, some frosty night, a thin plate of ice forms in the absciss layer, and the separation between leaf and branch is finished and final. When the morning sun melts the ice the leaves will shower from the boughs, however calm the air.

And now Nature doctors the wound made by the leaf's fall. The broken ends of the bundles of fibres and vessels left at the scar are covered (in many trees) with a protecting gum, and a little later they are encompassed by the growth of the cork-seal, and the healing of the scar is complete.

The falling foliage of the horse-chestnut leaves scars large enough to show clearly the marks of Nature's surgery. The cork-seal, which is much in evidence, has a horseshoe-shaped outline, and the slightly projecting ends of the fibro-vascular bundles, overlaid by a dark, glistening gum, suggest the horseshoe-nails (Fig. 99*b*).

What falls from the bough in autumn is little more than the dead skeleton of the summer leaf—mere dry skin, empty cells, and stringy fibre. Almost all the living substances which once filled the leaves were withdrawn from them before they fell, and are now safely stored away in trunk and boughs. Professor Von Sachs, author of the "Physiology

of Plants," has observed that in autumn the cell-contents of the leaves about to fall from the boughs "are changed into soluble substances, and these are conveyed to the permanent parts of the plant." The protoplasm, or clear jelly, disappears from the leaf-cells, and so do the little green grains of chlorophyll which float in it.

"I was able," says Professor Von Sachs, "by microchemical methods, to follow distinctly the travelling of the materials (especially of the starch) out through the tissue of the leaf-stalk . . . into the bark, or into the young wood of the branches; and, moreover, the ash-analyses of summer leaves, compared with those of autumn ones, show that the most valuable mineral constituents of the leaves, especially the potash and phosphoric acid, also pass out, through the leaf-stalks, back into the parts of the bough which survive the winter."



FIG. 99*b*.—Leaf-scar of the horse-chestnut, showing the cork-seal studded with the blackened ends of fibro-vascular bundles.

By time the leaves fall their tissues contain little else

than a few mineral crystals, but those of the branch, just under the cork layer, are rich in starch and protoplasm. And when the sun comes back to us from the South these living principles of the dead leaves are pushed up anew into the April buds, and help to form the tender foliage of another year.

When Nature begins to empty the leaf-cells in autumn the little green disks of chlorophyll "lose their normal outline, assume irregular shapes, and their coloring matter," says Professor Von Sachs, "undergoes changes." The crimson, purple, and golden-green leaves of early spring are leaves into which chlorophyll has not yet come. The crimson, purple, and yellow leaves of autumn are leaves in which chlorophyll has lost its green color and its active life. The splendor of the October woods was prophesied in April, but the leaves which mutely foretold it were too tiny and their colors were too evanescent to catch the attention of busy people. And the autumn glory, when it comes, more than fulfils the little hints and half-promises which the trees give us in spring.

Some plants, the annuals, never awaken from their winter sleep. One summer is their span of life. But these are but a small proportion of the vegetable world, and even these, by the time sum-

mer is ended, have attained full growth, blossomed, and set and ripened their seed. They are fading, not because frost has nipped them, but because old age has come upon them and their life-work is done. Dying, they bequeath their goods to their descendants and natural heirs. The materials drawn out of their leaves go into the ripening seeds, to be used, next spring, in the nurture of the seedlings. These annuals, after their seeds are ripe, are little else than an empty network of dry dead cells. The sweet alyssum and mignonette are metamorphosed into what he who clears up the garden calls "straw," their juices having gone to fill out the seeds, which are now ripe and ready, in innumerable little pockets, green or brown.

In scientific botany the little pockets of the fruit, which hold the ripened seed, are known as "loculi." If we cut an apple across we will see five of these loculi arranged in the form of a star. They have transparent, horny, brownish walls and in each is a seed or two.

Another use of the term loculi is familiar to the classicist and to the antiquarian. In the catacombs of Rome there are wall-spaces all honeycombed with niches designed to hold the bodies of the dead, or the urns containing their ashes. And each of these is called a "loculus."

372 Field, Forest, and Wayside Flowers

This twofold use of the word may be a mere philological accident. But it suggests to our minds the thought which the botanist who first applied the term to the seed-case had, perhaps, in his—the analogy used by the apostle in teaching that the dead body, sown with tears, is as the seed, and the soul is as the germ, which lives on in transfigured beauty when “God giveth it a body, as it hath pleased Him.”

Where each flower has perished, in garden or field, there is a seed, or more probably a pocket filled with seeds, each a prophecy and a pledge of the flowers which will gladden the earth next year. And each leaf, falling, leaves behind it a bud, from which a cluster of leaves or a cluster of flowers will unfold.

All things have their price, both in the spiritual and in the natural world. Without the torpor of winter, the freshness and gladness of spring could never be. Semi-tropic lands which escape the one miss the other. Only to lands which have known “the long dark nights and the snow” comes the ecstasy of the northern spring, when skies growing daily brighter, and earth awakening under them with joy foretell to us the “new heavens and the new earth” wherein shall dwell righteousness.

CHAPTER XVII

MARTINMAS SUMMER

Has time grown sleepy at his post
And let the exiled summer back?
Or is it her regretful ghost
Or witchcraft of the almanac?

—*E. R. Sill.*

THE still, sunny fall days are the serene old age of summer. In them the year seems to go back, as old people sometimes do, to the memories and ways of her early youth, and October and November sometimes behave like April, to the utter confusion and ultimate destruction of the flowers. For the flowers, not having "evoluted" to the use of almanacs, must regulate their affairs by guesswork, and when the sun shines brightly above them, and the earth feels warm and moist about their roots, they are grievously deceived, and mistake the Indian summer for the spring.

So it is by no means uncommon to find spring blossoms in late autumn, and this is especially apt to be the case when the early fall has been rainy. A week or two of mild and showery weather will



FIG. 100.—Witch-hazel (*Hamamelis Virginica*).
(From Report of Botanist in Annual Report of Secretary of Agriculture, 1885.)

sometimes coax a number of dandelions into bloom. The little blunderers will probably be overlooked, for we are apt to observe the things we expect to find and to miss those we are not looking for, and we certainly are not looking for October dandelions. There they are, however, gladdening the roadsides in many places. Let us hope that they will have time to set their seed and float it away to pastures new on gauzy parachutes before winter comes swooping down out of the North.

Violets, too, blossom sparingly in late fall sunshine. In golden Indian-summer weather one may gather them as late as Thanksgiving. Wild strawberries sometimes bloom quite luxuriantly in September or October. Here and there a willow pussy thrusts its furry foolish head above the bud-scales, which should have screened it till the spring, and in sheltered garden spots the early-flowering shrubs, especially the *pyrus japonica* and bridal-wreath, put forth a few fall-blossoms.

Some hardy weeds are so eager to seize upon every opportunity afforded by the chances and changes of our climate, that a few days of mildness and sunshine, in the heart of winter, will coax them into bloom.

There is no month in the year in which one may

376 Field, Forest, and Wayside Flowers

not see the flowers of chickweed, sow-thistle, and shepherd's-purse, the little pink-purple blossoms of the dead-nettle, and the dandelion's disks of gold. But the superstitious soul had better leave them to the mercies of Jack Frost, for it is highly unlucky, according to an old saying, to pluck flowers out of season.

Even the sight of these untimely blossoms is distressing to some superstitious souls. In the eastern townships of Canada, where Old World sentiments and sayings linger, many persons own to a decidedly uncomfortable feeling if an apple-tree blossoms in the fall. A like superstition prevails in New England, and probably the idea in both cases is traceable to Old England, where it has been embodied in the Northamptonshire jingle:

"A bloom upon the apple-tree when apples are ripe,
Is a sure termination to somebody's life."

But people have not always thus looked askance at belated blossoms. The "holy-thorns" of England won a great reputation for beneficent potency by putting on their adornment when all the woods were bare. Once upon a time the common folk firmly believed in the magical and medical virtues of these trees, and legends were told to account for their winter blossoming. The wealthy

gave large sums for cuttings from them, to plant in their own gardens. The patriarch among these beloved trees was the famous Glastonbury white-thorn, which sprouted, so runs the story, from a staff planted by Joseph of Arimathea. Its habit of late-fall flowering gained for it a widespread and holy reputation, which became its own undoing. A Puritan soldier, moved by that strange spirit which prompted the destruction of things because other people thought them beautiful or held them in reverence, cut it down as an "emblem of popery." It was supposed to flower every Christmas day.

Leaves, like flowers, are sometimes "born out of due time" under shining autumn skies. Among the last of the old foliage, when the trees are nearly stripped, sharp eyes may see, here and there, a cluster of two or three leaves unfolding in the tender green of spring. Horse-chestnut buds are particularly apt to open thus unseasonably, and elm buds are likewise prone to err.

The October dandelions and November violets make their ill-timed display on a stock of savings which was intended for their use next spring. Last spring, after the flowers faded and the precious seed was set, the plants turned their energies

toward providing for the wants of the future. The leaves drank in the summer sunshine, the roots soaked up what summer rain the weather-gods vouchsafed them, and the food thus gathered was stored away in the root for future use. The bridal-wreath and *pyrus japonica* shrubs were equally forehanded. In spring they were obliged to support a showy and expensive family of flowers, which needed for their maintenance all that the parent bushes could scrape together. When flowering time was over, however, the bushes began to gather a store of gums and starches, to be laid by till spring. All the trees and bushes have thus put by a store of nourishment. They will need it all next April, when the countless buds, studding the branches, begin to swell under our eyes, and they will need it still more in May, when young foliage begins to expand and when baby-blossoms are doing their growing.

The buds which open, here and there, in the autumn sunshine, are using capital which they ought not to touch for five months to come. But they can get only a small portion of this capital, and hence they seldom expand very far, even if mild weather continues. For the main stores of gum and starch are securely locked up, as we shall

see, in the centre of the larger branches, so that the erring buds can only draw upon a few neighboring cells of the plant-tissue. When the ill-timed growth has exhausted these very limited resources it will cease, whether it is checked by the cold winds of autumn or not.

As for the young leaves, so rash and so "forth-putting," Mother Nature recently tucked them up, all snug and safe, to sleep till spring.

As this summer's foliage falls we begin to see myriad buds studding the boughs, and every bud is a wind-rocked cradle for next year's baby-leaves or flowers.

The bare and silent woods are full of sweet mute promises of spring. Beneath the purple scales of the elder-buds we can find the blossom-cluster, already perfect though it is no larger than a pea. Next spring's "pussies" are formed and ready in the large golden-green buds which stud the twigs of the swamp-willows. And on the birch and alder branches, among the little cones which ripened last summer, are the staminate catkins which will shake out their gold to the April breezes. But all, if they be wise, will "lie low" till the sun returns from the South.

The tender spring-flowers which come in confid-

ing innocence into an autumn world recall Hans Andersen's pathetic story of the "Sommer Gowk." It is the Danish popular name for the snowdrop—"the summer-fool"—cheated by false hopes of summer into the clutches of present winter. The "Sommer Gowk" is chilled and beaten down by a shower of sleet, and gets hardly a glimpse of sunshine, and no summer at all. And yet in the South, "over the hills and far away," summer is filling all the fields with sunshine—summer fair and real—and drawing nearer day by day. The "Sommer Gowk," says Andersen, is like the noble souls born into a world as yet unfit to receive them. The prophets who gave their high spiritual message to ears dulled by sensuality or sloth, the poets who had no recognition save from posterity, the reformers, persecuted or laughed at by their own age, but honored by a later one—were they not Sommer Gowks, one and all? And science, too, has had its Sommer Gowks, for all its great schemes, from the discovery of America to ærial navigation, have seemed dreams in their day.

But "the world's dreamers have been its benefactors." And so in the November violets we may see a reminder of those who, in dark days and in

mental and spiritual loneliness, foresaw the coming of fuller life, light, and liberty.

How many there have been! From heavenly-minded Job, harshly criticised by his more material companions in the dawn of time, to Savonarola and Latimer, Columbus and Galileo, Andreas Hofer and John Brown, and thence on, through the years, to the "crank" or "dreamer" or "unpractical sentimentalist" who is the newspaper butt of our own day. But they have all been, like the Sommer Gowk, prophets of the spring.

The same Indian-summer weather which throws the violets out of their reckoning brings into bloom our very last wild flower, the witch- or wych-hazel.

Its popular name is due to a double mistake in nomenclature, which has mixed things up in confusion worse confounded. The early American settlers saw something in its foliage or habit of growth suggestive of the English witch-hazel, to which it is in nowise related. So they transferred the old English name to the newly-discovered American shrub, being influenced probably by the same love for the home-words which prompted them to call the red-breasted American thrush a robin and the marsh marigold a cowslip. But the English witch-hazel is not a hazel at all, but an elm

(*Ulmus montana*), and it got its popular name because its foliage somewhat resembles that of the hazelnut-tree (*Corylus Americana*).

The English witch-hazel or wych-elm was supposed to possess magic powers. It indicated the presence of hidden springs and of ores. Even at the close of the last century Cornish miners were so confident of its efficacy that they scarcely ever sunk a shaft but by its direction, and those dexterous in the use of the divining-rod professed to be able to mark, on the surface of the soil, the direction and breadth of the ore-vein beneath. A forked twig of the *Ulmus montana* was also used for the detection of witches, and hence the tree's popular name.

When the first settlers transferred the old English name to the New England shrub they also transferred all the folk-lore and wonder-lore thereunto appertaining and belonging.

Whether the American wych-hazel has lived up to the reputation thus suddenly thrust upon it we do not know. Certainly it has a half-uncanny look when one chances upon it, all abloom, in woods where the last autumn gold is growing sere. For it wears the aspect of an April blossom, yet we find it in latter October or November, when

all about it the leaves are falling, and when the brook by which it loves to grow runs turbidly, swollen by the heavy rains of the latter year.

The flowers provide a last feast for the flies and bees which are tempted abroad by the sunshine of Indian summer, and the pale gold of the strap-shaped petals is conspicuous in the general colorlessness of the thickets.

There are two sets of stamens,—longer ones which produce pollen, and shorter ones which do not and which have dwindled to mere reminiscent scales. The fruit, like that of the orange-tree, takes nearly a year to ripen, and will not be fully matured till next September, so that last year's fruit and this year's blossoms may be seen on the branches together.

The flowers issue in trios from little downy buds and begin to open as the leaves fall. Spring and summer, which called forth all the other blossoms of field and woodland, failed to draw out the hidden beauties of the witch-hazel buds, but now at the threshold of winter they don their gold. And as we gather them for the last wild-flower bouquet of the season, we think of their analogies in human lives—the late-developed talent, the fulfilling of the long-deferred hope, the coming of the happiness, denied in youth, to one whose hair is gray.

CHAPTER XVIII
IN WINTER WOODS

The Night is Mother of the Day,
The Winter of the Spring;
And ever upon old Decay
The greenest mosses cling.

Behind the cloud the starlight lurks,
Through showers the sunbeams fall;
For God, who loveth all his works,
Has left His Hope with all.—*Whittier.*

WHEN the "leaves have forsaken the trees and the forest is chilly and bare" it seems that the wandering botanist will find nothing there to interest or amuse him.

But botany, like evil doing, has all seasons for its own, and even when leaves and flowers are gone, there are still in the woodlands a few signs that the world's heart is beating still under its slumber-robe of snow.

Some humble plants go on growing, even at a season when one would suppose all vegetation to be benumbed with winter's icy breath.

In sheltered hollows, where the sunshine causes

a little thawing now and then, we can always find a few green ferns. Lichens, which make their homes as far north as the Arctic circle, are not discouraged by the worst our January can do. Some mosses are green, still, under the snow, and on the trunks of many trees, even now, we may notice a green film which is caused by the growth of some tiny and humble cousins of the rich green "sea-lettuces" which float at the edges of tidal pools on rocky coasts.

Probably the very great-grandparents of these little land algæ were seaweeds or fresh-water weeds, and the family love for coolness and shade is constant through all changes. For when the leaves are gone, and even subdued colors "tell" amid the general grayness of the woodlands, we see how persistently the land algæ choose the north sides of the tree trunks. Lichens, too, love best to grow where the direct rays of the sun cannot reach them.

We look southward through the woods, and every tree from earth to branches is spotted or filmed, or shrouded with a close-clinging growth of sober but living green. We see the north sides of all the tree-trunks and they are covered with minute shade-loving plants.

386 Field, Forest, and Wayside Flowers

But if we turn and look northwards through the woods the trunks appear bare. By this little bit of wood-lore Indian hunters used to "get their bearings" in the pathless forests.

Raising our eyes we notice the great beauty of the patterns which interlacing boughs and twigs trace against the sky. Each tree has its own beauty, for the form of the bare branches is almost as distinctive as that of the leaves, while bark is so characteristic that a hunter or a lumberman can often tell the name of a tree from its bark alone.

By time the dark days of November come the trees are all asleep and each is wrapped from its topmost twigs to its lowest roots in a slumber-robe of Nature's own weaving, a close tissue of cork-cells.

Though every plant of the field and every tree of the wood is entirely built of cells, these cells may differ widely from one another in shape, size, and use.

They may be filled or partly filled with colorless jelly, they may contain resin, tannin, mucilage, oil, or mineral crystals, or they may be empty. They may be many sided, or cylindrical, or spindle-shaped, or thread-like, and the thread-like ones may be straight or twisted or branched. Some-

times the cell walls are very thick, sometimes they are thin, and sometimes they are pitted or barred or ringed so that under the microscope they show patterns of great beauty.

A tiny sliver of wood may be made up of many kinds of cells, which are alike only in one respect—that the tree has had a use for them all.

Toward the centre of the trunk and larger branches lie the oldest cells, whose work is nearly or entirely done.

They form the "heart-wood" which, as every cabinetmaker knows, is darker in color and closer in texture than the younger "sap-wood" which surrounds it.

Outside the "sap-wood" there is in spring a layer of young growing cells which are building up new bark and new wood. In April we shall find this forming tissue lying just below the bark, between it and the wood.

But at this season no active growth is going forward, and no delicate new cells are forming and swelling between the tree and its bark.

In the bark itself, at varying depths according to the kind of tree, lie several layers of cork-cells.

In summer this cork undergarment covers all the tree except the tops of its tenderest twigs and

the ends of its slenderest rootlets. Nature has taken care that the water sucked in by the roots shall not be evaporated and lost as it goes up through trunk and branches to the thirsty little shoots at top. So the year-old twigs have a tough skin, which is nothing more nor less than a thin sheet of cork, while older branches are encased by a thicker cork-covering, which lies, as a rule, below the surface. Be it thin or thick it is perfectly water-proof.

The peel of a potato is nothing more nor less than a layer of cork-cells, and, by observing the quickness with which pared potatoes "dry out," we realize how effective even a thin cork-covering can be in preventing the transpiration of vegetable moisture.

The life-giving juices of the tree can not get through the cork-layers of the bark to nourish the outermost tissues of the trunk and branches. So all these parts of the tree which lie outside the cork-layer dry up, shrivel, crack apart, and at last flake off and fall to the ground.

These dried and drying tissues may include cells of many sorts and sizes, which in their younger days served various uses in the tree's domestic economy. But now we speak of them all together as the "outer bark."

The sheet of cork which is wrapped around a branch may lie near its surface or deep in its tissues.

And their various and sundry ways of wearing their union suits cause marked differences in the appearance of the trees even in winter, for the cracks which begin at the outer surface of trunk or bough will go "clear through" till they come to the cork sheet, wherever that may be.

If it lies deep, the cracks in the bark are deep, and the ridges between them are high and rough, as they are on the oak.

The beech, on the contrary, wears its cork-under-robe just beneath its outer dress, and so the rents in the bark are shallow, while in the canoe-birch the cork layer lies on the surface of trunk and boughs, and can be peeled away in thin sheets.

In some trees curved plates of cork form deep beneath the surface, and as the woody tissue lying outside them dies and dries, masses of bark are, as it were, gouged out of the living trunk.

When these plates are long and narrow, and are formed horizontally, the bark cracks across the trunk, and peels away in broken rings. But if the long, curving cork-plates stand upright in the tissue of the tree, the bark which they cut off comes away in scales, as it does from the trunks

of pines and larches. Sometimes the scales form, but remain clinging to one another upon the tree, so that, in the course of years, the trunk becomes covered with large plates of dead tissue, overlapping each other like shingles on a roof, and making what is called "scale-bark." Such dried-up flakes, clinging together, may be seen partly covering the trunks of old pine-trees.

The larger roots of the trees are wrapped in corky tissue, just as the trunk and branches are, but in summer the slenderest tips of growing rootlets are not. The chief use of the large roots is to anchor the tree to the spot where it grows. But the work of the little rootlets is to suck up moisture and nourishment from the surrounding soil, and if they were sheathed in cork they could not fulfil this office.

Each rootlet, just above its tiny tip end, is furred over with hairs (Fig. 101), slender and soft, yet tough enough to press in between the grains of close-packed soil, and draw food and drink out of it.

As winter approaches, these little "root-hairs" shrivel and drop off, and the root-tip from which they sprang becomes enwrapped, like the larger roots, with a layer of cork-cells. So the whole tree,

from its highest to its lowest point, is enfolded with a slumber-robe of cork, which keeps the vegetable juices in and helps to keep the cold out.

When spring comes to wake the earth, the deeper layers of soil feel the sweet influence while the

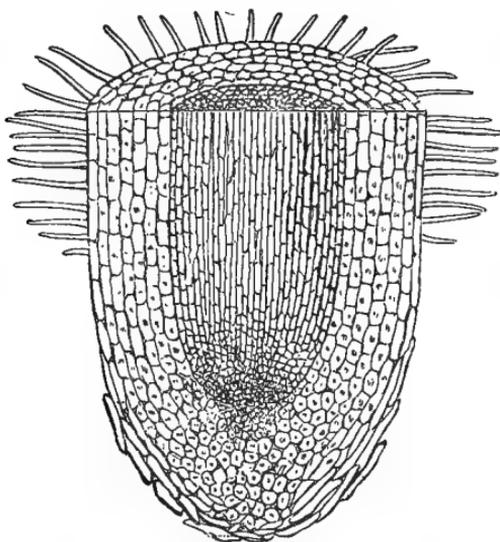


FIG. 101.—Lengthwise section of a root-tip, showing root-hairs.
(Much magnified.)

(From the *Vegetable World*.)

surface is still ice-bound. Then the least root-tips, far underground, cast off their slumber-robcs and begin to absorb moisture from the soil, which seldom freezes for more than forty inches below the surface, even in the bitterest weather. And all winter, alive but sleeping, a group of active cells

lies just behind the root-tip, ready to put out fresh root-hairs as soon as spring returns.

While the root-tips are being enclosed in cork-sheaths, preparations for a long winter sleep are going forward among the branches overhead.

All the trees which wear union suits of cork have on their youngest branches little ventilating holes, called "lenticels." These can be plainly seen on the twigs of birch, beech, cherry, and elder, as rough oval dots, slightly raised, and different in color from the bark around them (Fig. 102).

Those of the birch become greatly extended as time goes on and appear as sharply-drawn, blackish stripes, running horizontally around the trunk. But on the roughened older bark of most species of tree the lenticels are hard to find, though they are still there.

In the older bark of the cork-oak, however, we know them only too well, for the brown, powdery streaks which sometimes run through bottle-corks, and cause them to crumble vexatiously when one tries to draw them, were the lenticels of the growing tree.

A lenticel is a lens-shaped rift in the outer bark, filled in with a loose mass of cork-cells, which are not rectangular, and ranged in rows after the

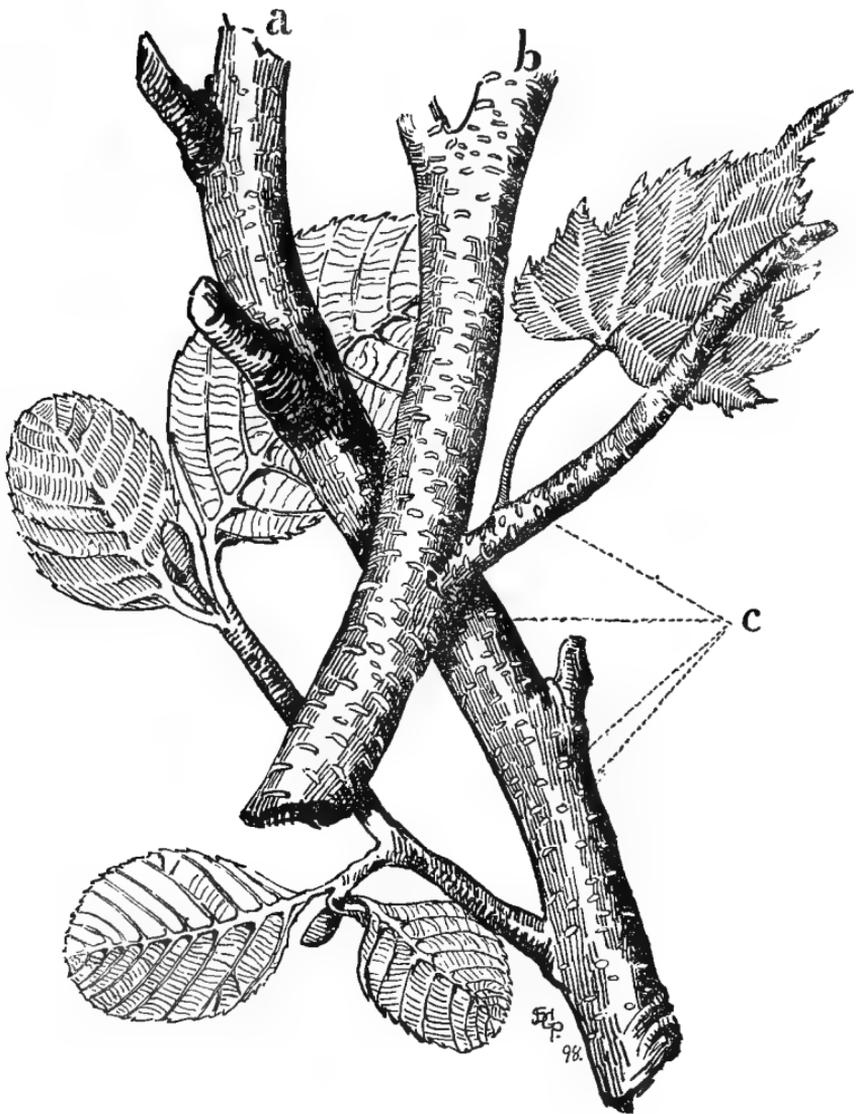


FIG. 102.—Branches of alder (*a*) and poplar-leaved birch (*b*), showing numerous lenticels (*c*).

usual custom of cork-cells, but rounded and, as it were, flung together, like stones tipped out of a wheelbarrow. Between them lie many little chinks and spaces, and by way of these the air gets into the wood, and the moist breath exhaled by the living tissue of the tree reaches the outside air. But as summer wanes, the trees fit themselves for their approaching slumber by an action which might be compared to that of the Hindoo fakir of Eastern wonder-lore, who, before entering his death-like trance, stops his nostrils with plugs of wax.

For at the end of the growing season a close layer of cork forms over the whole orifice of each lenticel, and seals up the tree.

So the breathing away of the tree's moisture is checked, as it has need to be, at this season, for now no active little root-hairs are at work down below, sucking up water from the ground. And also the little seals of cork help to protect the tissues of the tree against sharp and sudden frost.

At the return of spring a number of new cork-cells will be formed under the seal which Nature has placed upon the lenticel. These will be a light, loose mass, like that which fills the lenticels in summer, and by their vigorous growth they will

split the seal above them and open the lenticel once more. And as we have seen, a closing layer or seal of cork has grown across all the scars whence last summer's leaves have fallen.

Preparations for repose have taken place, not only on the surface of the tree, but in its inner tissues. The fluid which, in summer, mounts slowly from the tiniest rootlets toward the leaves, is the "crude sap." It is water, holding in solution chemical substances derived from the soil. In the leaves, as we remember, it is worked over into the "elaborated-sap" which builds up and feeds plant-tissues. And this, creeping blindly from cell to cell, finds its way to the tips of roots and branches where growth is being actively carried on.

So in latter spring and summer there is a constant slow movement of fluids in the trees, first from the roots upward and then from the leaves downward.

Though this movement is connected functionally with the tree's feeding and digestion, it resembles the circulation of the blood in one respect. Crude sap, like arterial-blood, flows always through one set of channels, while elaborated sap, like venous-blood, flows always through another. Crude sap,

as we have seen, travels *via* the young wood ; elaborated sap moves through the inner bark or "bast," where, in most trees, a way is prepared for it through what are technically known as "sieve-cells." These are long and narrow, and run lengthwise of trunk and boughs.

As the sap moves through them, it comes to places where the partition-wall between cell and cell is "punched full" of holes, like the top of a pepper-pot. Fine fibrils of plant-jelly reach through these, joining the contents of neighboring cells, and in summer, plant-fluids pass easily all along the route. But as autumn approaches, Nature seals these holes and isolates the "sieve-cells."

About midsummer, a glutinous plate, called the callus-plate, begins to form upon the little sieve, stopping up its pores. This gains thickness and solidity all through the waning of the year, and by time the leaves fall the route through the sieve-cells is closed as completely as is the route to Klondike in midwinter. This sealing of the little sieves has a beneficent purpose. At almost any time throughout the winter, in our latitudes, we may have a false promise or mocking similitude of early spring. We have seen that several gullible or foolhardy herbs may be cheated or dared

into blooming any month of the year. Their foliage is practically evergreen, so that their untimely energy results in nothing worse than the production of a few futile flowers, which ripen no seed. But if the trees were to put forth when summer was *not* nigh at hand, their indiscretion might cost us the bloom of spring orchards and the luxuriance of midsummer woods.

When vegetable life resumes its functions the starches and other food-substances stored in the wood follow the route of the elaborated sap. The starch-grains are dissolved and changed into fluid glucose, which, with other nutrient fluids, feels its way into the inner bark, and then creeps along through it into the buds where life is stirring.

But were the little sieves all open through the winter the plant-food stored in the wood could make its way to the buds at any time, and the buds, thus generously fed, could unfold in a few days. Lured by the false promise of a January thaw, baby-blossoms and delicate leaves would issue, all too quickly, into what would speedily prove a cold and inhospitable world. And all the energy used in putting them forth would be so much dead loss to the tree. So wise Nature keeps the stores of

food within the plant-tissues safely locked up throughout the winter.

And thus the minute pieces of callus in the inner bark help to preserve the beauty of the forests.

I have not been able to find any recorded case of the reopening of a little sieve which has once been closed and sealed.

It seems probable that the very first growth of spring buds is fed, as is the unseasonable growth of too forth-putting autumn ones, by the nourishment drawn from closely neighboring cells. By time the unfolding blossoms and leaves of March or April have exhausted this slender store the cambium, which is formed each spring, has come into being and has taken up its work. New sieve-cells have been formed just inside the old ones which were sealed up last autumn, and there is a newly organized bark-route from end to end of every trunk and bough. So nourishment travels on unchecked to the expanding buds, and when the trees are fully aroused by April sunshine, they all at once begin to leaf out and to blossom, as the awakened servants, in the palace of the Sleeping Beauty, took up each his task again.

When next spring's new bark is formed, last spring's sieve-cells will be pushed a very little way

outward, and each successive season's growth will force them still further from the centre of trunk or bough. So after awhile the sealed and disused sieve-cells of long-vanished summers find their way into the outer bark, and are sloughed off.

The forest where "frost hath wrought a silence," and where every tree is wrapped in its slumber-robe, sleeps as one who expects to be aroused and loves the expectation.

The danger guarded against is not that the trees will sleep too late, but that they may awaken too soon.

For the Earth's heart wakes for the Sun-prince, who is coming from the South, and the woods, hushed by winter, dream of spring.

And, as sometimes in summer nights day-birds rouse, call to their fellows, and sleep again, we can fancy that the trees now and then half awake, and whisper to one another, "Is spring drawing near?"

Then the great pine, which looks southward from the hill top, sends down through many branches the murmurous message, "Not yet," "Not yet."

Index

- Aaron Hill, 333
Abele, 50
Absciss layer, 367, 368
Abundant pollen of coniferæ, 286
Accessory buds, 60
Acorn, 71, 83, 84, 119, 120
Acorn-cup, 71
Acorns, 119
"Adam's Needle and Thread," 207
Adders' tongues, 251, 266
 prothalli of, 252
Adventitious buds, 61
Aerial roots, 234
Age of Reptiles, 285
Albuminous seeds, 119
Alcohol, 94
Aleurone, 119
Algæ, fresh-water, 94, 95
Algæ, land, 385
Alkali-grass, 153
Allen (Grant), quoted, 86, 319, 320
"Alternate" leaf arrangement, 122
Alternation of generations in ferns, 258
Amaranth, 353, 354, 355
American Beauties, 136
"American flannel-plant," 347
Andersen (Hans Christian), quoted, 380
Annuals, 370
Ants, 28, 79, 340, 341
Anthers, 24, 40
Anther-ring, 42
Apex of growth, 59
Apple-blossom, 136
Apple-seeds, 136
Apocynum androsæmifolium, 303
Apocynum cannabinum, 309
Aquatic flowers, 30, 31
Arbor vitæ, 270, 272
Archegonia, formation of, 255
Archegonia of the pine, 292, 293
Archegonia of selaginella, 291
Arrow-head, 112
Arrow-root, 295
Asclepias cornuti, 309
Ash, 62
Ash buds, 76
Ash, prickly, 74
Ash, white, 75, 76
Ash analyses of leaves, 369
Asparagus, 94
Asphodels, 355
Asters, 352
Atrophy, 84
Awn, 169
Bacteria, 97
Bald cypress, 270, 274, 298
Balsam, 282
Balsam fir, 276
Bamboos, 173
Barbed fruits, 350
Barberry, 114
Bark, green, 132
Bark, nature of, 386
Bark, outer, 388
Barley, 62, 103, 118, 151
Basis of life (physical), 90, 91
Bast, 128, 129, 130, 396
Bast-tubes, 128, 133
Bay, 273
Beach grass, 155

- Beach-grass committee of Prov-
 incetown, 155
 Beak rush, 193
 Bean, sprouting, 120
 Bear-grass, 131
 Beech, 69, 71, 389
 Bee, 19, 24, 29
 Bee-bread, 28
 Bee-flowers, 79
 Bees, larger, 32
 Bees, lesser, 32
 Beetles, 33
 Big-fly flowers, 32
 Bind-weed, 221
 Birds as sowers, 298
 Blackberry, 57, 326
 Black-eyed Susan, 352
 Blade-like foliage, 123
 Blessed thistle, 334
 Blue-eyed-grass, 124
 Bordered pits, 284
 Bonsilene roses, 136
 Bouncing Bet, 221, 222
 Bracteoles, 165
 Bramble, 60
 Branched leaves, 123
 Bridal wreath, 375, 378
 Broad-leaved evergreens, 273,
 274
 Buckeye, 56
 Buds, 55
 accessory, 60, 61
 adventitious, 61
 supernumerary, 60
 Bud-scales, 57, 58, 87, 88
 Bud-scale marks, 58
 Bud-scales of pines, 275, 276
 Bulrush, 193, 197
 Bulbs, 365
 Bundles, fibro-vascular, 128, 129,
 130
 Bundle sheath, 128, 159
 Burdock, 39, 320, 350, 352
 Bur, chestnut, 81
 Bur, horse-chestnut, 82, 83
 Bur-marigold, 45
 Buttercup, 139
 Butterfly-flowers, 33
 Butternut, 69, 71

 Cactus, 109, 110, 326

 Calamus, 143
 Calla-lily, 117
 Calla, 140, 143
 Callus, 396, 398
 Calyx, 19
 Calyx, modified to aid in plant
 distribution, 46
 Calyces, 21
 Cambium, 135, 398
 Champion, red, 225
 Champion, white, 225
 Canada thistle, 338
 Canada thistles, 339, 340
 Canoe birch, 389
 Caoutchouc, 235
 Carbon, 90, 100
 Carex group, 193, 194, 196
 Carices, 194
 Carrion-flies, 33
 Carrion-flower, 33
 Carrot, 126
 Caryopsis, 167
 Castor-oil bean, 119
 Catharine Mermets, 136
 Catkin, 51, 52
 Catkins, 51, 66
 Cat-tail flag, 144
 Cat-tail flags, 140, 148, 186
 Cedar, 270, 289
 Cedars, 280, 288, 289
 Cell, 91, 92
 Cells, 89, 92
 Celery, fibro-vascular bundles
 of, 128
 Cereus, night-blooming, 27, 200,
 227
 Cherry, 56
 Chestnut-bur, 81
 Chestnuts, blossoming, 81
 Chestnut-leaves, 126
 Chickory, 353
 Chickweed, 356, 376
 Chlorophyll, 93, 96, 97, 100
 Chlorophyll bodies, 93, 94, 95
 Chlorophyll in autumn, 370
 Christmas custom in Italy, 356
 Chufa, 197
 Chrysanthemum, 39
 Clasping leaf-bases, 124
 Classification (Delphino's), 32
 Clematis, 240, 241, 242

- Climbing-plants, 233
 Clock (flower), 228, 229
 Clock (De Candolle's), 230
 Clock of Linnæus, 230
 "Closed" bundles, 130
 Closing of night-flowers, 229
 Clover, white, 339, 340
 Club-moss, 251
 Club-mosses, 296
 Club-mosses, prothalli of, 252
 Coast-evergreens, 272
 Coast-grasses, 153
 Cockle-bur, 350, 352
 Cock's comb, 354
 Columbines, 35
 Compositæ, 39, 351, 352, 353
 Composite family, 338
 Composite flowers, 45
 Compound leaves, 126
 Common milk-weed, 309
 Concentric rings in timber, 132
 Conducting tissue, 26
 Cone-bearers, 157, 270, 280
 Cone-bearers, girdled, 283
 Cone-bearers, winged seeds of, 298
 Cone-bearers, wood of, 281, 282, 283
 Cones, 299
 Cone-scales, 299
 Coniferæ, 285, 286
 Coniferæ, pollen, 286, 287
 Conway (Moncure D.), quoted, 332
 Coontie, spermatozoids of, 295, 296
 Copper-hazel, 97
 Copper-leaved beech, 97
 Cork, 92, 105, 366, 386
 Cork cells, 367, 387
 Cork undergarments of trees, 387, 388, 389
 Corn (Indian), 103, 118, 151, 175
 Corn-cockle, 225
 Corn-stalk, 126, 127, 130, 131
 Corolla, 19, 23
Corylus Americana, 380, 382
 Cotyledon, 121
 Cotyledons, 119, 120
 Crepuscular moths, 200
 Crocus, 19, 20, 22, 24, 25, 27, 29, 35
 Crow-foot (water), 112
 Crude sap, 129, 395
 Cryptogams, 248
 Cycad, spermatozoids of, 296
Cyperus textilis, 197
 Cyprus (bald), 270, 274, 298
 Daffodils, 355
 Dandelions, 43, 45, 376
 Dandelions in October, 377
 Dandelion leaves, 320
 Darwin quoted, 237, 238, 286, 300
 Darwin's classification of climbing plants, 233
Datura stramonium, 214
Datura tartula, 217
 Day-lily, 204, 227, 229
 Dead-nettle, 376
 De Candolle's flower-clock, 230
 Deepest-throated flowers, 207
 Defences against browsing animals, 319, 320
 Degenerate flowers, 86, 359
 Degeneration, 144
 Degeneration of grass-blossoms, 156
 Delphino quoted, 32, 33
 Dent-de-lion, 37
 Development of sporangia in true ferns, 265
 Development of sporangia in adders' tongues, 266
 Devices to ensure cross-fertilization, 34
 Dicotyledon, 117, 121
 Dicotyledons, 119
 foliage of, 123
 stems of, 132, 133, 134, 135
 Differences between diurnal and nocturnal flowers, 225
 Digested sap, 129
 Dioecious flower, 75
 Diurnal primroses, 227
 Distinction between prickles and thorns, 325, 326
 Dock, 352
 Dog-bane spreading, 303
 Door-yard weeds, 350, 353

- Down, 53, 56, 320
 Dr. Ogle, 80
 Drosera, 300
 Dung-flies, 33
 Dyer (Thistleton), quoted, 62,
 333, 334, 357

 East Indian nettle, 329
 Eel-grass, 31
 Elaborated sap, 395
 Elasticity of tendrils, 245
 Elm, 53, 61, 62, 74
 Elms, 50, 54, 75
 Embryo-sac, 27
 Empty glumes, 162
 English daisy, 347
 Evanesence of grass-flowers,
 173
 Evening lychnis, 225
 Evening primrose, 213
 Evening primrose, garden, 214
 Evening primroses, 227, 229
 Evergreen woods:
 flowers of, 268
 character of, 268
 Evolution, 86
 Exalbuminous, 119

 Fall of the leaf, 366, 367, 368
 Falling of needle-like leaves,
 274
 Ferns, 246
 Fern-spores, 247
 Fern-spores, germination of,
 249, 250
 Fertilization of the coontie, 295
 Fibro-vascular bundle, 128, 129
 Fibro-vascular bundles, open,
 134
 Fibro-vascular bundles of Di-
 cotyledons, 133, 134
 Fibro-vascular bundles of Mo-
 nocotyledons, 130, 159
 Fir, 274, 282
 Firs, 299
 First-born of flowering plants,
 270
 First flowers in the world, 156,
 285
 Flags, cat-tail, 124
 Flag, sweet, 143

 Flax, 332
 Flaxseed, 119
 Flies:
 carrion and dung, 33
 big, 32
 smaller, 33
 Floret, 40, 43
 Florets, 39, 43, 44, 45
 Flower-clock, 228, 229
 of De Candolle, 230
 of Linnæus, 231
 Flower:
 of death, 353, 355
 of immortality, 354, 355
 perfect, 77
 pistillate, 77
 staminate, 77
 tendrils, 243
 Flowering fern, 265
 Flowering glumes, 164, 165
 Flowering plants, 248
 Flowerless plants, 249
 Flowers:
 imperfect, 66
 naked, 66
 of life, 355
 of the evergreen woods, 268
 of the nettle, 330, 331
 Folding creases of young leaves,
 56
 Foliage:
 floating, 112
 submerged, 112, 113
 of parasites, 98
 Forest-trees, 64
 Forests of Maine and Canada,
 272
 Formic acid, 329
 Fraxinus excelsior, 77
 Fronds, 259
 Fruit as defined in botany, 46
 Fuchsia, 139
 Fungi, 99
 Funkia Japonica, 204

 Garden evening primrose, 214
 Generative cell, 293, 294
 Generative cells, of pine pollen,
 274
 Georgia yucca, 212
 Geranium, rose, 126

- Germination of fern-spores, 249, 250
 Gingko, 270
 spermatozoids of, 296
 Girdled cone bearers, 282, 283
 Girdled maples, 283
 Girdled oaks, 283
 Gladiolus, 35
 Glastonbury white thorn, 377
 Glucose, 102, 103
 Glumes, empty, 162
 flowering, 164, 165
 outer, 162
 Golden-rod, seeds of, 349
 Gorse, 114, 323, 326
 Grain, 118, 167, 168
 Grain-fields, weeds of, 351
 Grains, 118
 "Grains" of chlorophyll, 94
 Grant Allen quoted, 86, 319, 320, 359
 Grape tendrils, revolution of, 243
 Grape-vine, 242
 Grass, 149, 156
 Grass-blades, 123
 Grass-blossoms visited by insects, 173
 Grass-flowers, 161, 173
 Grass, leaves of, 160
 Grass-pollen, waste of, 170
 Grasses, 118, 151, 152, 157, 165
 as sand-binders, 153, 154
 blossoms of, 139, 140, 165, 166
 coast, 153
 modes of seed-distribution of, 169
 mud-binding, 153
 nodes of, 158
 number of species of, 168
 sheaths of, 158
 spikelets of, 168
 stems of, 188
 Gray, Prof., 83
 "Grete Herbale" quoted, 356
 Great Britain saved by a thistle, 337
 Green bark, 132
 Groundsel, 39, 110, 352
 Growing-point, 120
 Gums, 63
 Gymnosperm, 297
 Gymnosperms, 290, 296
 Gymnosperms (prothalli of), 292
 Hackberry, 74
 Hairs of ferns, 261
 Hairs, various uses of, 42, 46, 110, 320
 Hans Andersen quoted, 380
 Hare's palace, 356
 Hartford fern, 262
 Haulm, 160
 Hawk moths, 202, 203
 Hawthorn, 323, 326
 Hawk-moths, 203
 Hazel, 26
 Hazel, copper, 97
 Hazel-nut, 69
 Hazel-nut tree, 382
 Heart-wood, 387
 Heather, 99
 Hedgehog grass, 169
 Hemlock, 270
 Hemlock, seedlings of, 270
 Hemlock, staminal leaves of, 288
 Hemlocks, 299
 Hemp, 332
 Heraldry, 334
 Herbivorous animals, 96
 Herbert, George, 65
 Hickory, 71
 Hickories, 75
 Hobble-bush, 57
 Holland, 155
 Hollow stems, 38, 157
 "Holy thorns," 376
 Honey, 42
 Honeysuckle, 201, 204, 227
 Honeysuckle, twining of, 239
 Honeysuckles, 228
 Hook-climbers, 235
 Hooks at tips of vine-sprays, 237
 Hop-vine, 239
 Horse-chestnut, 78, 79, 80, 82, 85, 86
 Horse-chestnut bur, 83
 Horse-chestnuts, 84, 120
 Horse-tails, 248, 251
 Horse-tails, prothalli of, 252
 Humming-bird, 34

- Humming-bird moths, 203
Huxley, 90
Hydrogen, 90, 100
- Ill-timed growth, 378, 379
Immortelles, 354
Imperfect flowers, 66
Indian corn, 118, 126, 175
Indian hemp, 309
Indian pipe, 99, 269
Indian shot, 103
Insect-fertilized flowers, 157, 285
Insect messengers, 32
Insects, 42, 75, 173
Involucre, 44
Iris, 35, 124
Irish gorse, 114, 323
Iron-wood, 69
Ivy, English, 235
Ivy, poison, 235
- Jacqueminots, 136
Jamestown weed, 214
Japan lily, 204
Japan lilies, 212
Jasmine, 207, 239
Jean Paul Richter quoted, 230
Jersey pine, 275
Jimson-weed, 214, 217, 227
Juniper :
 berries of, 289, 298
 seedling, 270
Junipers, 288, 296
- Kerner quoted, 286
Kinship of flowering and flowerless plants, 295
- Lace-flower, 349
Law of disused organs, 45
Laws for preservation of forests, 155
 of grasses, 154, 155
Leaf-bud, 59
Leaf-buds opening in autumn, 377
Leaf-climbers, 233, 240
Leaf-scars, 368
Leaf-skin, 368
Leaf, structure of, 89, 90
- Leaf tissue, 90
Leaves converted into prickles, 114
 into store-houses, 113
 into traps, 115
Leaves, floating, 112
Leaves, submerged, 112, 113
Leptosporangiateæ, 266, 267
Lichens, 248, 385
Light necessary to protoplasm-making, 105
Ligule, 160
Ligulifloræ, 353
Lily, 116, 117, 123, 148
Lily-kin, 119, 121, 126, 129
 leaves, 108, 123
 stem, 131
Lilies, 130
Links connecting flowering and flowerless plants, 290
Linnæus' floral clock, 230
Little panic-grass, 153
Liverworts, 248
Loculi, 371
Locus, 371
Locust, 323
Longfellow quoted, 282, 355, 361
Love charms, 359
Love divination, 334
Love lies bleeding, 354
Lubbock quoted, 341
Lychnis, evening, 225
Lycopodineæ, 296
Lycopodiums, 251
- Macrospore, 27, 28
Macrospores, 28
Magnolia, 33
Maiden-hair tree, 270
Maple, 56, 59, 84, 85
 red, 50, 54
Maples, 80
 red, 75
Marram-grass, 153, 155
Marsh-flies, 143
May-apple, 56
May-flower, 268
Melancholy thistle, 336
Mesquit, running, 153
Microbes, 248
Microspore, 24, 27

- Microspores, 24, 25, 27, 28
 Midsummer-dream plant, 357
 Milkweed (of South Africa), 110
 Milkweed, trap of, 309, 310, 311, 313, 314, 315
 Milkweed, seeds of, 349
 Milton quoted, 355
 Mineral crystals, 386
 Mistletoe, 98, 108
 Monocotyledon, 121, 128
 Monocotyledons, 117
 leaves of, 123
 Monœcious flowers, 69
 "Monœciously polygamous" flowers, 73
 Moonworts, 266
 Morning-glory vines, 236, 239
 Mosses, 248, 385
 Moth, 34
 Moths :
 crepuscular, 200
 hawk, 202, 203
 humming-bird, 203
 nocturnal, 33, 200
 twilight, 33
 sphinx, 203, 221
 Mountain evergreens, 272
 Mucilage, 186, 187, 255, 386
 Mullein, 320, 347
 Müller quoted, 42, 173, 211, 304

 Naked flowers, 66
 National flower of Scotland, 337
 Natural wind-break, 271, 272
 "Nature's most valuable colonists," 156
 Nectar, 29, 30
 Neck-canal cells, 255
 Needle-like leaves, 272, 274, 276, 279
 Nettle, 332, 333
 flowers of, 330, 331
 sting of, 329, 330
 Nettles, 317
 Net-veined leaves, 148
 Night-blooming cereus, 27, 200
 flowers, 200, 227
 Nitrogen, 90, 300
 Nocturnal flowers, 225
 moths, 200
 Nodes of grasses, 158

 November violets, 375, 378
 Nuts, 71, 84

 Oak, 56, 62, 64, 69, 85, 86, 120
 Oaks, 93
 Oat, 161
 Oat-blossoms, 162, 165, 166
 Oats, 151
 Oat-spikelets, 16
 October dandelions, 377
Oenothera biennis, 213
 Ogle (Dr.), 80
 Oil, 119, 249, 386
 Oleander, 106
 Oosphere, 256,
 Oospore, 256, 257, 259
 Open fibro-vascular bundles, 134
 Ophioglossaceæ, 266
 Orange-tree, 326
 Orchid, 27, 48
 Orchids, 25, 34, 117
 Osmunda, 262, 265
 Ovary, 47
 Ovule of a cone-bearer, 290
 Ovule of the yew, 297
 Oxygen, 90, 100, 101

 Painted-cup, 98
 Paleæ, 164, 165
 Palet, 164
 Palmetto trunk, 127, 130, 131
 Palmettos, 126, 140
 Palms, 117
 Panic-grass, 153
 Papyrus, 197
 Parallel veins, 123
 Parasites, 98, 99, 269
 Parasitism, 97, 98
 Pasture-thistles, 342
 Pear-tree, 55
 Peas, 119
 Peel of a potato, 388
 Peony, 28
 Perfect flower, 77
 Perigynium, 196
 Petals, 21
 Phanerogams, 248
 Phosphorus, 90
 Phosphoric acid, 369
 Phragmites communis, 175

- Pickerel-weed, 186
 Pigment, 94, 95, 97
 Pig-weed, 354
 Pinaceæ, 270
 Pine, 270, 272, 283
 Pineapple, 326, 329
 Pine, archegonia of, 292, 293
 Pine-drops, 269
 Pine-family, 270
 Pine, Jersey, 275
 Pine, pitch, 275, 283
 Pine, pollen of, 287, 293
 Pine-sap, 99
 Pine, scrub, 275
 Pine, white, 281
 Pines, 299
 vitality of, 283
 Pinks, 139
 Pink family, 222, 225
 Pistil, 22, 29
 Pistillate flower, 77
 Pith, 102, 130, 132
 Plantago lanceolata, 359
 Plantago major, 357
 Plantain, 128, 357
 Plantain, flowers of, 359, 360
 Plumed fruits, 349
 Plum-leaves, 56
 Poison-ivy, 235
 Pollen, 22, 28
 Pollen-carriers, 30
 Pollen-grain, 24, 27, 28
 Pollen-grains of the honey-suckle, 204
 Pollen-tube, 26, 27
 Pollen of "water-fertilized" flowers, 30, 31
 Pollen of "wind-fertilized" flowers, 30, 31
 Pollen of oat blossoms, 165
 Pollen of rushes, 185
 Pollen, waste of, 28, 31
 Polygamous flowers, 73
 Pond-weeds, 31
 Poplar, 31, 50, 51, 52, 54, 61, 73
 Poplars, 49, 51, 73, 75, 93
 white, 53
 Populus alba, 50
 Potato, starch-grains of, 103
 Potash, 369
 Prickles, 110, 319, 325
 Prickles, how they differ from thorns, 325, 326
 Prickly-ash, 74
 Primroses, diurnal, 227
 Primroses, evening, 227, 229
 Problems of nature, 345
 Procambium, 130
 Prof. Gray quoted, 83
 Prof. von Sachs quoted, 368, 369
 Proteids, 91
 Protoplasm, 90, 91, 100, 105
 Prothalli, 251
 of adders' tongues, 252
 of club-mosses, 252
 of ferns, 252
 of gymnosperms, 292
 of horse-tails, 252
 of selaginellas, 292
 Prothallus, 250, 258, 259, 298

 Rag-weed, 39, 350, 352
 Rape, 119
 Ray flowers, 352
 Red campion, 225
 Red cedars, 288, 296, 298
 Red maple, 54, 74
 Red maples, 75
 Red-top, 169
 Reed, 175
 Reeds, 175, 176
 Reptiles, age of, 285
 Resin, 282, 386
 Reversion to type, 136
 Revolving of vine-tips, 236, 237
 Rib-wort, 357
 Ripple-grass, 359
 Rice, 118, 151
 blossom of, 172
 wild, 175
 Richter (Jean Paul) quoted, 230
 Rings in timber, 135
 Rogue type, 98, 99
 Rolled fronds of ferns, 260
 Root-climbers, 234, 235
 Root-hairs, 250, 390
 Root-stocks, of ferns, 260
 Root-stocks, of grasses, 152, 153
 Root-tips, 390
 Rose, 116, 117, 123, 128
 Roses, 136
 Rose-bush, 131

- Rose-geranium, 126
 Rose-kin, 126, 129, 132
 Royal osmunda, 265
 Rudiments, 80
 Running mesquit, 153
 Rush-lights, 180
 Rushes, 117, 179, 180
 dependent upon the wind, 185
 flowers of, 182, 183
 knotty-leaved, 181
 pollen of, 185
 ripe seed-vessels of, 187, 188
 water, 180, 181, 185, 186, 187
 wood, 180, 182, 183
 Ruskin quoted, 115
 Rye, 103, 118, 151
- Salts, 105
 Salvia, 35
 Sand-bur, 169, 172
 Sand-binders, 154
 Sap, crude, 129, 395
 Sap, digested, 129
 Sap, elaborated, 395, 397
 Saw-palmetto, 329
 Scale-bark, 390
 Scale-leaves, 276
 Scale-like foliage, 272
 Scales of the bud, 57, 58, 87, 88
 of ferns, 261
 Scars left by bud-scales, 58, 59
 Scotch cloth, 332
 Scotland, national flower of, 337
 Scouring rushes, 251
 Scrub-pine, 275
 Scypanthus elegans, 239
 Sealing of leaf-scars in autumn,
 368, 395
 Sea-weeds, 97, 248
 Sea-sand reed, 153
 Sedges, 117, 179
 blossom of, 139, 190
 leaf arrangement of, 188, 190
 seed distribution of, 191
 small value of, 196
 Seed, 22, 247, 248
 Seed-bearing scale, 297
 Seed-leaves, 119, 120
 Seed distribution of water-
 rushes, 187
 Seeds of water-rushes, 185, 186
- Seeds of wood-rushes, 185
 Seedling, 75, 120
 cone-bearers, 270, 271
 Seedlings, 73, 74, 86
 Selaginella, 290
 Selaginella, archegonia of, 291
 prothalli of, 292
 spermatozoids of, 291
 spore of, 290, 291
 Seniors of the forest, 285
 Sensitive fern, 262, 265
 Sepals, 21, 22
 Sheaths of grasses, 158
 Shear-grass, 188
 Shepherd's purse, 376
 Silence of the evergreen woods,
 269
 Silene, 227
 Silver fir, 274
 Silver poplar, 50
 "Skeleton" of the leaf, 89
 Sneeze-weed, 352
 Snowdrop, 380
 Soft-rush, 182
 "Sommer-gowk," 380
 Sori, 261
 Sorus, 261
 Spadix, 143
 Spathe, 140, 144
 Spermatozoid, 254
 Spermatozoids, 256
 of ginkgo, 296
 Sphinx Carolina, 218
 convolvuli, 221
 moths, 202, 203
 Spider-wort, 124
 "Spike-rush," 193
 Spikelet, 162, 164, 165, 168
 Spikelets, 162, 168
 Spinach, 38
 Spines, 110, 323
 Spore, structure of, 247, 249
 Sporangia, 261, 262
 Sporangium, 261, 262
 Sporangium, development of, in
 true ferns, 265
 in adders' tongues, 266
 Spore-bearing fronds of the
 sensitive fern, 265
 Spring blossoms in late autumn,
 373, 375

- "Spring-wood," 134
 Spruce, 270, 274
 Spruces, 299
 Spurges, 110
 Squirrel-tail grass, 169
 Stamens, 22
 Staminate flowers, 74, 288
 Staminal leaves, 287, 288
 Starch, making of, 100, 102, 113
 Starches, 63, 119, 121
 Starch, grains of, in leaves, 102
 in barley, 103
 in Indian corn, 103
 in Indian shot, 103
 in rye, 103
 in wheat, 103
 in timber, 102, 103
 Stemless lady-slipper, 268
 Stems of grasses, 188
 of sedges, 188
 Stephanotis, 207, 227
 Stigmatic surface, 25
 Stigmas of forest-trees, 69
 of wind-fertilized flowers, 31
 Sting of the nettle, 329, 330
 Stoma, 107, 108
 Stomata, 106, 107, 108, 109
 Submerged foliage, 112, 113
 Succulent leaves, 109
 Sulphur, 90
 "Summer-wood," 134
 Sundew, 300
 Sunshine necessary to starch-
 making, 100
 Swamp-thistle, 340, 342
 Sweet alyssum, 371
 Sweetness of night-flowers, 227

 Tannin, 386
 Taraxicum, 37
 Tassels of the poplar, 52
 Taxaceæ, 270
 Teasel, 323, 325
 Tendril, 113, 244, 245
 Tendril-bearers, 233, 235, 240
 Tendrils, 242, 244
 elasticity of, 245
 flower, 243
 of the grape-vine, 243
 of the Virginia creeper, 244
 revolution of, 243

 Tendrils, strength of, 245
 useless, 245
 Tennyson quoted, 76
 Thistle, 326, 345, 349, 352
 in folk-lore, 333, 334
 in folk-medicine, 334
 in heraldry, 334
 pasture, 342
 swamp, 340, 342
 Thistles, 317
 Thistleton Dyer quoted, 62, 333,
 334, 356, 357
 Thor, 334
 Thorn, definition of, 325, 326
 Thorns, 323
 Thread made from nettles, 332
 Three-ranked arrangement of
 sedge-leaves, 188
 Thrift of nature, 242
 Timber, 103
 Timothy-grass, 168
 Tissue, new, 91
 of leaves, 89, 90
 waste, 91
 Tobacco-worm, 218
 Tomato-worm, 218
 Tracheids, 283, 284
 Trailing evergreen, 251
 hemlock, 269
 Transpiration, 106
 Traps for snaring insects, 33
 Trap of the dogbane, 304, 306
 Trap of the milk-weed, 310, 311
 Trap-setting plants, 300
 Tree-blossoms, 65
 Trunk of the palmetto, 127, 130
 131
 Tubers, 102, 103
 Tube put forth by the pollen-
 grain, 25, 26
 Tubulifloræ, 353
 Twilight moths, 33

 Ulmus Montana, 382
 Upas tree, 333

 Veins, 89, 126
 parallel, 123
 Veinlets, 126
 Venus fly-trap, 300
 Vessels, wood, 128

- Vestiges of grass-petals, 166
 Vestiges of the prothallus in
 flowers, 295
 Vestiges of atrophied seeds, 83
 Vine-tips:
 hooked, 237
 revolution of, 237
 Vine-tips, speed of, 239
 Vines, Sidney, quoted, 320
 Virginia creeper, 237, 242, 245
 tendrils of, 243, 244
 Vitality of pines, 282, 283
 Von Sachs, Prof., quoted, 367,
 368
- Walnut, 69, 71
 Walnuts, 75
 Wasp, 34
 Waste of pollen, 28, 286
 Water-crowfoot, 112
 Water-fertilized flowers, 30, 31
 Water-loving plants, numerous
 seeds of, 185, 186
 Water-rushes, 180, 181
 capsules of, 185
 seeds of, 185, 186, 187
 Wayfaring tree, 57
 Webber, Herbert, 295
 Webster's definition of a weed,
 347
 Weed of civilization, 361
 Weeds, 36, 37
 as weather prophets, 355, 356
 how they sow themselves, 349,
 350
 of grain-fields, 351
 Well-water, 103
 Wheat, 151
 blossom of, 172, 173
 Wheat-germ, 118
 White ash, 75, 76
 White campion, 225
 White clover, 339
 White lily, 108
 "White man's foot," 361
 Wide range of wind-fertilized
 plants, 286
- Wild carrot, 349
 Wild lettuce, 320
 Wild orange, 323
 Wild rice, 175
 Wild strawberries, 375
 Wild yew, 270
 Willow, 58, 61, 62
 pussy, 50
 swamp, 50, 54
 Willows, 49, 75, 93
 Wind-fertilized flowers, 30, 31
 Winged fruits, 85, 349
 Winged pollen of the coniferæ,
 287
 Winter bud, 88
 Winter refuge of birds, 280
 Wistaria, 239
 Witch-hazel, 381
 Wood, 132, 133, 134, 135
 of cone-bearers, 281, 282,
 283
 Wood-rushes, 180, 182
 capsules of, 185
 seeds of, 185
 Wood-thrushes, 345, 346
 Wood-vessels, 128, 130, 133
 "Wool grass," 191, 193
 Wound cork, 366
 Wych-elm, 382
 Wych-hazel, 381, 382
- Xyris flexuosa, 187
- Yarrow, 126, 165
 Yellow-eyed grass, 187
 Yew, 274, 276
 European, 270
 wild, 270
 Yews, 270, 298
 Yucca, habit of growth of, 131
 fertilization of, 208, 211
 filamentosa, 207, 208
 recurvifolia, 212
- Zamia integrifolia, 295

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