THE STRUCTURE OF GRASSES EXPLAINED FOR BEGINNERS

AGNES CHASE

HONORARY FELLOW, SMITHSONIAN INSTITUTION

THIRD EDITION



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## FOREWORD

The first edition of the First Book of Grasses by Agnes Chase was published in 1922. A new and revised edition was brought out in 1937. The third edition of this unique and valuable small volume is here offered in the belief that the present generation of beginning students of grasses will find it continuingly useful. This edition is novel in having a frontispiece reproduced through the courtesy of the Staatliche Kunstsammlung, Albertina, Vienna, and a revision of parts of the General Information at the end of the book, and other minor changes.

And now a word about the author!

Mrs. (Mary) Agnes Chase, since October 1, 1958, an Honorary Fellow of the Smithsonian Institution and previously for 20 years a Research Associate of the Smithsonian Institution, is the dean of agrostologists. Born in Iroquois County, Illinois, on April 20, 1869, she was educated in Chicago. She became intensely interested in botany at an early age and while in Chicago worked at night as a proofreader on the Inter Ocean newspaper and botanized during the day. From 1901 to 1903 she was an assistant in botany at the Field Museum of Natural History (now the Chicago Natural History Museum), where she worked with Charles Frederick Millspaugh in

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the preparation of the Gramineae, Cyperaceae, and Compositae for *Plantae Yucatanae*. Each species was illustrated by beautiful line drawings prepared by Mrs. Chase.

In 1903 she was appointed a botanical illustrator in the United States Department of Agriculture. Outside of office hours she worked in the grass herbarium, then under that Department. During this time she started a series of scientific papers on the genera of the Paniceae, the first of which was published in December, 1906.

Her professional career began in 1907 with her appointment as scientific assistant in systematic agrostology, a post she held until 1923, when she was made assistant botanist. Two years later, in 1925, she became associate botanist, and in 1936 after the death of Prof. A. S. Hitchcock, she was made senior botanist in charge of all systematic agrostology. For nearly 30 years she was closely associated with Professor Hitchcock.

Mrs. Chase officially retired in April, 1939, but did not give up her botanical work. In the same year she was appointed Research Associate in the Smithsonian Institution, where she had already done much of her research during her years with the Department of Agriculture. Since that time she has been at her desk nearly every day, including many Saturdays. During this period she completed two major projects: a revision of Hitchcock's Manual of Grasses of the United States and the preparation of a second copy of the index to grass species consisting of nearly 80,000 cards. Each card of the index was edited, verified, and, when necessary, cross-indexed. There are tentative plans to have the grass index duplicated to make it available to other institutions and individuals.

Mrs. Chase has not been merely a library and dried plant botanist. She has always realized the need and advantage of studying grasses in the field. She collected extensively in the local area during her early years in Washington and made several trips through the southeastern States, the latter for studying species of Panicum. At the time a revision of the North American species was being prepared by her jointly with Professor Hitchcock. The revision was published in 1910 and has remained the standard reference work in its area. Two extended collecting trips were made to Brazil, the first in 1924-25, the second in 1929-30. Other collecting. trips were to Puerto Rico in 1913 and to Venezuela in 1940, the latter made at the request of the Venezuelan Ministry of Agriculture.

For the purpose of studying type specimens of American grasses, she has visited and studied in botanical institutions in various European cities, including Vienna, Munich, Florence, Pisa, Geneva, Berlin, Leiden, Brussels, Paris, and London. The results of these studies have been invaluable in American agrostology.

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Mrs. Chase richly deserves her world-wide reputation. Continually and for many years she has been in contact with other agrostologists in Europe, Asia, South America, and Australia. She has assisted and inspired students from Argentina, Chile, Venezuela, Brazil, China, Canada, and the Philippines, and other countries who have spent extended periods of time studying grasses under her direction in the U. S. National Herbarium. Most of these students have continued their agrostological work in their own countries. She was selected as one of the fifty botanists to receive a certificate of merit at the fiftieth anniversary of the founding of the Botanical Society of America in 1956. In June 1958, the University of Illinois awarded her the honorary degree of Doctor of Science.

Mrs. Chase's productive scientific work has thus already extended over almost 60 years. She has made more than seventy published contributions to scientific botanical literature. But in none of these are her thorough approach, enthusiasm for her subject, and innate modesty better exemplified than in the *First Book of Grasses*, which is here issued for its third time.

The Smithsonian Institution is proud of its long and happy association with this truly distinguished scientist and takes deep satisfaction in being able to present this new edition as she approaches her ninetieth birthday. As it appears, the reader may think

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of Dr. Chase in her workroom in the United States National Herbarium in the Old Smithsonian Building in Washington, still diligently at work from morning to evening on scientific problems related to one of man's great friends, the grasses of the world.

> LEONARD CARMICHAEL, Secretary, Smithsonian Institution

EDITION'S NOTE: Mrs. Chase died on September 24, 1963, in Washington, D. C.

#### PREFACE

Of all plants grasses are the most important to man. The different kinds are known by very few, even among botanists. This is largely because they are supposed to be very difficult. When the structure of grasses is clearly understood, they are not more difficult to study than are other plants. The method here offered has been used by the author for some years in teaching special students.

The introduction explains the method followed. The body of the primer consists of twelve lessons, graded from the simplest to the most complex. Each lesson is accompanied by figures bringing out the facts in the text. The difference in the size of the flowering organs is so great that the figures are not drawn to the same scale. The organs are enlarged as much as necessary to illustrate the character discussed.

Grasses of the United States are used for the lessons and the commoner ones are selected so far as possible; however, our native grasses cover so wide a range that the principles laid down in the lessons are applicable to grasses generally.

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Washington, D. C.

AGNES CHASE.

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## INTRODUCTION

THE purpose of this primer is to give those with little or no knowledge of botany such an understanding of the structure of grasses as will enable them to use manuals of botany and other technical works, to the end that our native grasses may become better known and their worth and beauty be more fully appreciated.

The best method of studying any organisms is to observe and examine the organisms themselves. Since these can not be provided in a book, drawings of the objects studied are here offered as the best substitute. These drawings are purposely somewhat diagrammatic in order to bring out particular characters that may be less prominent in the actual plants. While the drawings convey clearer ideas of structure than can words and are to be used constantly with the text, they can but inadequately take the place of the plants themselves. The student, therefore, should collect for study as many different kinds of living grasses as possible.

The idea of a primer has been kept in mind. The subject is presented as simply as possible, and only enough grasses are examined in each lesson to illus-

## FIRST BOOK OF GRASSES

trate the different modifications and to prepare the student to comprehend the greater modifications shown in subsequent lessons.

The classification of grasses, that is, the grouping together of related forms, is based on the characters of the aggregate of minute flowers and bracts known as the *spikelet*. It is necessary, therefore, for anyone who wishes to be able to identify a given grass to understand the structure and modifications of the spikelet. This primer is really an elementary study of the morphology of the spikelet. [Morphology is a branch of science that treats of form and structure. The study of the morphology of the spikelet enables one to recognize its various organs under whatever form they may assume.]

#### USE OF TECHNICAL TERMS

Many persons who might otherwise make an effort to learn something about our common wild flowers and trees, as well as grasses, are deterred by the sight of the unfamiliar words used in botanical descriptions. This supposed lion in the way, if one will but draw near enough to see, is only a "harmless necessary cat." No boy learns a trade, no girl learns to sew without learning the names of the tools used. Words like hames, whippletree, terrets, and a hundred more, meaningless to the city-bred rider on a trolley-car, are familiar terms to the farmer.<sup>1</sup> Such

<sup>1</sup> Mark Twain's description (in "A Tramp Abroad") of how they hitch horses in Europe is a good example of the confusion

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terms as carburetor, accelerator, clutch, spark-plug or magneto, unknown a few years ago, are now understood by nearly everyone, and those who do not as yet understand these terms are by no means deterred thereby from buying (or wishing for) an automobile. Spikelet, glume, and lemma are words no more difficult to learn than are hames, crupper, or whippletree, carburetor, clutch, or magneto. The reason for using these botanical terms is the same as that for using the names of the different parts of a harness; they are simpler and more exact than would be a descriptive phrase. It is simpler to say "terrets" than to say "the rings that stick up in the middle of the harness on the horse's back that you pass the reins through" and it is simpler to say

caused by want of technical terms: "The man stands up the horses on each side of the thing that projects from the front end of the wagon, throws the gear on top of the horses, and passes the thing that goes forward through a ring, and hauls it aft, and passes the other thing through the other ring and hauls it aft on the other side of the other horse, opposite to the first one, after crossing them and bringing the loose end back, and then buckles the other thing underneath the horse, and takes another thing and wraps it around the thing I spoke of before, and puts another thing over each horse's head, and puts the iron thing in his mouth, and brings the ends of these things aft over his back, after buckling another one around under his neck, and hitching another thing on a thing that goes over his shoulders, and then takes the slack of the thing which I mentioned a while ago and fetches it aft and makes it fast to the thing that pulls the wagon, and hands the other things up to the driver."

"glume" when speaking of that organ of a grass than to say "the little green scale on the outside of the thing with the seed in it."

In the first lesson nearly all the new words that a study of grasses will require are explained and illustrated by figures. The few additional terms necessary are explained as they are used. No attempt is made to write a primer of grasses in words of one syllable or to produce a work on "how to know the grasses" without mental effort. It can not be done.

#### USE OF LATIN NAMES

Besides unfamiliar terms there are the unfamiliar Latin names of the plants which some hesitate to encounter. But many of the names in common use for trees and herbs are the botanical names. Magnolia, Rhododendron, Petunia, Asparagus, Chrysanthemum, Phlox are the Latin botanical names and are freely used by all without hesitation. Panicum, Paspalum, Bromus, Festuca, Hordeum are no more difficult. As in the case of such terms as glume and lemma, the Latin names of plants are used for the sake of exactness. Common names of plants, especially of those which are useful, troublesome, or conspicuous, are more definitely applied in older countries where the inhabitants have dwelt in a region for many generations than they are with us. Our ancestors brought names of Old World plants with them to their new homes and applied them to

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plants something like the familiar ones. Consequently, many common names are used in different parts of the country for widely different plants. In Illinois "June-grass" is Kentucky blue-grass (Poa pratensis), a valuable pasture grass; in Maine "Junegrass" is Danthonia spicata, an almost worthless little relative of wild oats; and in parts of the West it is Kocleria cristata. The name "blue-joint" is used for three very unlike grasses. On the other hand, many plants have different names in separate parts of the country. Around Washington, D. C., for example, Azalea is commonly called "honeysuckle." Many economic plants (such as potato, turnip, and ryc) have common names uniform in any one language but different in distinct languages. When the Latin name of a plant is used, it is definitely understood not only throughout the United States but throughout the world what species is referred to. However, the primary reason for using the botanical names is that these indicate the relationship of the plants. All plants of a kind have the same genus (or generic) name. [Genus is the singular, genera the plural, generic the adjective.] Kentucky blue-grass and all its kind are Poa: P. pratensis, P. trivialis, P. annua, P. secunda, and so on. The common names of these, Kentucky blue-grass or June-grass, rough meadow-grass, speargrass, little bunch-grass, respectively, give no clue to their relationship or kind. Knowing Poa pratensis anyone hearing of any grass named Poa has an idea

of what it is like; it is something like *Poa pratensis*. Some common names, especially those of trees, indicate the kind: Oak, with black, white, scarlet, swamp, and post oak, for example, and also hickory and ash; but for herbs, and especially grasses, the common name usually gives no indication of the kind of plant it refers to. Often the name is misleading. Rib-grass is not a grass, but a plantain; poison ivy is not an ivy, but a sumach. To convey definite ideas we must use definite terms and definite names.

#### TOOLS NEEDED

Any work that one engages in requires tools. For the study of grasses we need but few. Grass flowers are too small to be seen distinctly with the naked eye. A lens magnifying about ten diameters is necessary. This may be mounted on a stand or it may be a hand lens. A simple dissecting microscope with two or three lenses of different magnification would be more convenient and would well repay the cost, but it is not absolutely necessary. If one has only a hand lens, an eye-piece, such as watchmakers place in the eye, will also be found very useful in dissecting, as it leaves both hands free. One or two dissecting needles are needed. These can be made by forcing the heads of coarse sewing needles into a pencil-shaped piece of soft wood. After some practice one learns to use the nail of the left forefinger skilfully in dissecting. One can work more rapidly

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with this and one needle than with a pair of needles. A scalpel is useful, but the small sharp blade of a penknife will answer instead. It is well to have a piece of black paper or cardboard on which to place hairy spikelets. The hairs on the different parts show up well against this background.

It is the aim to use, so far as possible, the characters that may be seen in the different parts of the spikelet with but little dissection. When further dissection is necessary, instructions will be given at the end of the lesson requiring it.

## LESSON I

#### THE GRASS FAMILY

To most persons grass is almost any green vegetation of rather low growth, especially such as may be grazed. To the student of plants, a grass is a member of the natural family Poaceae, or Gramineae, distinguished by its structure.

Grasses are herbs with round or flattened (never 3-angled), usually hollow stems (culms) solid at the joints (nodes), and 2-ranked, alternate, parallelveined leaves, composed of two parts, the sheath, which surrounds the culm like a tube split down one side, and the blade, which is usually strap-shaped, flat, folded, or with rolled margins. At the junction of the sheath and blade, on the inside, is a small appendage (the ligule); this is commonly thin in texture; sometimes it is only a ring of hairs, rarely it is obsolete. The plants may be annual or perennial. The root, stem, and leaves are the vegetative part of the plant (Fig. 1). These are all that are concerned with the life of the individual plant. The flowers have to do with perpetuating the species. In grasses the vegetative parts are more uniform and characteristic than in most other families.

Having stem and leaves of any plant, one can always readily decide whether or not it is a grass. The

#### THE GRASS FAMILY

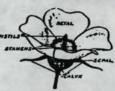


FIG. 2. Typical complete flower, showing calyx, corolla, stamens, and pistils.

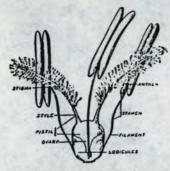
only plants that may reasonably be mistaken for grasses are the sedges. In these the culms are solid or pithy, are not jointed, and are commonly 3-sided; the leaves are always 3-ranked, and the sheaths always closed.

The flowers of grasses are small and inconspicuous. They consist of a single pistil with a 1-celled, 1-ovuled ovary, two styles, each with a feathery stigma, and three (rarely one or six) stamens with delicate filaments and 2-celled anthers. Two minute scales. called lodicules, situated back of the pistil, at blooming time become turgid and force open the enveloping scales.

FIG. 1. Vegetative part of grass plant; part of leaf opened out.

In Fig. 2 are shown the parts of a common flower

(the wild prairie rose with long styles). The calyx and corolla are the floral envelopes; the stamens and pistils are the essential organs of a flower, the parts that produce seed. The floral envelopes protect the essential organs in the bud and, by secreting nectar which attracts insects or in other ways, commonly aid in securing the fertilization of the flower.



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The pistil consists of the ovary, style, and stigma. The ovary contains the ovules, which when fertilized develop into the seeds. The style serves to lift the stigma into the air. The stigma is more or less expanded and has a viscid surface to which the pollen-grains adhere and upon which they germinate, sending their con-

FIG. 3. Grass flower, showing stamens and pistil and the rudiments of floral envelope.

tents in a minute tube which pushes down through the style to the ovules, fertilizing them.

The grass flower (Fig. 3) is reduced to the essential organs, the floral envelopes being represented by the minute lodicules. Each flower is borne in the axil of a small green bract (the lemma) and is subtended and enveloped in a second bract (the grain, The flower with its lemma and palea is termed the floret (Fig. 4). The ripened ovary (the or palea). caryopsis) (Fig. 5) consists of a small embryo lying at the base

#### THE GRASS FAMILY

of a mass of starchy endosperm. [Endosperm means within the sperm or seed. It is the store of food

used by the infant plantlet when it begins to grow.] The "germ" of a kernel of corn is the embryo, while the remainder of the kernel is starchy endosperm. The grain lies in the palea with the hilum (the scar of the point of attachment) toward it, and the embryo on the side toward the lemma. "Jon

one showing the hilum, the other

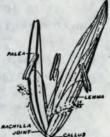


Fig. 5 gives two views of a grain, FIG. 4. A floret at flowering time.

the embryo. In Fig. 81, A (page 91), are two kernels of corn showing the embryos. The grain with

very few exceptions is permanently inclosed in the lemma and palea, the mature floret being the fruit, that is, the seed with its permanent envelopes. The florets are borne in two ranks and alternate upon an axis (the rachilla). Below them are two bracts without flowers (the glumes). The glumes, rachilla, and florets together form the spikelet.

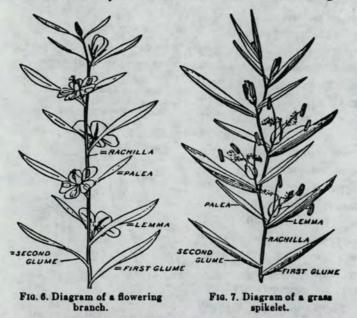
FIG. 5. Two views of a grain.

Fig. 6 is a diagram of a branch with leaves and flowers arranged as are the glumes, lemmas, paleas, and flowers of a grass spikelet. Fig. 7 is a diagram

of a spikelet for comparison with Fig. 6. [The hypothetical flower-bearing branchlet is never elongate,

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as here shown for the sake of comparison. The palea is immediately above the lemma and the flower immediately above the palea.] It will be seen that the spikelet is theoretically a leafy flowering branch with a jointed main axis, the flowers, except



for the minute lodicules, reduced to the essential organs. In Fig. 8 a typical grass spikelet is shown, the lemmas and paleas nearly closed together and concealing the flowers.

The spikelet is characteristic of grasses and is not found in any other family except that of the sedges.

#### THE GRASS FAMILY

In the spikelets of sedges the florets are commonly, but not always, spirally arranged, there never is a palea, and the fruit is an achene or nutlet. [The "seeds" of buttercups and

mints are achenes or nutlets.]

In grasses specialization takes place mostly in the spikelet. By its vegetative characters we know a given plant to be a grass, but it is by its spikelets and their arrangements that we know what kind of a grass it is. The genera of grasses and the groups of genera called tribes are based on the structure of the spikelets and their arrangement in the inflorescence.

SECOND ELLINE PEDIGEL

Before studying the spikelet we must observe the rela-

FIG. 8. Generalized spikelet.

tively few specializations of the vegetative parts. As in other plants, stems or parts of stems may be underground. These underground stems (rhizomes, or rootstocks) are borne at the base of the main culm under the earth, spread out horizontally, and in due time send up shoots which form young plants at a distance from the parent. Sod-forming grasses have this kind of underground stem. Kentucky blue-

#### THE GRASS FAMILY

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grass (*Poa pratensis*, Fig. 9) furnishes an excellent example. Sometimes the rhizome is thick and woody, sending up shoots from its nodes, the whole forming a dense colony, as in gama-grass (*Tripsacum dactyloides*). A rhizome, being a stem, is jointed and bears scales, which are reduced leaves. By these it may always be distinguished from a root, which is not jointed and never bears scales. In some



grasses the shoots borne at the base of the culm are on the surface of the earth instead of beneath it. Such shoots are stolons, or runners. These, like rhizomes, are

jointed and bear

scales or, some-

FIG. 9. Base of plant and underground parts, roots and rhizomes, of Poa pratensis.

times, well-developed leaves. Rhizomes and stolons both bear roots at the under side of the nodes. In a few species, Bermuda-grass for one, a plant may produce either rhizomes or stolons according to the conditions under which it is growing. There is no real difference between a rhizome and a stolon, the one is below ground and colorless, the other above ground and green.

Culms are hollow in most grasses, but in corn, sugar-cane, sorghum, and related grasses they are

pithy. They may be erect, spreading, or creeping; they may be simple or freely branching. A branch is borne only at a node in the axil of a sheath, that is, between the sheath and the culm. Either it grows up parallel with the parent culm until it emerges from the sheath or the young branch splits the sheath and grows outward. In manuals of botany these two methods of branching are called intravaginal, that is, inside the vagina (Latin for sheath), and extravaginal, outside the sheath. In bunch-grasses, like orchard-grass and the wheat-grasses of the West, the branching is intravaginal; in Kentucky blue-grass, quack-grass, and others producing rhizomes or stolons, the branching is extravaginal. The branches borne at the middle and upper nodes of a culm are nearly always intravaginal. If they spread from the parent culm they do not burst through the sheath but carry it with them.

Leaves are always borne at the nodes and are always 2-ranked (see Fig. 1, page 9). In corn and other large grasses the leaves sometimes appear to be all on one side instead of 2-ranked. This is due to a twisting of the culm inside the sheath. Sometimes in large grasses, particularly in sugarcane and in bamboos, the leaves fall, leaving the culm naked. In relatively few grasses the edges of the sheath are grown together, forming a tube. Sometimes the blade of the leaf is not developed. This is always the case in the leaves or scales of rhizomes (Fig. 9), and often in those of stolons and in the

## LESSON II

#### FIRST BOOK OF GRASSES

lowermost leaves of a culm, especially in bamboos. Blades may be flat or folded (often called conduplicate) or involute; that is, rolled lengthwise. Rarely the inrolled edges are grown together, so that the blade really has no upper surface. Such leaves are called terete (meaning rounded). Blades vary greatly in size, shape, and texture, smoothness or hairiness. In broad leaves there is sometimes a narrow neck, or **petiole** (leaf-stalk), between the sheath and the blade.

#### SUMMARY

Grasses are distinguished by jointed, round or flattened, usually hollow, culms, with solid nodes; 2-ranked leaves, composed of sheath and blade, with a ligule at their junction; and by the spikelets with 2-ranked glumes and florets.

#### REVIEW

(1) How is a grass distinguished from all other plants?

(2) Break a cornstalk and note the arrangement of the torn fibers standing out of the pith. Compare this with the cut end of any twig of a tree or shrub. Cut across a wheat, oat, or rye straw and compare with the cornstalk and with the twig.

(3) Examine the culm (nodes and internodes) above and below ground and leaves (sheath, ligule, and blade) of any available grass.

(4) How is a rhizome distinguished from a root?

(5) What is the difference between a rhizome and a stolon?

#### THE SPIKELET AND THE INFLORESCENCE

THEORETICALLY the spikelet is a reduced leafy branch. In the generalized spikelet shown in Fig. 8 the likeness to a jointed culm with 2-ranked leaves (Fig. 1) is readily seen, the glumes and lemmas corresponding to sheaths, their blades not developed. The palea, with two nerves and with its back to the axis, corresponds to a minute bract (the prophyllum) borne at the base of a branch in the axil of a sheath. The prophyllum is always 2-nerved, with its back (that is, the space between the nerves) against the main axis and its margins clasping the young branch. The flower, also, is theoretically an ultimate branchlet. In the flower-bearing lemmas, therefore, the palea is developed, while in the glumes, bearing no flowers, there are no paleas. Glumes and lemmas are, morphologically, reduced leaves, the lower pair, not flower-bearing, being termed glumes, the flowerbearing ones being termed lemmas. (See Fig. 7.)

The jointed axis of the spikelet (the rachilla) corresponds to the jointed culm and, like it, usually breaks at the nodes, the internode (the part of the rachilla between two nodes) remaining attached to the floret at its base (Fig. 4), just as in a broken grass stem the internode of the culm remains with

#### THE SPIKELET AND THE INFLORESCENCE 19

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the sheath that surrounds it; that is, the break normally comes just under the node. Rachis (which means the spine, or backbone) and axis (the imaginary central line of any body) are



often used interchangeably as botanical terms. In most recent works on grasses and in these lessons, axis is used for the main axis of a compound inflorescence, rachis for the axis or support of the spikelets. In Fig. 10 are shown the axis of a panicle (A) and the rachis of a raceme (B): the rachis of the spike

Fig. 10. Forms of inflorescence: A, panicle; B, raceme; C. spike.

(C) is concealed by the overlapping spikelets.

Spikelets are borne pediceled (that is, on a pedicel or foot stalk) or sessile (without a pedicel) in leafless panicles, racemes, or spikes (Fig. 10). These different types of inflorescence insensibly grade into one another. The axis and branches of a panicle and the rachis of a raceme or spike may be as elaborately modified and specialized as may be the parts of a spikelet. The axis, rachis, or branches may be continuous (not jointed), or articulate (jointed) and usually disarticulating (breaking up). The breaking up takes place at definite points and has to do with scattering the seed. The point of disarticulation is the same in grasses of the same kind (or genus) and is usually alike in related genera, and for this reason is of great importance in the classification of grasses. When there are no joints in the axis or branches, the disarticulation comes in the spikelet, either above the glumes and between the florets or below the glumes. Modifications of these two ways of disarticulating will be met with later. The study of the form of inflorescence and the modification of its parts will be carried on together with that of the spikelet.

#### SUMMARY

A spikelet consists of glumes and florets, in two ranks and alternate on the rachilla, the florets consisting of lemma, palea, and the inclosed flower. Every organ found in the most highly specialized spikelet is to be interpreted as an elaboration or a reduction of one of these parts. The spikelet is the unit of the inflorescence; the floret is the unit of the spikelet. The spikelet is always simple; that is, the rachilla never branches. The floret is always 1-flowered with never more than one lemma and one palea; the glumes and florets are always alternate, two consecutive ones never being borne one above the other.

These basic facts kept in mind will aid in the recognition of complicated or congested spikelets and in the correct interpretation of their parts.

#### REVIEW

(1) Examine a spikelet of a brome-grass, such as cheat or chess. Separate the florets from one another and from the glumes. Note that these disjoint without tearing. Open out the lemma and palea. Note that these permanently adhere at their base; that they can only be torn or cut apart.

(2) Name the parts of a spikelet.

(3) What is their arrangement?

(4) What is the difference between a rachis and a rachilla?

## LESSON III

#### **MODIFICATIONS OF THE SPIKELET**

TAKING the generalized spikelet as a beginning, examine Figs. 4 and 8. Note that the glumes and lemmas have nerves or veins (fibro-vascular bundles) running from the base to the apex or nearly to it, one nerve in the middle and an equal number on each side, there being an odd number of nerves in the glumes and lemmas. In the palea there are only two nerves; none in the middle. The modifications and variations of spikelets will be studied, as nearly as possible, in the order of their increasing complexity. No attempt should be made to fix in mind the forms of specialization here enumerated. This lesson is only meant to put one on the lookout for modifications, so that one may be prepared to recognize a given organ under various guises.

(1) Spikelets differ in size. (Bromus or bromegrass, meadow fescue, and blue-grass are examples.)

(2) The number of florets may be reduced to one or increased to twenty or more.

(3) The parts of the spikelet vary in their relative sizes. The glumes may be large and the florets small or the florets large and the glumes small.

(4) The rachilla joints may be slender or thick, so short that the florets appear to be opposite, or nearly

#### MODIFICATIONS OF THE SPIKELET

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as long as the florets themselves; the node at the base of the floret (the callus) is sometimes prolonged into a sharp point; the uppermost rachilla joint may bear no floret and may extend into a little bristle.

(5) The glumes may vary in shape, in texture, and in the number of their nerves and may be glabrous (smooth) or pubescent (hairy); sometimes they are reduced to rudiments and sometimes they are suppressed.

(6) The lemma is subject to such great modifications that we shall now note only the simplest ones. As in the glumes, the shape and texture and the number of nerves vary. The summit of the lemma may be acute (pointed) or acuminate (long-pointed) or obtuse (blunt) or it may be lobed or cleft. The nerves may be faint or strong, or may extend into awns (bristles) beyond the body of the lemma. The lemma is sometimes minute, but it is never suppressed.

(7) The palea is always 2-nerved, but in a few grasses the nerves are so close together as to appear like a single one. In others they are far apart and the palea may split between them. The palea differs in size and texture. In a few genera it is reduced or even suppressed.

(8) Spikelets are compressed (flattened) laterally (sidewise), as in Figs. 11–14, or dorsally (on the back), as in Figs. 60–66. The side or back of a spikelet is recognized from the position of the florets on the rachilla. The palea side of the floret is always toward the rachilla. Taking this as the "front" of a floret, the back (or dorsum) is the back of the lemma. Spikelets with many florets, or those in which the glumes or lemmas are folded on the midnerve, are generally laterally compressed; those with a single fertile floret and with convex (rounded) glumes and lemma are generally dorsally compressed.

(9) Spikelets are sometimes unisexual (of one sex) instead of perfect (having both stamens and pistil). The two kinds, pistillate (the ovule-producing) and staminate (pollen-producing), may be borne on a single plant, as in corn, with pistillate spikelets in the ear and staminate spikelets in the tassel, or in different plants, as in salt-grass and buffalo-grass. Grasses with staminate and pistillate spikelets on the same plants are monoecious (which means dwelling in one house); those with staminate and pistillate spikelets on different plants are dioecious (dwelling in two houses). The unisexual spikelets of a single species may be similar in appearance, or they may be very unlike, as in corn.

(10) Some grasses with perfect spikelets bear in addition staminate spikelets or **neuter** spikelets (having neither stamens nor pistils). These additional spikelets may be similar in appearance to the perfect ones or very unlike them. They are borne in the same inflorescence as the perfect spikelets and are usually paired with them.

(11) The florets of a single spikelet may be of two kinds, perfect and sterile, the sterile being either

## LESSON IV

#### PEDICELED SPIKELETS OF FEW TO MANY FLORETS

TAKING the spikelet of cheat or chess (Bromus secalinus), Fig. 11, as a starting point, we have one but little different from the

diagrammatic spikelet (Fig. 8). [Names incidentally mentioned should not be memorized.] The lemmas are convex on the back, several-nerved, 2-toothed at the apex and bear an awn from between the teeth. The awn is the midnerve extending beyond the body of the lemma. The rachilla joints are short, bringing the florets (Fig. 11, B) close together. The articulation is above the glumes and between the florets. The palea is grown

fast to the grain. All species of

FIG. 11. A, several-flowered spikelet of Bromus secalinus; B, single

Bromus have spikelets of this character, differing in size, texture, length of the awn, which may be much longer or reduced to a mucro (a minute point) or even suppressed, in being glabrous, as in cheat, or pubescent. The pubescence may cover the lemma

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floret.

staminate or neuter. In spikelets like those of Figs.

11-14, with several to many florets, the uppermost florets are commonly sterile (not perfecting seed), though they are like the fertile florets in appearance and have rudimentary stamens and pistils. In some grasses the sterile florets are very different from the fertile ones and may be borne above or below them on the rachilla. The position of sterile florets in the spikelet is the same in large series of related grasses; hence it is of great importance in classifying genera. The type of modification of the sterile floret is also uniform within a genus, and generally in related genera. It commonly consists of a lemma without a palea, but there may be a rudimentary or even a well-developed palea.

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These types of modification will be brought out and illustrated in the succeeding lessons.

#### SUMMARY

All spikelets are built on the simple plan of 2ranked florets with a pair of glumes at the base. The spikelet as a whole and each of its organs is subject to modification. The palea and one or both glumes may be suppressed; the lemma may be reduced but is never suppressed. The position and type of modification of sterile florets are of importance in classification.

The parts of a spikelet, however complex, are recognizable as rachilla, glumes, lemma, or palea.

or be along the margins only. These differences distinguish the species. A genus is composed of one to many species having few to several important characters in common, and presumably descended from a common ancestor. Groups of species having less important characters in common form related genera. Festuca (Fig. 12) is related to Bromus,



having few to several-flowered spikelets, disarticulating above the glumes and between the florets and with several-nerved lemmas; but the lemmas are awned from the tip, or pointed only, and not toothed, and the palea is not grown to the grain.

A large number of grasses

have laterally compressed

Fio. 12. A, spikelet of *Festure a opina*; B, lemma detached. Spikelets of this general type, disarticulating above the glumes and between the few to many florets. They are

sorted into genera and the genera separated from one another chiefly according to the modifications of the lemma. In Glyceria (Fig. 13) the lemmas are broad and obtuse with strong parallel nerves. In Poa (Fig. 14) the lemmas are keeled on the back and have five nerves converging toward the acute but never awned apex. The species figured (Kentucky blue-grass, *Poa pratensis*) and many others are villous (having soft curly hairs) on the lower part of the midnerve and the marginal nerves and

> have a tuft of white cottony hairs at the base, but this pubescence is not found in all the species.

In all the grasses mentioned so far, the spikelets are borne in panicles (see Fig. 10, A). Spikelets much

like those of Glyceria (Fig. 13) but borne in a raceme and having awned lemmas are found in Pleuropogon (shown in Fig. 10, B). In these spikelets the palea is crested or winged on the nerves (Fig. 15, showing a three-quarter view of a palea removed from the floret).

Returning to Fig. 11, A, we Fig. 13. note the midnerve of the lemma *Byikelet of Clyceria* extending as an awn beyond the *septentria* minutely toothed apex. The midnalis.

nerve and the two lateral nerves as well are extended into awns in *Tridens* flavus (Fig. 16, the floret seen from the back); the apex of the lemma is toothed and Palea of the nerves are villous below. In Fig. 17 Pleuropogon (floret of *Cottea pappophoroides* opened out and seen from the back) the lemma is lobed and nine

and seen from the back) the lemma is lobed and nine to eleven of its many nerves are extended into awns.



FIG. 14. Spike-

let of Poa pratensis.

After the foregoing the spikelet and its parts will be recognized in most of the genera of the group

having few to many-flowered pediceled spikelets. As stated in Lesson III the florets in a single spikelet may be of two kinds. The simplest spikelet of this type is found in the reed (Phragmites communis). In this, the lowest Tridens



flavus. floret is staminate or neu-Fig. 17. Lemma of ter and its lemma is much longer Cottea pappophoroides. than in the other florets (Fig. 18, A). In the perfect floret (Fig. 18, B) it will be seen that the palea is very much shorter than the lemma, that the

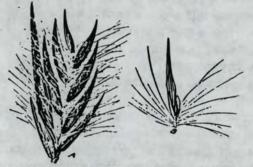


FIG. 18. A, spikelet of Phragmites communis; B, floret.

rachilla bears copious long soft hairs, and that instead of disarticulating at its summit and remaining attached to the floret next below, it disarticulates at its base, remaining as a tiny feathery stem to the floret next above, its copious long hairs carrying the

floret before the wind, dispersing the seed. [The hairs are much more copious than shown in the figure; they are slighted to avoid obscuring the difference in the florets.]



Another spikelet with two kinds of florets is shown in Fig. 19 (Melica mutica). In this the lemmas of the F10. 19. Spikelet of

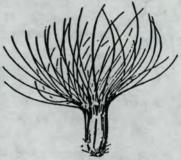
upper florets are reduced in size,

Melica mutica.

changed in shape, and contain no flower. Two or three of them are crowded together in a little clubshaped body. In the species figured, this modification is more marked than in most of the species.

In Fig. 20 is shown a side view of the florets of a spikelet of Pappophorum mucronulatum, glumes removed. The lowest floret is perfect. Its broad lemma is cut into many spreading awns (compare with Fig. 17).

florets are crowded on



The two to four other Fia. 20. Florets of Pappophorum inucronulatum.

the very short rachilla and are sterile; their lemmas are similar to that of the one fertile floret. The

#### FIRST BOOK OF GRASSES

rachilla does not disarticulate, the sterile florets remaining permanently attached to the fertile one, the numerous awns of all together forming a pappus-like crown which carries the seed before the wind. [Pappus is the "down" on the seed of a dandelion, thistle, or other plant of their family.]

Next we shall examine the inflorescence of a grass having spikelets entirely of sterile florets in addition



to spikelets of fertile florets. Examine Fig. 21, A (Cynosurus cristatus), which shows a small part of a spike-like panicle. The spikelets are borne on minute

F10. 21. A, part of a panicle of Cynosurus pedicels on very cristatus; B, sterile spikelet; C, fertile short compound spikelet. branches. The

lower one to three spikelets of each little branch are sterile, the lemmas containing no flowers (Fig. 21, B). The upper one to three spikelets are smaller and fertile (Fig. 21, C). When the bracts of the sterile spikelet are all alike empty, why are all but the lower pair called lemmas, instead of glumes? In many cases the nature of modified organs can be recognized only by their correspondence to organs in the same relative position in allied but more simple forms. In all the spikelets examined so far (and in all but a very small number of grasses) the bracts above the lower pair are flowerbearing or have a palea, which indicates their structural identity. Corresponding parts in a modified spikelet are, therefore, regarded as lemmas. In the grass just examined the sterile spikelets remain on the panicle branches after the fall of the ripened fertile florets from their glumes.

In Fig. 22, A (Lamarckia aurea), is shown a fascicle of one fertile and three sterile spikelets of another grass. In this the fascicles hang from the short slender branches of a narrow panicle and disarticulate from them, falling entire. This is the first example we have had so far of disarticulating branches of the inflorescence. In the figure the fascicle is seen from the inner face to show the fertile spikelet, which from the outside is nearly hid-



F10. 22. A, fascicle of three sterile and one fertile spikelet of Lamarckia aurea; B, fertile spikelet.

den by the sterile ones. Fig. 22, B, shows a separate fertile spikelet. It will be seen that except for the glumes the two forms are strikingly different. The fertile spikelet is reduced to one fertile and one rudimentary floret, both awned.

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while the sterile spikelets are many-flowered and awnless.

We shall next examine a grass having unisexual spikelets (see Lesson III, page 23), the two forms



borne on different plants (dioecious). (In the group with relatively simple spikelets which we are now studying there are no monoecious grasses). In Fig. 23 are shown the pistillate and staminate spikelets of salt-grass (*Distichlis spicata*). They differ but little in appearance and are both

FIG. 23. Pistillate and staminate spikelets of Distichlis spicata.

borne in narrow panicles. [2 signifies female, d' male. These signs are commonly used to indicate pistillate and staminate plants, respectively.]

In Fig. 24 are seen the strikingly Fig diverse staminate and pistillate spikelets

F10. 24. Staminate and pistillate spikelets of Scleropogon brevifolius.

and pistillate spikelets of another dioecious species

(Scleropogon brevifolius). The lemmas of the staminate spikelet are merely pointed; those of the pistillate spikelet bear three long slender twisted spreading awns. The pistillate florets fall from the glumes as a whole (the rachilla not disarticulating between them) and roll before the wind as tiny tumbleweeds.

#### SUMMARY

The inflorescence and the two- to several-flowered spikelets of the brome-grasses, blue-grasses, and their relatives are comparatively simple. In a few genera sterile spikelets are developed and in a few others the spikelets are unisexual.

#### REVIEW

Collect specimens of orchard-grass, meadow fescue, any species of brome-grass, or of Poa, or of any available grasses having laterally compressed, few to several-flowered spikelets. Identify the different parts of the spikelets. Lemmas may be spread out for examination by cutting off the very base with a sharp knife or scalpel. Spikelets of tough or rigid texture if soaked in water for a few minutes may be dissected without tearing. If very tough or hard, boiling the spikelets in water with a little glycerine (a drop of glycerine to about a teaspoonful of water) will make them manageable and keep them from drying out during dissection.

## LESSON V

#### SESSILE SPIKELETS IN TWO-SIDED SPIKES

again to the spikelet of Bromus

secalinus (Fig. 11), we shall strike

out in another direction. Differentiation among living beings does

not follow a line, but radiates like

waves following the falling of a peb-

ble in the water, or rather like waves

of sound, in all directions. Hence we

can not follow an unbroken line in

studying the increasing complexity

RETURNING



of the inflorescence of grasses. We can only return to the center and start out on another line. Compare Fig. 10, A and B, with C, and with Fig. 25 (couch-grass or quack-grass, Agropyron repens). A raceme is a panicle reduced to its lowest terms. Eliminating the pedicles of the spikelets of a raceme we have a spike, the spikelets set directly upon the rachis. In such an inflorescence the rachis is usually more or less thickened. In Fig. 25, A, part of a spike is shown all but from the flat side of the spikelet. The rachis is jointed and a spikelet is

Fig. 25. A, part of a spike of Agropyrepens; B, of rachis seen from the edge, two spikelets removed.

# borne at each joint, alternating on opposite sides.

The rachis is thickened and the joints slightly hollowed on alternate sides. (See Fig. 25, B, a diagrammatic illustration of the rachis seen from the edge with all but two spikelets removed.)

SESSILE SPIKELETS IN TWO-SIDED SPIKES

The spikelet is not very different from that of

Bromus (Fig. 11) and as in that, the ripened florets fall from the glumes.

In the group of grasses taken up in this lesson the specialization is mostly in the rachis and in the position of the relatively simple spikelets.

In Fig. 26, a spikelet of cultivated wheat (Triticum aestivum), we have the same type of



FIG. 26. Spikelet of Triticum aestivum.

spikelet as in Fig. 25 but with fewer and much plumper florets, with broader lemmas slightly toothed at the apex, and with long awns that are scabrous (rough, like a file). [Awns form the "beard" of wheat.] The spikelets are borne on a jointed rachis as in Fig. 25 (Agropyron repens) but the joints are shorter, bringing the spikelets closer together and hiding the rachis. In this, cultivated wheat, the florets do not readily fall from the glumes but re-

#### SESSILE SPIKELETS IN TWO-SIDED SPIKES 37

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main in the spike and the ripened grain is thrashed from them. This persistence of the lemma and palea has been fixed by selection in cultivation. In the closely related emmer (*Triticum dicoccum*) the



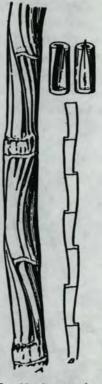
rachis breaks at the joints, each joint remaining attached to its spikelet.

Compare Fig. 27 (Lolium multiflorum) with Fig. 25. Note that in Fig. 25 the spikelets are borne flat side against the rachis, while in Fig. 27 they stand with their edges against the rachis. The rachis itself is of the same type as that in Fig. 25. The diagrammatic rachis with two spikelets seed edgewise (Fig. 25, B) is shown from the same position as is Fig. 27. In this, as in Agropyron, the rachis is continuous (not disarticulating) and the florets fall. If

Fig. 27. Part of a spike we separate a spikelet from the of Lolium multiforum.

rachis we find that the first glume (the one that would be against the rachis) is suppressed, the first floret lying directly against the rachis. In the single spikelet borne at the summit of the rachis the first glume is developed and is about as large as the second. When but one glume is present, we know which glume it is and which is suppressed by the position of the first floret, which is always above the first glume. When no glume is found below the first floret, it is obvious that it is the first glume which is suppressed.

In Fig. 28 (Monerma cylindrica) we have a greatly thickened, strongly nerved rachis with spikelets placed as in Fig. 27 but reduced to the second glume and a single floret. This little spikelet is sunken in the hollow of the rachis joint, the second glume fitting snugly over the hollow, the whole forming a long, slender, wiry cylinder. At maturity the rachis disarticulates with the spikelets firmly embedded in the joints. (See diagram of rachis, Fig. 28, B, and, above, a joint with spikelet removed, showing the hollow, and a second with the spikelet in position.) The plant bearing these spikes grows along mudflats near the sea. The rachis joints are cylindrical and readily roll down the slope to the water. Being corky, they are carried by the lightest ripples and are thus spread over wide areas. The grain



F10. 28. A, part of a spike of Monerma cylindrica, B, diagram of rachis, spikelets removed; above, diagram of single joint.

germinates within its little cell, and the young roots and leaves push aside the water-soaked glume.

Returning to Fig. 25 with its one spikelet at each joint, flat against the rachis, compare with it Fig. 29 (Elymus vir-

In this there are two

spikelets at each joint

glumes back to back,

the spikelets somewhat

distorted, each pair

reaching around the

edges of the rachis. The figure shows a pair of

spikelets and two joints

of the rachis, with the

pair of spikelets next

above, on the opposite

side of the rachis, lightly

sketched in behind; two

more internodes of the

rachis, with spikelets re-

moved, are shown by

dotted lines. A diagrammatic sketch of a

pair of spikelets, the dis-

tortion reduced, is

shown above. A com-

parison of the diagram-

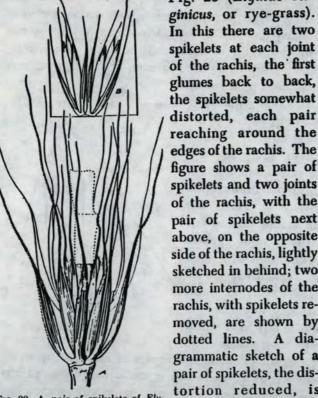


FIG. 29. A, pair of spikelets of Elymus virginicus; B, diagrammatic figure of the pair of spikelets.

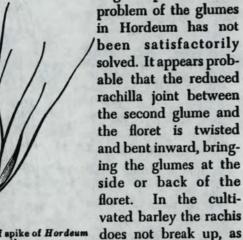
matic spikelet with the spikelet in Fig. 25 will show the structural similarity. In their natural position the

## SESSILE SPIKELETS IN TWO-SIDED SPIKES

spikelets, overlapping on the short joints and extending around the edges of the rachis, so that at least one is seen nearly edge-wise, form a spike that may well be confusing to the beginner, especially when, as in the species shown in Fig. 29 and several others, the glumes stand out like a 4-rayed involucre below the appressed florets. However, a single joint with its spikelets attached cut out of the spike readily discloses the structure. In some species of Elymus there are three spikelets and occasionally four or five at a node, the distortion being correspondingly greater. In several species the glumes are so narrow as to appear like bristles or awns only. In most of the species the rachis is continuous and can not be disjointed. In a closely related genus, Sitanion, the rachis disarticulates at the base of each joint, the slender rigid joint remaining as a tiny sharp-pointed stem below the cluster of long-awned spikelets. The awn-like glumes of Sitanion commonly split between the nerves, sometimes to the very base, appearing like a cluster of awns below the florets.

In Elymus and Sitanion the spikelets are all alike (or some occasionally variously aborted) and all sessile (set directly on the rachis). In Fig. 30 (Hordeum brachyantherum, one of the wild barleys), a group of three spikelets and a joint of the rachis are shown. As in Sitanion the rachis disarticulates at the base of the internode, the joint remaining attached to the spikelets above it. Note that the central spikelet is sessile and the lateral ones pediceled, that the lower

floret of the central spikelet is well developed while those of the lateral florets are rudimentary, and that the back of the floret is turned from the rachis with the glumes (bristle-like in this species) at the sides or back, contrary to the arrangement characteristic of grass spikelets. The



F10. 30. Joint of spike of Hordeum brachyantherum.

continuous rachis having been fixed by selection. The florets fall from the spike in thrashing, or in naked or hull-less barley the grains fall from the lemma and palea, as in wheat. In cultivated 2-rowed barley the lateral spikelets are pediceled and sterile, as in the wild species, but in a 4-rowed and 6-rowed barley the lateral spikelets are sessile and fertile, characters fixed by selection.

in the wild species, the

The grasses characterized by the spicate in-

#### SESSILE SPIKELETS IN TWO-SIDED SPIKES 41

florescence dealt with in this lesson form the barley tribe, which from the standpoint of man is the most important group of grasses, if not of all plants, in the world, containing wheat, barley, and rye.

#### SUMMARY

The specialization in spicate inflorescence is chiefly in the rachis and next in the position of the relatively simple spikelets.

When the glumes are distorted, standing side by side, as often found in species of Elymus, or when one of them is suppressed, we can tell which is which from the fact that the first, or lowermost, floret is always above or on the same side of the spikelet as the first glume.

#### REVIEW

Collect heads of wheat, rye, barley, quack-grass, species of Elymus, Lolium, or squirrel-tail grass (one or more of these will be found anywhere in the United States). Note whether the rachis readily disjoints. If so, separate out a single joint with the spikelets attached. Note where the rachis breaks, at the summit or base of the joint; note the number of spikelets at a joint and the number of florets to a spikelet. Distinguish the individual spikelets and their parts. If the rachis does not disjoint, cut across the middle of the internodes, taking out a single joint with attached spikelets. Note the number of spikelets to a joint; whether there are one or two to several fertile florets to the spikelet and whether the spikelet is placed flatwise or edgewise to the rachis.

Note how spikes bearing spikelets with scabrous awns push themselves forward when handled.

#### PEDICELED SPIKELETS WITH LARGE GLUMES

which the midnerve leaves the body of the lemma about the middle of its back and becomes a free awn, while the lemma above the departure of the awn is nerveless. This is invariably the case when

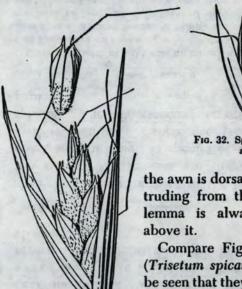


Fig. 33. Spikelet of Danthonia

spicata; floret above.

FIG. 32. Spikelet of Trisetum spicatum.

the awn is dorsal (that is, protruding from the back); the lemma is always nerveless

Compare Figs. 31 and 32 (Trisetum spicatum). It will be seen that they are the same type of spikelet. In Trisetum the awn is loosely twisted and is borne nearer the apex of the lemma, which is tipped with two slender teeth.

In Danthonia spicata (Fig. 33) the florets are more numerous and are smaller in proportion to the glumes. The broad strongly twisted awn arises from

## **LESSON VI**

## PEDICELED SPIKELETS WITH LARGE GLUMES AND OTHER MODIFICATIONS

TURNING again to the spikelet of Bromus secalinus (Fig. 11), compare with it Fig. 31 (wild oats, Avena fatua). The

> glumes are greatly enlarged and the rachilla joints are

so short that the

florets appear to be almost oppo-

site. The awn,

instead of extend-

ing from the apex

of the lemma, pro-

trudes from the

back and is

twisted for about

half its length.

We noted in Les-

son IV that the

awn is an exten-

sion of the mid-



Fig. 31. A, spikelet of Avena fatua; B, floret.

nerve. This fact is well shown in the floret of wild oats (Fig. 31, B, the floret seen from the back), in

between the teeth or lobes of a bidentate (2-toothed) apex (see floret above, seen from the back).

In these three spikelets, as in all-but a few of the grasses of the oat tribe, the florets fall from the glumes which remain on the pedicel. In velvet



grass, Holcus lanatus (Fig. 34), the spikelet falls entire. The articulation of the spikelet, taken throughout the grass family, is so nearly uniform for related genera that it is relied on to differentiate large series. (See Lesson II, on inflorescence). There are exceptions to the mode of articulation characteristic of the group as a whole in the case of a few genera in

F10. 34. A, spikelet of Holcus lanatus; B, pair of florets.

three of our tribes. Such exceptions are puzzling to the beginner, leading him astray in using keys. We must learn to observe all the characters of the inflorescence and base our judgment on the sum total of the characters, remembering that "Nature does as she pleases" and rejoicing that in grasses she at least pleases to keep invariably to the 2-ranked arrangement of the spikelets. (See the summary of Lesson II.) In Lesson IV, Figs. 18 and 19, we observed spikelets in which the florets were of two kinds. In *Holcus lanatus* the lower floret is perfect and awnless and the upper is staminate and

#### PEDICELED SPIKELETS WITH LARGE GLUMES 45

bears a hook-like awn from the back (Fig. 34, B, florets removed from the glumes. Note the curved and exceptionally long lowermost rachilla joint).

In Sphenopholis, closely related to Trisetum (Fig. 32), the spikelets fall entire, as in velvet-grass. In tall oat-grass (Arrhenatherum elatius) the spikelets bear one perfect awnless floret and one staminate awned floret, as in velvet-grass, but their position is reversed, the staminate being below and the perfect above.

#### SUMMARY

In the oat and its relatives the large glumes and the awn of the lemmas are the most prominent characters, although in species of some genera the awn is wanting. Pubescence is commonly conspicuous. The inflorescence is an open or contracted panicle.

#### REVIEW

Collect panicles of wild oats or awned specimens of cultivated oats (cultivated oats growing wild commonly bear awns), of Danthonia, one or more species of which are to be found throughout most of the United States, and any of the related grasses available, and examine the spikelets. Place a floret with a twisted awn in a drop of water and observe the result. In awnless florets of cultivated oats note that the midnerve of the lemma, if it is not at all produced into an awn, stops abruptly at the point where the awn would arise normally and that the lemma is nerveless above this point, just as if it were awned.

## LESSON VII

#### PEDICELED ONE-FLOWERED SPIKELETS

TURN to the spikelet of wild oats (Fig. 31) and in imagination eliminate all but the lowest floret and the glumes. Better still, with a spikelet of oats in hand break off all above the lowest floret. Now we have a large model or pattern of the reduced spikelet of a very large number of grasses, redtop, timothy, and their kind.

Examine Calamagrostis canadensis (Fig. 35, the floret raised from its glumes) and note how it corre-



sponds to the pattern obtained by reducing the spikelet of oats to a single floret. The only vestige remaining of the other florets is the minute rachilla joint back of the palea (shown, exaggerated somewhat, in Fig. 35). In all but a few genera the rachilla is entirely suppressed. Compare Fig. 35 with Fig. 32

FIG. 35. Spikelet of Calamagrostis canadensis.

and note that Trisetum reduced to a single floret would closely resemble Calamagrostis.

In Agrostis (Fig. 36) the rachilla is normally suppressed. In two species in the far West it is present as a minute rudiment. In most of the species

## PEDICELED ONE-FLOWERED SPIKELETS

the palea also is suppressed or represented by a rudiment only (Fig. 36, Agrostis hiemalis, the floret

with palea wanting, raised from the glumes). Here we have specialization through elimination, the spikelet reduced almost to its lowest terms, one floret with no palea, no awn, no callus hairs. In this particular species the very open panicles break off and roll before the



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wind as tumbleweeds, scattering the FIG. 36. Spikeseed. Several species of Agrostis have awned lemmas and some have callus

let of Agrostis hiemalis.

hairs, shorter and less copious than in Calamagrostis. In Sporobolus (Fig. 37, the floret raised from the

> glumes and containing a mature grain) the nerves of the palea are wide apart and the internerve (the space between the nerves) is thin in texture and readily splits as the grain matures. In some species it splits to the apex, resulting in an object sorely puzzling to the beginner, the two halves appearing like two 1-nerved lemmas or paleas, in addition to the lemma itself. It is

F10. 37. Spike- in such cases as this that a knowledge let of Sporobolus airoi of the structure of the grass spikelet is necessary for the correct interpretation

of the organs observed. In this genus and in a few others the pericarp (meaning around the fruit), the wall of the ripened ovary which forms a covering

for the grain and is usually grown fast to it, is free from the grain. In most of the species it is a loose thin sac, which readily tears when moistened, leaving the grain naked. In one of our species (Sporobo-

lus heterolepis) the pericarp is firm, like a thin shell about the grain. In Cinna the two nerves of the

palea are so close together that they appear to be a single nerve. In one of the species this nerve may be easily split into two, demonstrating the derivation of the apparent single nerve.

FIG. 38. Spikelet of Phleum pratense; floret above. In several genera the glumes are enlarged. In timothy (Fig. 38) they are firm in texture, strongly

keeled, and abruptly awned, while the lemma is much smaller, thin in texture, and awnless. The spikelets are so congested on the short branches of the cylindrical spike-like panicle that the beginner may be puzzled to know just what is the unit of inflorescence. Keeping in mind that a spikelet never is compound, the student will divide and redivide the cluster until he finds an object having a single pair of glumes containing the floret. F Another modification of the glumes

F10. 39. Spikelet of Alopecurus geniculatus. is shown in Alopecurus (Fig. 39). The margins are grown together for half their length. As in *Holcus lanatus* (Fig. 34) the articulation is an exception to that generally characteristic of its allied genera, the spikelets falling entire. The lemma bears a delicate dorsal awn and the palea is suppressed. In most species of Alopecurus the panicle is as dense and spike-like as that of timothy.

In some genera the glumes are reduced (see Fig. 42), and in a few species the first glume is suppressed.

In Lesson IV, Fig. 21, we noted perfect and sterile spikelets in the same panicle and in Fig. 22 we found the spikelets falling in clusters of three sterile and one perfect spikelet. In Lycurus (Fig. 40) the spikelets are in pairs on the ultimate branchlets of the spike-like panicle, the lower spikelet sterile, the upper perfect. The ultimate branchlet itself falls with the spikelets attached, as in Lamarckia (Fig. 22). Lycurus shows an-



FIG. 40. Pair of spikelets, sterile and fertile (spread apart) of Lycurus phleoides.

other peculiar character in the 2-nerved first glume, one lateral nerve being undeveloped or very faint. The midnerve is extended into a long awn and the one lateral nerve is usually extended into a shorter awn, but is sometimes a mere tooth.

The glumes and lemma in the spikelets so far examined in this lesson have been of like texture, membranaceous (like a membrane or skin).

In Muhlenbergia (Figs. 41 and 42) the lemma is

firmer in texture than the glumes. In some species of the genus the glumes are much reduced, and in some they are well developed and often awned. The lemmas are promi-F10. 41. Spike- nently 3-nerved and are lenbergia fo. awned or mucronate, that let of Muhis, the midnerve extend-

ing in a minute point.

In four of our genera the lemma at



liosa.

maturity is firm and hard in texture and the nerves are scarcely visible. In Milium (Fig. 43) the lemma is rigid, smooth, and shining and the palea is of

FIG. 42. A, spike-

let of Muhlenbergia schre-

beri; B, branchlet with the mi-

nute glumes of

two spikelets

from which flo-

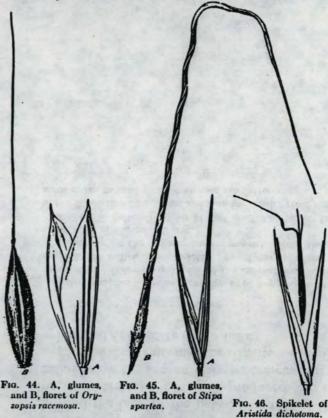
rets have fallen.

43. A, spikelet FIG. of Milium effusum; like texture. In Oryzopsis (Fig. 44) the B, floret.

lemma bears an awn that readily disarticulates at its base. The palea is nearly inclosed by the lemma.

#### PEDICELED ONE-FLOWERED SPIKELETS 51

In Stipa (Fig. 45) and Aristida (Fig. 46) the palea is entirely inclosed in the lemma. The callus (see



page 22) is developed into a needle-like point that readily penetrates clothing or works its way into the wool of sheep.

In Stipa the awn is composed of all the nerves of the lemma, forming a solid slightly flattened elongate body, the point of departure from the body of the lemma being marked by an abrupt contraction or a ring of hairs. In some species the lower part of the awn is plumose (covered with soft fluffy hairs, like a feather).

In Aristida the awn is divided into three; that is, the three nerves at first unite, then separate. The lemma tapers into the awn with no visible junction, as in Stipa. Sometimes the undivided part of the awn is elongate, forming a slender neck and sometimes this neck is twisted. In Aristida dichotoma, the species shown (Fig. 46), the lateral awns are much shorter than the central one. In many species the three are subequal, and one or all may be recurved or loosely twisted at the base. They are never tightly twisted, as in Stipa.

#### SUMMARY

The specialization in this group of grasses consists in the reduction of the relatively simplified spikelet to a single floret. In most of the genera the spikelets are very small. The glumes may be reduced to rudiments or suppressed or may be well developed and somewhat elaborated. The lemma may be delicate or indurate (hardened) and may be awned from the back or the summit. The palea shows more modification in this group than in any other. It may be suppressed or it may be as long as

#### PEDICELED ONE-FLOWERED SPIKELETS 53

the lemma; the two nerves may be coherent, appearing as one, or widely separated with the delicate internerve splitting. The rachilla may be extended beyond the base of the palea, a vestige of the suppressed florets, or it may be produced into a sharp callus below the lemma. The inflorescence is always a panicle, but this may be diffuse or dense and cylindrical or capitate (like a head).

#### REVIEW

Collect panicles of redtop, timothy, or of any grass with laterally compressed 1-flowered spikelets. If the inflorescence is dense, distinguish the individual spikelets. Dissect the spikelets and note whether any of the organs are suppressed. Note the point of attachment of the awn, if any.

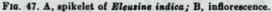
If possible, collect panicles of any species of Stipa. Lay a few of the florets in a little water and note the result. Note that twisted awns or the twisted parts of an awn are flattened.

## LESSON VIII

#### SESSILE SPIKELETS IN ONE-SIDED SPIKES

As stated in Lesson V, development does not follow a single line, so, having come to the end of one line, we must repeatedly return to the center and start in a new direction. In the group of grasses taken up in this lesson the principal character common to all is the spicate inflorescence. In the grasses related to barley (Lesson V) we found solitary 2-sided spikes, the spikelets sessile on opposite sides of the rachis. In the present group we have 1-sided (unilateral) spikes, the spikelets sessile or nearly so along one side of the rachis. The spikelets themselves range from the simple one of yard-grass, Eleusine indica (Fig. 47), to highly specialized ones. Compare Fig. 47, A, with Figs. 11 and 14. It will be seen that, although the glumes and lemmas of Eleusine are strongly keeled, the spikelets are of the same type; but these spikelets are very differently arranged (Fig. 47, B), being crowded and imbricate (overlapping like shingles) in two rows on one side of the rachis. Two to several of these spikes are borne together, digitate or nearly so. [Digitate means arranged like fingers (digits), but as a botanical term it indicates an arrangement more like that SESSILE SPIKELETS IN ONE-SIDED SPIKES 55





of a bird's toes, the spikes borne on so short an axis that they appear to spring from the same point.]

In Lesson VII we obtained the pattern of the 1-flowered spikelet by eliminating all but the lowest floret and the glumes from a several-flowered spikelet. Eliminating all but the lowest floret of Eleusine we have a model



F10. 48. A, spikelet of Cynodon dactylon, floret raised above the glumes; B, inflorescence.

of the spikelet of Bermuda-grass, Cynodon dactylon (Fig. 48, A). A vestige of the eliminated florets re-

mains in the prolonged rachilla, often with a rudimentary floret at its apex. The arrangement of the inflorescence (Fig. 48, B; three of the spikes indicated in skeleton only) is the same as in Eleusine.



F10. 49. A, spikelet of Chloris latisquamea; B, fertile lemma spread out; C, sterile lemma spread out; D, inflorescence.

Compare Figs. 48 and 49 (Chloris latisquamea). In the latter, the upper florets instead of being suppressed are developed into one or a few sterile florets, consisting of modified lemmas without paleas. Turn to Lesson III in which sterile florets are discussed

#### SESSILE SPIKELETS IN ONE-SIDED SPIKES 57

(page 23). In Melica (Fig. 19) we had an example of such sterile florets, and in Chloris we have another. In each case, the sterile lemmas if spread out show their derivation from the ordinary fertile lemmas.

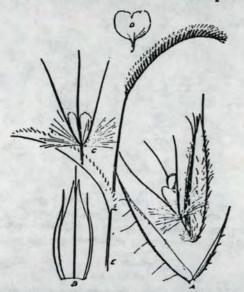
In grama grass, Bouteloua (Figs. 50 and 51), is found the greatest specialization of the sterile floret. It is often more prominent than the fertile floret and so modified that its derivation is not always obvious. The pattern of its lemma, however, is like that of the fertile one, 3-nerved, the nerves extending into awns (Figs. 50, C, and 51, C). The internerves are commonly broadened and reduced (as in Fig. 51, C), or even suppressed. There is usually a single such floret, but in some species there are two, or even three. A second sterile lemma when present may have a single awn or be



F1a. 50. A, spikelet of Bouteloua curtipendula; B, fertile lemma spread out; C, sterile lemma spread out; D, inflorescence.

awnless, or even nerveless (Fig. 51, D). In a few species the sterile floret sometimes incloses a palea and stamens. Note that in Bouteloua the spikes are not digitate, as in the foregoing genera, but are

racemose (Figs. 50, D, and 51, E); that is, the axis between the spikes is elongate instead of greatly reduced. (In Fig. 10, B, is shown a raceme of spikelets; in Bouteloua we have a raceme of spikes, each



F1a. 51. A, spikelet of Bouteloua gracilis; B, fertile lemma spread out; C, first sterile lemma spread out; D, second sterile lemma spread out; E, inflorescence.

composed of few to many sessile spikelets.) In Bouteloua gracilis (Fig. 51) and related species the florets, as is usual in this group, fall from the glumes, these remaining on the rachis. In B. curtipendula (Fig. 50) and its relatives, the entire spike falls from the main axis. 1.11

In an allied genus, Cathestecum (which looks like a diminutive Bouteloua), with but one species in the United States, the spikes consist of three spikelets crowded on the short rachis, the uppermost fertile, the two lower staminate or neuter. The spikes fall as a whole from the axis.

In Lesson III (page 24) it is stated that the position of sterile florets in the spikelets is the same in large series of related grasses. In the spikelets so far studied in this lesson the sterile florets are above the perfect one. There is a single exception to this rule in Ctenium, in which the two lower lemmas are well developed but empty, the third fertile, and the upper one to three empty, like the lower.

In two genera in this group, Spartina and Beckmannia, the spikelets fall entire. (See Lesson VI, page 44, on exceptions). In Spartina the spikelets are strictly 1-flowered; in Beckmannia they are usually 1-flowered, but sometimes a second floret is developed.

Throughout we have seen widely different forms, such as Eleusine and Bouteloua, connected by intermediate forms like Cynodon and Chloris. Such an intermediate between pediceled spikelets, as in Bromus, Poa, and others of Lesson IV, and sessile spikelets, as in the group we are now studying, is found in Leptochloa, in which the spikelets are arranged along one side of the slender rachises, but are borne on very short pedicles. The spikelets of our other genera in this highly specialized group present

no special difficulty, except those of buffalo-grass, to be studied later.

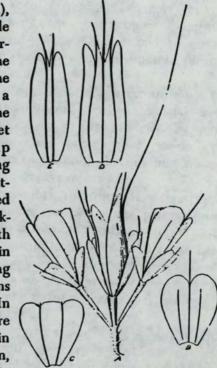
#### SUMMARY

In this group the spikelets are sessile in 1-sided spikes, solitary, digitate, or racemose. In most of the genera the upper florets are sterile, their lemmas greatly modified, or they are wholly suppressed.

#### REVIEW

Collect the inflorescence of Bermuda-grass, yard-grass, any of the grama-grasses, or of any available grass with 1-sided spikes. Note the arrangement of the spikes on the main axis; distinguish the individual spikelets and identify their parts.

IN Lesson IV, Fig. 22 (page 31), we had an example of fertile and sterile spikelets in the same fascicle, the fascicle falling as a whole. Because the type of spikelet showed kinship with grasses having many-flowered laterally compressed spikelets, Lamarckia is placed with them, although in its fascicles falling as a whole it forms an exception. In the grasses we are about to study in the present lesson, tic specialization.



clustered spikelets are the characteristic specialization. Fig. 52. A, fascicle of Aegopogon tenellus; B, lemma, and C, palea, spread out, of sterile spikelet; D, lemma and E, palea of perfect spikelet.

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# LESSON IX

### **DIVERSELY SPECIALIZED SPIKELETS**

Examine Fig. 52 (Aegopogon) in which A represents a fascicle (spread apart) of one fertile and two sterile spikelets attached to the branch which falls with them. These little fascicles are racemose and nodding on the main axis.

In Hilaria (Fig. 53) the plan is the same, but the fascicles are sessile on the axis and erect, the spikelets are sessile in the fascicle, the glumes are elaborated



FIG. 53. A, fascicle of *Hilaria belangeri*; B, glumes (inner face) of staminate spikelet; C, two views of perfect spikelet; D, fertile floret.

and very unsymmetrical, and the sterile spikelets have two florets. The species figured is the commonest one. The fascicles of some of the other species are even more fantastic than these. The glumes and lemma are always sharply folded and compressed laterally. In one species the glumes of the sterile spikelets are broad and fan-shaped, in another they are curiously lobed and awned. In all the species they are exceedingly variable, but in each they follow a general pattern. The glumes of

### DIVERSELY SPECIALIZED SPIKELETS

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the fertile floret are often slightly adnate to (grown to) those of the sterile spikelets, making the fascicle somewhat difficult to dissect. It is in such cases as this that the fundamental concept of the structure of a grass spikelet enables one to recognize the spikelet and its parts. So much elaboration for the production of a single grain is very exceptional in grasses, which as a whole tend to the elimination of non-essentials.

A third grass having spikelets in little fascicles is Tragus (see Fig. 54). This is probably not closely

related to Aegopogon and Hilaria, but is commonly grouped with them because of its fascicles falling entire. This little bur-like fascicle is composed of two spikelets, both usually perfect (some-



FIG. 54. A, bur-like fascicle of Tragus berteronianus; B, single spikelet; C, floret.

times with a third reduced one). The minute first glumes are back to back, and the large second glumes, covered with stout hook-like hairs, face outward. Note that the glumes are not folded as in Aegopogon and Hilaria but convex. These spikelets afford an excellent example of spine-like hairs. Hairs are an outgrowth of the epidermis (skin) and have no connection with the fibrous structure of the plant. The "thorns" of the rose furnish a well-known

### DIVERSELY SPECIALIZED SPIKELETS 65

#### FIRST BOOK OF GRASSES

example. However stout they may be, they may readily be broken from the bark without tearing the wood. The thorns of hawthorns, plums, and locusts, on the contrary, however slender, can not be broken off. Being reduced branches, the woody fiber (vascular bundles) extends into them from the skeleton of the plant.

In all the spikelets figured heretofore the sterile florets when present were above the perfect floret.

> In a group of grasses represented by only three genera

in the United States, the

spikelets bear a pair of sterile florets below the single per-

fect floret and these fall attached to the fertile one. In

sweet vernal-grass, or An-

thoxanthum (Fig. 55) the

sterile florets consist of

empty lemmas unequally awned from the back and

divided above the insertion

of the awn. The fertile floret

is much smaller, awnless,

smooth, and shining. A be-



FIG. 55. A, spikelet of Anthoxanthum odoratum; B, pair of sterile florets below the perfect floret; C, perfect floret.

foret. ginner, in dissecting this spikelet, might mistake this fertile floret for the grain and so take the sterile florets for a lemma and a very peculiar palea. Whenever a spikelet or any of its parts seems to present a marked departure from the normal type (such as a 1-awned palea would be), it is advisable to reëxamine and to reconsider. A close examination of this fertile floret will reveal the thin edges of the lemma infolding the palea. A grain may always be recognized by the embryo at the base on the back. (See Fig. 5, A.)

In Hierochloe (called holy-grass, vanilla-grass, or Seneca-grass) the sterile florets are awnless and contain paleas and stamens. Like Anthoxanthum, the

whole plant is fragrant. These are the grasses of which sweet-grass baskets are made.

In Phalaris the glumes are enlarged and strongly keeled or, as in canarygrass, *P. canariensis* (Fig. 56), wingkeeled, and the sterile florets are reduced to small empty lemmas. In one species, *P. minor*, the first sterile floret is reduced to a minute rudiment, and in the common reed canary-grass, *P. arundinacea*, both sterile lemmas are narrow and hairy.

In Lesson VII, Fig. 42 (page 50), we had an example of greatly reduced glumes. In rice, Oryza sativa (Fig.

F10. 56. A, spikelet of Phalaris canariensis; B, fertile floret with pair of small sterile florets attached at base.

57), the glumes are minute, and the lemma and palea are indurate (hardened) and compressed laterally. Some varieties of rice have an awned lemma. In an allied genus, Leersia (Fig. 58), the glumes are wholly suppressed.

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anomalous in that it has three nerves. Throughout the grasses the palea has two nerves, rarely suppressed, as in Agrostis, where the palea itself is much reduced, or so close together as to be merged into one, but in no case are more than two nerves known. The problem presented by this spikelet has not been satisfactorily solved. It is possible that the two organs are, respectively, the second glume and the lemma, the first glume and the palea being suppressed. In the pistillate spikelet the palea is 2-nerved. In the perennial wild rice of the southeastern States, Zizaniopsis miliacea, this 3-nerved organ is present in both the staminate and pistillate spikelets, and in another related genus, Luziola, both bracts of the spikelets are several to many nerved.

#### SUMMARY

In the highly specialized spikelets studied in this lesson the various organs are identified (1) by their position, bearing in mind that the bracts of a spikelet are 2-ranked and alternate on the rachilla, and (2) by their resemblance to corresponding organs in allied grasses.

#### REVIEW

Hilaria, Tragus, and Aegopogon are found only in the Southwest, but the other grasses studied in this lesson are widespread. In any region in the United States will be found one or more of them. Collect any that are available, examine the inflorescence, distinguish the spikelets, and identify their parts.

If in a species of Phalaris but one sterile floret is found below the perfect one, how can you tell which of the pair is suppressed?

FIG. 57. Spikelet of rice (Oryza sa-

tiva).

F10. 58. Spikelet of Leersia hezandra.

In Lesson IV, Figs. 23 (page 32) and 24 (page 32), we had unisexual spikelets, the staminate and pistillate on distinct plants. Wild rice, Zizania aquatica (Fig. 59, A and B), is monoecious, staminate and pistillate spikelets borne in the same panicle, the awnless staminate ones pendulous on the spreading lower branches, the awned pistillate ones erect on the ascending upper branches. In the pistillate spikelet the suppressed glumes are represented by a very shallow ridge around the base of the spikelet. The staminate flower consists of six stamens instead of three, as in the grasses studied heretofore. The palea of this spikelet is

F10. 59. A, pistillate spikelet, and B, staminate spikelet of Zizania aquatica.



### LESSON X

# SPIKELETS WITH MEMBRANACEOUS GLUMES AND HARDENED FRUITS

ALL the spikelets heretofore studied have been more or less compressed laterally (that is, a detached spikelet under observation lies on its side, the two ranks of glumes and lemmas to right and left of the rachilla, as in Figs. 11-14) and, with relatively few exceptions, the articulation has been above the glumes, these remaining on the pedicel after the fall of the florets. These two characters in common pertain to more than half of all our grasses. In many of the laterally compressed spikelets the florets themselves are dorsally compressed (see Fig. 11, B). We come now to a lesser group, in which the spikelets are dorsally compressed (the spikelet under observation lying on its face or back, the two ranks above and below the rachilla). In this group of grasses the rachilla joints are usually so short that the glumes and lemmas are borne one immediately above the other. The rachilla is never prolonged beyond the base of the fertile floret, as in many of the spikelets heretofore studied.

Examine Fig. 60. Note that the first glume is much smaller than the second. Turn to Fig. 11 (page 25). In imagination, remove the glumes and

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all but the two lower florets. The result is comparable to the two florets (Fig. 60, C) of Panicum, but in this genus the lower floret is staminate or sterile, and its lemma and palea differ in form and texture from those of the perfect floret (Fig. 60, D). The sterile lemma (commonly termed the "third glume" in all but recent books) resembles the second glume and incloses a small thin palea, while the

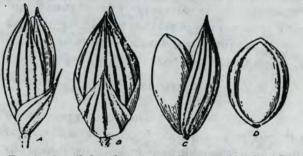


FIG. 60. A, spikelet of *Panicum miliaceum*, side view; B, same seen from the back; C, sterile and fertile florets removed from the glumes, side view; D, fertile floret.

fertile lemma is indurate, its nerves obscured in the thickened tissue, and firmly clasps a palea of like texture. At maturity the grain is inclosed in this fast-locked little case (the whole commonly termed the fruit) and germinates within it, sending its rootlet through a thin place near the base of the lemma (seen as a crescent-shaped depression at the back) and thrusting its sprout between the lemma and palea at the summit or side. In dissecting a spikelet of Panicum or its related genera the palea of the

sterile floret often adheres to the palea side of the fruit (the mature fertile floret) as a small thin scale, difficult for the beginner to account for unless he understands the structure of the spikelet.



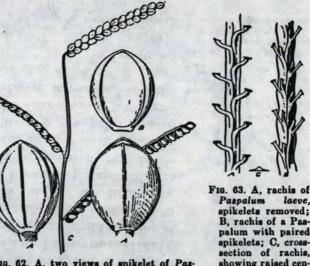
This type of spikelet is characteristic of the large number of grasses forming the millet tribe. In Panicum the inflorescence is an open or contracted panicle. In crab-grass, Digitaria sanguinalis (Fig. 61) and its relatives, the spikelets are borne in 1-sided racemes, much like those of Bermuda-grass (Fig. 48). In the crab-grasses the first glume is mi-

FIG. 61. A, two views of spikelet of Digitaria sanguinalis; B, fertile floret; C, inflorescence.

nute or suppressed, and the second is commonly much shorter than the sterile lemma and the fertile floret. The fertile lemma and its palea are less indurate than those of Panicum and the margin of the lemma is thin in texture and flat instead of being firm and inrolled, as in Panicum.

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In Paspalum (Fig. 62) the spikelets are more like those of Panicum in texture, and the margin of the fertile lemma is firm and inrolled, as in that genus. The first glume is wholly suppressed except in a few species. The spikelets are subsessile in two rows on one side of a rachis, either single (Figs. 62 and 63, A)



F10. 62. A, two views of spikelet of Pas-palum lacve; B, fertile floret; C, inflorescence.

spikelets removed; B, rachis of a Paspalum with paired spikelets; C, crosssection of rachis, showing raised center and thin margins.

or in pairs (Fig. 63, B). [In descriptions these are often referred to as 2-rowed or 4-rowed, respectively.] In species with paired spikelets some of the secondary ones (those next the center of the rachis) are always abortive. The racemes in Paspalum are sometimes solitary and sometimes digitate, as in Digitaria,

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but more commonly they are racemose on the main axis (as in Fig. 62). The rachis is sometimes winged, and in a few species the broad wings fold up over the base of the spikelets.

In Reimarochloa (represented by but one species in the United States) the spikelets are arranged as in Paspalum, but both glumes are suppressed except



in the uppermost spikelet. (Recall Lolium, Lesson V. Fig. 27, page 36). If it were not for its obvious relationship to Paspalum, in which an occasional first glume is developed in several species and regularly in a few, the spikelet of Reimarochloa might be

F10. 64. A, part of raceme of Stenota-taken to be strictly phrum secundatum, front view showing 1-flowered with spikelets; B, back view of three joints. 1-flowered with only the first glume

suppressed except in the terminal spikelet.

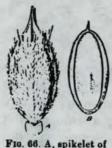
In Paspalum we have seen a slightly broadened rachis (Fig. 63). In Stenotaphrum, or St. Augustinegrass (Fig. 64), the rachis is broad, thick, and corky, and the spikelets are partly embedded in it. At maturity the rachis breaks up into short joints with

the spikelets attached. (Recall Lepturus, Lesson V. Fig. 28, page 37.)

In Digitaria, Paspalum, Reimarochloa, and Stenotaphrum, with subsessile spikelets borne on one

side of a rachis, the spikelets are placed with the back of the fertile lemma against the rachis, that is, with the first glume (developed or hypothetical), sterile lemma, and the palea of the fertile floret outward. In Axonopus (Fig. 65), Brachiaria, and Eriochloa the spikelets are reversed, the back of the fertile lemma being turned from the rachis and the palea toward it. In Axonopus the first glume is wholly suppressed. In Eriochloa (Fig. 66) the first glume is reduced

to



Eriochloa

floret.

tata; B.

punc-

fertile

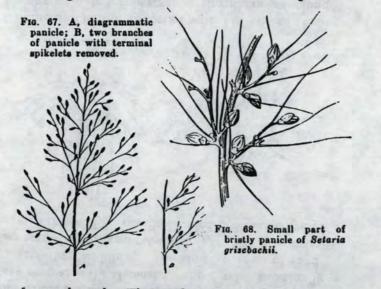
FIG. 65. A, part of raceme a miof Azonopus furcatus; B, inflorescence; C, nute sheath cross-section of rachis. around the

enlarged rachilla joint below the second glume and grown fast to it. The fertile lemma is tipped with a minute awn, which breaks off readily.

In barnyard-grass, Echinochloa crusgalli, is the same type of spike-

let as in Panicum, but the second glume and sterile lemma are awned or awn-tipped, and the pointed tip of the palea is not inclosed in the lemma, which also is sharp-pointed. The glumes and sterile lemma bear spine-like hairs, but not so thick as those of Tragus.

Observe the diagrammatic panicle in Fig. 67, A. In imagination, remove all the terminal spikelets



from a branch. The result is Fig. 67, B. Compare Fig. 68 with this. It will be seen that the bristles of the latter are branches of the panicle which are without spikelets at their tips but which bear subsessile spikelets at or toward their base. This

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modification of sterile branches and branchlets into rough bristles is found in the millets (Setaria) common millet, yellow foxtail, and green foxtail. These branchlets are the "involucre of bristles" referred to in many manuals and descriptions. The spikelets fall from their

pedicels, as in Panicum, and the bristles remain on the axis. In most of the species the panicles are dense and spike-like, the spikeletbearing branches fascicled and very short and the sterile ones, or bristles, long and slender. In yellow foxtail, Setaria lutescens (Fig. 69), the fascicle consists of several branches, only one of them spikelet-bearing, the others transformed into slender bristles.

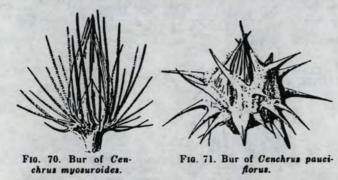


FIG. 69. A, fascicle from panicle of Setaria lutescens; B, spike-like panicle of same.

Between the ordinary panicle represented in Fig. 67 and the bristly spike-like one of yellow foxtail (Fig. 69, B) there is every degree of gradation.

A further specialization of sterile branches is shown in the sand-burs (Cenchrus). Compare Fig. 70 with Fig. 69, A. Instead of the nearly simple fascicle of

branchlets found in the millets, the sand-burs have a complex fascicle of many compound branches. The primary branches disarticulate from the axis, and the whole fascicle, or bur, falls entire with the spikelet permanently inclosed, the grain eventually germinating within it. The simplest form of sandbur is in Cenchrus myosuroides (Fig. 70). The structure of this will be comprehended if we conceive of



a dense fascicle of branches with but one of them bearing a single sessile spikelet, the others branching at the base and surrounding the spikelet-bearing one. In the common inland sand-bur, Cenchrus pauciflorus (Fig. 71), the sterile branches are much thickened and flattened and are grown together below, their free summits sharp and spine-like. The numerous secondary branchlets, in the form of stout spines, spread from the body of the bur formed by the cohesion of the main branches surrounding the one or few sessile spikelets.

In all the seed-bearing spikelets so far examined, the stamens and stigmas project at flowering time, resulting in cross fertilization of the ovules. A few grasses bear cleistogamous (close-fertilized) as well as

openly fertilized spikelets. Such spikelets do not open, and there is usually but a single small stamen which empties its pollen directly on the short stigmas. The grain is larger than that of open-fertilized spikelets. Two of our native grasses, forming the genus Amphicar-



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pon, related to Panicum, F10. 72. Base of plant of Amphiare remarkable in that

carpon purshii.

they produce large cleistogamous spikelets underground in subterranean branches (Fig. 72). The plants also bear terminal panicles of ordinary and much smaller spikelets, but these seldom perfect seed.

#### SUMMARY

In Paniceae, the millet tribe, the spikelets fall entire. They bear one perfect floret with a sterile floret below it. The lemma and palea of the perfect floret are indurate. The sterile lemma resembles the second glume, the two simulating a pair of glumes, while the first glume is small and looks like an addi-

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tional one (in some older works it is called the accessory valve or glume) or is entirely suppressed. The genera differ chiefly in the arrangement of the spikelets in the inflorescence. In a few genera some of the panicle branches are without spikelets and are transformed into bristles or burs.

#### REVIEW

Collect the inflorescence of broom-corn millet, old witch-grass, or of as many species of Panicum as are available, and dissect the spikelets. Collect heads of barnyard-grass and compare the spikelets with those of Panicum. Compare the spine-like hairs with those of Tragus, Fig. 54.

Collect the inflorescence of crab-grass and of any species of Paspalum available; note the arrangement of spikelets and compare the form and texture of the fruit (fertile floret) with that of Panicum.

Collect heads of common millet or of yellow or green fortail. Remove enough branches from the axis to show clearly the form and arrangement of the few remaining.

If available, examine a sand-bur, splitting the bur with a sharp knife.

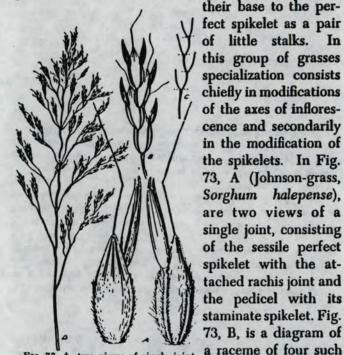
### LESSON XI

# PAIRED SPIKELETS WITH HARDENED GLUMES AND THIN LEMMAS

In the sorghum tribe, which we are about to study, the spikelet, as in the millet tribe, falls entire and is dorsally compressed, but the glumes are hardened and the lemmas thin, while in the millet tribe the glumes are thin and the fertile lemma and palea are hardened. The glumes entirely inclose the two florets. The midnerve of the first glume is commonly suppressed, while a pair of nerves near the margin is often prominent and sometimes keeled, or even winged. The second glume may be like the first or the midnerve may be slightly keeled. The lower floret consists of an empty lemma only, the upper of a perfect flower with a small thin often awned lemma (sometimes so small as to appear like a bit of membrane at the base of the awn) and a minute palea (sometimes suppressed).

Examine Fig. 73, A, and compare it with Figs. 21 (p. 30), 22 (p. 31), 30 (p. 40), 40 (p. 49), 52 (p. 61), and 53 (p. 62). In all the figures referred to, fertile spikelets are associated with sterile ones. These are grouped in various ways. In the sorghum tribe the typical arrangement is a jointed raceme with a sessile perfect spikelet and a pediceled sterile spikelet

(staminate or neuter) at each joint, the rachis disarticulating at the summit of each joint, this and the pedicel of the sterile spikelet remaining attached at their base to the per-



F10. 73. A, two views of single joint of raceme of Sorghum halepense; B, diagram of raceme of four joints; C, diagram of rachis and pedicels; D, inflorescence.

removed and the points of disarticulation shown by dotted lines. In sorghum, these few-jointed racemes are borne on the ultimate branchlets of a panicle

joints and 73. C. a dia-

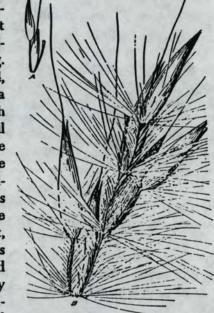
gram of the rachis and

pedicels, the spikelets

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(Fig. 73, D). In the closely related Indian-grass, Sorghastrum, the racemes are reduced to one or two joints, and the sterile spikelets are wholly suppressed, the slender hairy pedicel alone being developed.

Compare Fig. 74, A, a diagrammatic single joint of Erianthus giganteus, with Fig. 73, A, and Fig. 74, B, three joints of a long raceme, with Fig. 73, B. It will be seen that, while the spikelets are paired, the pediceled spikelet is as large as the sessile one and, like it, is awned. In this genus the pediceled spikelet is usually perfect. The racemes are long and slender and copiously hairy, and



F10. 74. A, diagram of single joint of raceme of *Erianthus giganteus*; B, three joints of raceme.

are crowded on a stout main axis forming large, dense, woolly panicles. In sugar-cane the inflorescence is like that of Erianthus, but the spikelets are awnless.

Examine Fig. 75, A, a joint of a raceme of one of the broom sedges (Andropogon scoparius). It will be seen to have the same general plan as a joint of sorghum, and the racemes, shown in Fig. 75, B, though slender and flex-

uous, are in structure

similar to the racemes of

ghum and Erianthus the

inflorescence is a leafless terminal panicle, such as

broom-sedge are borne on

branches arising in the

axils of leaves on the

main culm or branches,

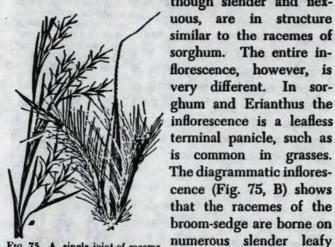


FIG. 75. A, single joint of raceme of Andropogon scoparius; B. small part of compound inflorescence.

the whole forming a compound inflorescence. The leaves, especially the ultimate ones immediately below the racemes, are mostly reduced to bladeless sheaths and are sometimes bright colored. Such transformed leaves subtending or surrounding single inflorescences are commonly termed spathes.

In some species the racemes are partly inclosed

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in the spathes. The racemes may be solitary (that is, one to a branch, as shown) or two to several, digitate, on a single branch. In some species the sterile spikelet is suppressed, only the pedicel being developed. In a few species of Andropogon the

racemes are in leafless panicles, as in Erianthus, but the pediceled spikelets are sterile and awnless.

Examine Fig. 76, A (Manisuris cylindrica), and compare it with 73, A. In Sorghum and Erianthus the rachis joint and the pedicel of the second spikelet are about equal in thickness. In Fig. 75 the rachis joint is stouter than the pedicel. In Manisuris the rachis joint is greatly thickened and hollowed out below on the inner face. (See Fig. 28, p. 37, for an earlier example of a thickened rachis.) The pedicel of the sterile spikelet is also thickened, but much less so, and the two lie close together (instead of

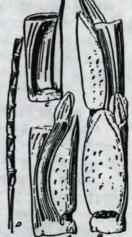


FIG. 76. A, single joint of raceme of Manisuris cylindrica; B, another view of two joints; C, inner face of rachis joint and pedicel, spikelet removed; D, part of cylindrical many-jointed raceme.

spread apart, as in Figs. 73 to 75) and entirely cover the second-glume side of the spikelet which fits into the cavity formed by the rachis joint and pedicel. Fig. 76, C, shows the inner faces of the rachis joint

and pedicel, the perfect spikelet removed. The spikelets are awnless and the marginal nerves of the



of raceme of Hackelochloa granularis; B, reverse view; C, diagram of rachis and of raceme, spikelets removed; D, view of verse view.

first glume are winged at the summit. This inflorescence and that of Lepturus (Fig. 28) are so similar in appearance and function, disjointing with the mature seed permanently attached, that the student may wonder why they are placed in tribes so remote as the barley grasses and sorghum. The two illustrate what is not seldom shown in nature, that very different structures may arrive at the same function, although the forms from which they are derived were very remote. The inflorescence of Monerma is a spike, and its F10. 77. A, single joint spikelet shows it to be a reduced and specialized relative of Lolium. The inflorescence of Manipedicels of three joints suris is a raceme with two spikelets at a joint, one pediceled, and inner face of first the perfect spikelet not greatly glume of sessile spike-let; E, raceme; F, re- different from that of sorghum.

We have just observed the rachis joint and pedicel lying closely pressed together. In Hackelochloa (Fig. 77, A) they are grown together. Examine the diagram of three joints with

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the spikelets removed (Fig. 77, C) and note that the rachis joints (the thicker parts) form a central axis with the pedicels borne on alternate sides, just as they are in Sorghum (Fig. 73, C). In this raceme we have just the reverse of the arrangement of Manisuris. In that, the fertile spikelet fits into a cavity formed by the rachis joint and pedicel; in Hackelochloa the rachis joint and pedicel fit into a cavity formed by the fertile spikelet. (See Fig. 77, D, showing the inside face of the first glume of the perfect spikelet, and examine the two views of the joints, A and B, and the two views of the raceme, E and F.) The sterile spikelet is well developed but usually contains no flower. The perfect spikelet with its peculiar gray, ridged and pitted, subglobose first glume suggests the achene of some species of Scleria (a sedge). The whole inflorescence is very unlike that of any other known grass.

Return to Fig. 73, A, and compare with it Fig. 78, A (Chrysopogon pauciflorus), which shows a raceme reduced to a single joint consisting of the sessile perfect spikelet and two pediceled sterile spikelets, the rachis joint (found in Sorghum and the others studied) often being replaced by a second pedicel and sterile spikelet. This second sterile spikelet is not always developed. In Chrysopogon this 1-jointed raceme has a sharp hairy callus at the base. Fig. 78, B (the base of a raceme and the summit of a branch, the hairs removed), shows the source of this callus. The racemes are borne on the long slender branches of a

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spreading panicle (Fig. 78, D) which disarticulate obliquely below the raceme, the line of articulation bordered by a dense brush of hairs (Fig. 78, C). The



F10. 78. A, one-jointed raceme of Chrysopogon pauciflorus; B, base of raceme and summit of branch; C, hairy summit of branch from which raceme has fallen; D, inflorescence. F10. 79. A, single joint of raceme of *Heteropogon contortus*; B, perfect spikelet from which sterile spikelet has fallen; C, base of fertile spikelet and its callus; D, raceme; E, diagram of raceme; F, diagram of rachis and pedicels of four joints of raceme.

sterile spikelets with their pedicels fall off before the maturity of the perfect spikelet, which, with its hairy callus and long awn, closely resembles a mature floret of Stipa (Fig. 45).

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In Heteropogon (Fig. 79) is a more complicated arrangement. In A is shown a joint of the raceme, consisting of the sessile perfect awned spikelet and the pediceled large pale sterile spikelet, with the short hairy rachis joint below forming a pointed callus. In Fig. 79, C, is seen the base of the fertile spikelet and the callus, with enough hairs removed to expose the very base of the pedicel, which has fallen with the sterile spikelet, and (to the left) the oblique scar from which the rachis joint next above has disarticulated. The articulation is at the base of the rachis joint instead of at the summit, as in Sorghum and the others (Figs. 73-77), and forms a callus to the spikelet next above. The rachis joints are very short and the fertile spikelets (except their awns) are hidden by the overlapping sterile spikelets, the long flexuous awns forming a tangle beyond the end of the raceme (Fig. 79, D). Besides having this modified rachis and large unsymmetrical sterile spikelets, the raceme of Heteropogon presents a further modification in that its lower two or three pairs of spikelets are all sterile, instead of each pair consisting of a perfect and a sterile one, as typical for the sorghum tribe. In these lower pairs the sessile spikelet is staminate and the pediceled one empty, but both have large unsymmetrical glumes and appear to be alike. Examine the diagram of the raceme (Fig. 79, E, the rachis greatly lengthened to show the structure and arrows indicating the points of disarticulation) and contrast it with Fig. 73, B. Fig.

## LESSON XII

HIGHLY SPECIALIZED UNISEXUAL SPIKELETS

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79, F, is a diagram of the rachis of four joints, showing the points of disarticulation. Contrast it with Fig. 73, C.

The mature fertile spikelets of Chrysopogon and Heteropogon closely resemble mature fruits of Stipa and function in the same way, disseminating the seed by attaching themselves by their sharp calluses to passing animals and securing their hold by the untwisting and twisting of their hygroscopic (moisturesensitive) awns. They afford another example of the same function performed by different organs.

#### SUMMARY

The grasses of the sorghum tribe have spikelets with hardened glumes and thin lemmas. Typically they are arranged in pairs, one sessile and perfect, the other pediceled and sterile on a jointed rachis, forming racemes. In several genera the rachis is elaborately modified.

#### REVIEW

Collect the inflorescence of Johnson-grass and of any of the broom-sedges. Break the raceme into single joints, noting the points at which it readily separates. Examine the spikelets and the rachis and distinguish the rachis joint from the pedicel.

If you had a panicle of Chrysopogon (Fig. 78, D) from which all the sterile spikelets with their pedicels had fallen, how would you know it was not a species of Stipa?

Make diagrams of the inflorescence of any available species of the sorghum tribe.

EXAMINE Fig. 80, gama-grass (Tripsacum dactuloides). This grass is monoecious (see p. 23). The pistillate spikelets are borne on the lower part of the one to three stout digitate racemes and the staminate spikelets on the upper part of the same racemes (Fig. 80, D). The part of the rachis bearing the staminate spikelets is relatively slender and falls off after flowering time; the part bearing the pistillate spikelets is greatly thickened and disarticulates with the spikelets permanently embedded in the joints. Fig. 80, A, shows two joints with spikelets embedded; B, a

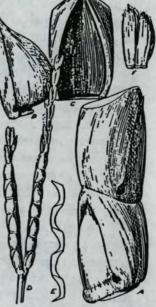


FIG. 80. A, two joints of pistillate part of raceme of *Tripsacum dactyloides*; B, spikelet removed from the joint; C, rachis joint from which spikelet has been removed; D, inflorescence; E, diagram of rachis of pistillate part; F, pair of staminate spikelets.

spikelet removed from its joint; C, the joint from which a spikelet has been removed; and E, a diagram of the rachis. Compare the joints with those of Manisuris (Fig. 76). Note that in Tripsacum the pistillate part is a simple spike with no vestige of a second spikelet. The structure of the spikelet is similar to that of spikelets of the sorghum tribe, having firm glumes (the first hard and like the rachis joint in texture), a thin sterile lemma, and a very thin fertile lemma and palea. The staminate spikelets are in pairs (Fig. 80, F) and one of each pair is usually on a very short pedicel. The glumes are much like those of different species of Andropogon; both florets are staminate, their lemmas and paleas thin.

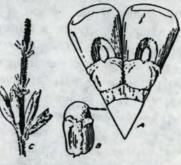
Indian corn, or maize (Zea mays), the most highly specialized grass known, is believed to be related to Tripsacum. It is monoecious, but the staminate and pistillate spikelets are borne in distinct inflorescences. The staminate spikelets are in pairs on a slender rachis forming racemes, these arranged in a panicle, the "tassel," at the summit of the culm. The pistillate spikelets are in pairs, crowded in 8 to 16 rows (rarely more) always an even number, on a greatly thickened compound axis, the "cob," borne in the axils of the leaves and enveloped in numerous leafy bracts ("husks"), the long styles (the "silk") protruding from the summit, the whole called the "ear." The staminate spikelets (Fig. 81, C) are much like those of Tripsacum and contain two

#### HIGHLY SPECIALIZED UNISEXUAL SPIKELETS 91

staminate florets. The pistillate spikelets stand at right angles to their axis, the cob (Fig. 81, A). The glumes are minute, scarcely covering the ovary at flowering time (Fig. 81, B), and in the ripened grain remain as chaff on the cob, the greatly enlarged

grain being naked. This grain, "a kernel of corn," remains on the axis until loosened by force.

Indian corn is known only in cultivation. The problem of its origin has not yet been solved. We know only that it originated somewhere in America, probably on the uplands of the tropics. It was



F10. 81. A, part of cross-section of an ear of corn, Zea mays, showing two pistillate spikelets standing at right angles to their axis (the cob); B, pistillate spikelet about flowering time; C, part of raceme of staminate spikelets.

widely cultivated by the aborigines when the western continents were discovered. The problem of the morphology of the ear of corn has not yet been satisfactorily solved, but it is not at all difficult to recognize the individual spikelets, both staminate and pistillate.

The student who has come this far will find it possible to dissect the inflorescence of any of our grasses, with the possible exception of buffalo-grass, and to distinguish the spikelets and the different organs.

Buffalo-grass (Buchloe dactyloides) is placed in the same tribe as the grama-grasses (page 57), but it has been left until the last, so that the student might have greater experience to draw on. It is dioecious (p. 23), and the staminate and pistillate inflorescences are strikingly different. (Recall Fig. 24, p. 32.)

Examine Fig. 82, B,

showing a pistillate

spikelet with a small

narrow first glume and

a very large, broad, 3-

toothed second glume

entirely infolding the

body of the floret. The

floret, removed from

the glume, is shown

in Fig. 82, C. Its 3-

toothed lemma ap-

proaches in form the

lemma of some of the

grama-grasses. (Com-

pare with Fig. 50, B.)

This pistillate spike-

let as presented is not

at all puzzling, the



FIG. 82. A, pistillate inflorescence of Buchloë dactyloides; B, pistillate spikelet cut from the rachis; C, pistillate floret; D, diagram of half a head, showing one of the two rows of spikelets; E, staminate inflorescence; F, staminate spikelet.

large thick second glume with overlapping edges entirely inclosing the floret being the only remarkable feature. These spikelets, however, are borne in the curious inflorescence shown in Fig. 82, A. These little hard white heads are borne, mostly two together, on

### HIGHLY SPECIALIZED UNISEXUAL SPIKELETS 93

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a very short slender axis, in the axils of broadened sheaths at the summit of short culms and very much overtopped by the blades. If we cut off the base of one of these little heads we have three to five such spikelets, as shown in Fig. 82, B, which had been held rigidly together by the hard thickened base, the overlapping backs of the second glumes forming a thick white wall surmounted by their green-toothed summits. The base can be nothing but a rachis, shortened, broadened, and thickened, though all trace is lost of the junction of the spikelets and the rachis. Fig. 82, D, is a diagram of half a head, showing one of the two rows of spikelets. Compare this with Fig. 51, E, showing a great number of spikelets on an elongate rachis. As in Bouteloua gracilis the spikelets stand nearly at right angles to the rachis and the first glume is inward, that is, it would be against the rachis, as in Bermuda-grass, if the spikelets were appressed. The difficulty the student encounters in comprehending the pistillate inflorescence of buffalo-grass is not so much due to its complexity as to the difficulty of dissecting the rigid little structure, and also to the suppression or deformity of some of the organs. When spikelets are closely crowded, as in the Cenchrus bur, in some species of millet, and in buffalo-grass, some of them are nearly always deformed from pressure. In buffalo-grass one or two of the spikelets in a head are not fully developed. The first glume is commonly reduced to a minute scale in two or

three of the spikelets, and sometimes it is suppressed.

The staminate inflorescence (Fig. 82, E) resembles the spikes of grama-grass (Fig. 51, E) but the spikelets (Fig. 82, F) are awnless, and the second floret is well developed and contains a staminate flower.

#### SUMMARY

In the case of greatly modified structures the different organs are to be interpreted by their relative position and by their analogy to corresponding organs in related grasses.

#### REVIEW

Collect the inflorescence of Tripsacum if available, disjoint it, and dissect the spikelets.

Examine a very young ear of corn and note that the spikelets are always in pairs (consequently an ear of corn always has an even number of rows). Distinguish the glumes and lemmas. Examine the staminate spikelets.

If available, collect buffalo-grass and dissect the staminate and pistillate inflorescence, preparing the latter by boiling it a few moments in water to which a few drops of glycerine have been added. When no glume but the large thickened one is found in the pistillate spikelet of buffalo-grass, how do you know which glume that is?

### DIAGRAMMATIC SUMMARY OF THE PRIMARY CHARACTERS OF THE TRIBES

#### SERIES I.-POATAE

Spikelets laterally compressed; florets mostly falling from the persistent glumes

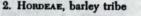
1. FESTUCEAE, fescue tribe

Spikelets many-flowered. Glumes relatively small. Lemmas awned from summit or awnless.

Inflorescence a panicle. [Contains fescues, bromegrasses, and blue-grass.]



FIG. 83.



Spikelets 1- to many-flowered, sessile on opposite sides of a jointed rachis, forming a spike.

Rachis rather than spikelets specialized.

Inflorescence a solitary spike. [Contains wheat, rye, and barley.]

3. AVENEAE, oat tribe

Like Festuceae, but glumes enlarged and florets fewer in number. Rachilla joints short. Lemmas awned from the back. Inflorescence a panicle. [Contains oats.]



F10. 84.



### 4. ACROSTIDEAE, timothy tribe

Like Festuceae reduced to its lowest terms; spikelets 1flowered. Lemmas awnless or awned, the awn from back or summit. Glumes sometimes awned, sometimes suppressed. Inflorescence a panicle. [Contains redtop and timothy.]



5. CHLORIDEAE, grama tribe

- Spikelets 1- to several-flowered, sessile on one side of a continuous rachis.
- All but the lowest floret commonly sterile and variously modified.
- Inflorescence of two to several 1-sided spikes, solitary, racemose or digitate. [Contains grama-grasses.]

#### 6. ZOYSIEAE, curly-mesquite tribe

Spikelets 1- or 2-flowered, in fascicles, the whole falling from the main axis entire. [Not a natural tribe, some of the genera included not being closely related.]



F10. 87.



#### SUMMARY OF PRIMARY CHARACTERS

7. PHALARIDEAE, canary-grass tribe

Spikelets with one perfect floret and two sterile florets below, these falling attached to the fertile floret. Inflorescence a panicle. [Contains canary-grass and sweet vernal-grass.]



8. ORYZEAE, rice tribe Spikelets 1-flowered, falling from the pedicel entire. Glumes reduced or suppressed. Inflorescence a panicle.

[Contains rice.]



F10. 90.

9. ZIZANIEAE, Indian rice tribe Plants monoecious. Spikelets 1-flowered, falling entire. Clumes suppressed. Inflorescence a panicle. [Wild or Indian rice.]



F10. 91.

### SERIES II.—PANICATAE

### Spikelets dorsally compressed, falling entire, singly or together with parts of the axis.

10. PANICEAE, millet tribe

- Spikelets with one perfect terminal floret and a sterile floret below.
- Rachilla joints very short.

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- Glumes membranaceous, the first small, suppressed in some genera; sterile lemma like the second glume, the two appearing like a pair of glumes.
- Fertile lemma and palea indurate.
- Inflorescence a panicle or of one to many racemes, these digitate or racemose on the main axis.

[Contain millets and crabgrasses.]



# SUMMARY OF PRIMARY CHARACTERS

11. ANDROPOGONEAE, sorghum tribe

Spikelets paired, one perfect and sessile, the other sterile and pedicellate, borne on a jointed rachis.

Fertile spikelets with one perfect terminal floret and a sterile lemma below; falling with joints of rachis and sterile pediceled spikelet attached.

Clumes indurate, inclosing the florets; lemmas very thin; palea often suppressed. [Contains sugar-cane, Johnsongrass, and broom-sedges.]

### 12. TRIPSACEAE, corn tribe

#### Plants monoecious.

Pistillate spikelets with one perfect terminal floret and a sterile lemma below, falling embedded in the joints of the rachis. (Persistent on the thick compound axis in Zea.)

Staminate spikelets 2-flowered in pairs, racemose. [Contains gama-grass and Indian corn.]





#### **GENERAL INFORMATION FOR THE BEGINNER**

It is hoped that after completing the twelve lessons the student will be eager to study and identify the grasses of his region.

To aid the beginner in the study of the plant, the following outline is offered, suggesting points to be observed:

#### OUTLINE FOR STUDY OF A GRASS PLANT

Duration-Annual: Winter annual, summer annual.

- Perennial: Without rhizomes (with or without winter rosette); with rhizomes (these short or long, thick, knotty, or slender).
- Habit-Erect, ascending, prostrate, geniculate, creeping, rooting at nodes, or stoloniferous. Tufted or culms few or solitary.
- Culm—Height; slender or robust; simple or branching (from upper nodes, lower nodes, all nodes); glabrous, scabrous, or pubescent (throughout or below nodes or inflorescence].
  - Nodes: Glabrous or pubescent (hairs appressed, spreading, retrorse, i. e., pointing backward).
  - Sheaths: Close, loose, or spreading; glabrous or pubescent (note margin and summit); open (as common) or closed.
  - Ligule: Length; membranaceous; hairy (stiff or delicate); obsolete.
  - Blades: Erect or spreading, length and width. Shape: Rounded, clasping or narrowed at base; flat, folded, or involute. Texture: Thin, thick, rigid, lax. Surface: Clabrous, pubescent (pilose, villous, hispid), scabrous (note each surface and margin).

- Inflorescence—Terminal only on main culm and branches, or axillary also. Simple or compound. Panicle, size (length and width), loose or compact, few-flowered or manyflowered, nodding or erect. Raceme, size, etc. Spike, size, etc.
  - Axis of panicle: Size, pubescence, etc.; branches solitary, fascicled or whorled, flexuous or stiff, ascending, spreading or reflexed.
  - Axis of raceme or spike: Continuous or disjointing; slender, stout, narrow, winged; pubescence.
- Spikelet—Pediceled or sessile; laterally or dorsally compressed; falling entire, alone, or with joints of axis; florets falling from the glumes; number of florets.
  - Glumes: Similar or unlike; size (compared to spikelet, onehalf, one-third, etc.); shape, awned, toothed, etc.; texture, nerving, pubescence.
  - Lemma: Fertile or sterile, size, shape, texture, pubescence. Palea: Flower bearing or empty, size (sometimes obsolete), shape, texture.

It will further the student's self-training if he writes down the characters of the first few grasses studied and of any particularly puzzling or interesting later ones, making drawings of the spikelet and its parts or diagrams of complicated inflorescences. One should not hesitate to make drawings merely because he "can not draw." However crude a sketch may be it is of great value, not only as a record of observations, but for its training in powers of observation. The one who "never could draw" is the very one who should make frequent drawings, however crude they may be.

Anyone wishing to make a serious study of grasses

In actual work, of course, one never has so simple a problem as that. With exceptions (such as are noted pages 44 and 59) and closely related genera and species, it often demands careful weighing of all the facts to use an extended key successfully, but it is excellent training in judgment.

The name reached in the key is verified or rejected by reading the description in the text and noting how the characters of the plant agree with those specified. When the description does not apply to the plant in hand, one must return to the key and try again.

One who finds interest and delight in the study of grasses will want to accumulate a working library. A bibliography of even the most important works would be too long to be included here and would be out of place in a first book of grasses. However, it may be well to call attention to two papers on grasses that have been issued by the United States Department of Agriculture:

FIRST BOOK OF GRASSES

should prepare an herbarium, that is, a collection of plants pressed and dried in such a way that they may be mounted by gummed straps to sheets of heavy paper and arranged in folders for reference. Grasses so prepared keep indefinitely.

In studying grasses the first thing is to understand the structure of the plant in hand, particularly its inflorescence; the second is to learn its relationship to other grasses and what name has been applied to it. The latter is what is meant by "identifying" or "determining" a plant. Practically all the grasses of the United States are described in one or more manuals of botany or State floras. Most of these manuals give "keys" to genera and species. [The word key is used figuratively-an instrument by means of which a way is opened.] A key is an arrangement of contrasting characters by which, choosing one and rejecting the other, the student is led to the name which applies to the plant in hand. For example, take Figs. 23, 27, 45, 48, 65, and 76, and trace them through the following key, reading both of the lines having like indention, these giving the contrasting characters from which to choose.

Spikelets laterally compressed, the florets falling from the persistent glumes.

Inflorescence a panicle, spikelets pediceled.

- Hitchcock, A. S. Manual of the Grasses of the United States. U. S. Dept. Agr. Misc. Publ. No. 200, pp. 1-1040, 1935. Revised edition by Agnes Chase, 1951.
- Hitchcock, A. S. The Genera of Grasses of the United States. Revised by Agnes Chase. U. S. Dept. of Agr. Bull. 772, pp. 1-302, 1936.

#### BOTANICAL NAMES

In the introduction, the reasons were given for using Latin names of plants. It will have been noticed that these names are made up of two words, the generic name (a noun) and the specific (an adjective or a noun in the possessive case or in apposition), and that the generic name is placed first, like the surnames of persons in a directory.

Both words of the name are generally supposed to refer to some characteristic or property of the plant to which they are applied, as Chrysopogon (golden beard), Chrysopogon pauciflorus (few flowered), Erianthus (woolly flower) saccharoides (like Saccharum, that is, sugar-cane), and Beckmannia erucaeformis, named for Johann Beckmann, professor at Göttingen, Germany, and erucaeformis (like Eruca, a plant related to mustard), but often botanical names do not fit any better than do names of persons-Paul (meaning small) Baker may be a tall blacksmith, or Martha (meaning bitter) Stern may be sweet and gentle. Many of the Linnaean genera bear the ancient classic Greek or Latin names, such as Quercus for the oak and Ulmus for the elm. In many other cases Linnaeus used classic names but applied them,

#### GENERAL INFORMATION

not as anciently used, but to a different group. Bromus to the Greeks was the oat, but Linnaeus used it for the brome-grasses; Zizanion was the tares (supposed to be Lolium temulentum) sown by the enemy among the wheat, in the parable of Scripture, but Linnaeus used the feminine form of the word for our wild rice. On the whole, however, botanical names are more or less descriptive, and it is helpful as well as interesting to be mindful of their meaning, especially of the names of species. Any plant with the name "asper" or "scaber" will be rough in some part; "pubescens" will be hairy; "alba" will have white flowers or bark probably, and "rubra" red. The name Bromus secalinus implies that the species was a weed in the rye (Secale) fields of Europe, as it is in our wheat fields. Sorghum halepense was known in the early ages from Aleppo (Haleb) in Syria, and Phalaris canariensis from the Canary Islands.

The present system of botanical nomenclature dates from 1753, when Linnaeus's Species Plantarum was published, using binomials (names of two words) for all the species. Before this, plants were given phrase names, more or less descriptive, such as "Panicum with lax drooping panicle, the sheaths of the leaves pubescent," for proso millet (*Panicum miliaceum*) or "Grass with a very long spike, like cat-tail," for timothy. These phrase names were in Latin, of course. Linnaeus's binomial plan so simplified the hitherto cumbersome system that

it was nearly everywhere adopted in less than a generation.

In botanical works it will be noted that plant names are followed by the initial, abbreviation, or the full name of a person, as Poa pratensis L., Phragmites communis Trin. This stands for the name of the person who gave the plant the name, L. for Linnaeus, Trin. for Trinius. It has often happened that the same species has been given different names by men working in various places and not in touch with each other. In such cases the name first given is the one now generally used. It has also happened that two species in a genus have been given the same name. In this case the name stands for the earlier one and the second is renamed. These superabundant names constitute what is termed synonymy. (Synonyms are two or more names for the same thing.) Superabundant names are also due to the fact that many species when first described were placed in genera to which more intensive study shows they do not belong. Tridens flavus, for example, was first named Poa flava by Linnaeus, and Danthonia spicata was named Avena spicata by him. When these species are placed in Tridens and Danthonia, respectively, the name of the original author is given in parenthesis with the name or abbreviation of the person who made the change following it; thus Tridens flavus (L.) Hitchc., Danthonia spicata (L.) DC.

#### GENERAL INFORMATION

#### CLASSIFICATION OF PLANTS

As stated in the introduction (page 2), the classification of grasses is based on the characters of the spikelet. The classification of plants is itself but a human attempt to show natural relationship, and the attempt is based on knowledge of but an infinitesimal part of the plant kingdom. The plants occupying the earth today are the survivors of millions of generations. Countless forms have become extinct. Some of these are known from fossils, but far more have vanished, leaving no record. Linnaeus said, "Nature never makes jumps." Connecting links exist or have existed between the greatest extremes. When no such link is known, we conjecture that the missing intermediates are among the countless extinct forms. Human minds approaching a given problem from various angles form different conjectures; hence it is that botanists of different periods or even of the same period have diverse ideas of relationships. The species that Linnaeus described under Poa, for example, are today recognized as belonging in three genera and his species of Panicum in nine genera. As a vastly greater number of plants are known today, botanists have wider knowledge on which to base conclusions, but the main difference between the Linnaean and the present-day idea of genera is due to the modern concept of a genus as a network of related species as

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contrasted with the earlier concept of a genus as a sort of receptacle built of certain characters and open to any species having those characters. Linnaeus's idea of Cenchrus, for example, was primarily a genus of bur-grasses, and, besides what is now recognized as Cenchrus (represented by Figs. 70 and 71), he included in it a species of Tragus (Fig. 54) and a Mediterranean grass in which the "bur" is composed of the rigid lobes of the lemmas of the dense head of spikelets, as well as a plant that is not a grass.

This brief explanation is offered to save the beginner undue bewilderment when he finds in using different books that the standard excuse offered by botanists of all times and places, that the Latin name of a plant is the same throughout the world, is not as true as could be wished.

It will be noted in using botanical works that certain characters are accepted as generic, that is, as indicating that species having these characters in common belong to a single genus. Such are the 5-nerved keeled lemmas of Poa. Other characters, sometimes quite as conspicuous, such as the pubescence or want of it in Poa, and the presence or absence of an awn in Bromus and Festuca, are regarded as specific, that is, as differentiating species. It might seem as though by some revelation certain characters are known to be generic and others to be specific. Such is not the case. A species consists of a group of individuals presumably capable of freely interbreeding. A genus is a group of species which

#### GENERAL INFORMATION

in the sum total of their characters are so much alike as to warrant the assumption that they have had a common ancestor. Characters taken as generic and specific are analogous to theories or working hypotheses. We use them as far as they work; if they do not work, we discard them for other characters. Botany is a science of living things, and its problems can never be settled once for all. It is this enduring interest that makes it so fascinating.

### POSITION OF GRASSES IN THE PLANT KINGDOM

Flowering plants (excluding the pines and their allies) fall into two rather distinct groups, (1) monocotyledons, characterized by an embryo having a single cotyledon and by stems having woody fibers not in layers but distributed through them (as seen in the cornstalk) and not increasing in thickness by age, and (2) dicotyledons, with an embryo having two cotyledons and stems with their woody fibers forming a zone between pith and bark and increasing in thickness by annual layers. Cotyledons are the seed leaves. Anyone will have observed that sprouting corn, rye, and other grasses send up a single leaf first, while squash, radishes, lettuce, and morningglories, for example, have a pair of opposite seed leaves. Grasses belong in the first class, with sedges, rushes, lilies, and the like. They form a highly specialized family with a greater number of species than any other except the orchids and the composites (asters, dandelions, thistles, and their kinds).

Venezuela; the high campos of central and southern Brazil; the pampas of Uruguay and Argentina; the steppes of Russia and western Asia; the plains of Siberia, Mongolia, and China; the "sud," bordering the upper Nile; the veldt of semiarid East and South Africa, which supports the vast numbers of great game animals made familiar to us by moving pictures; and the steppes of central Australia. Our own Great Plains (before broken by the plow) were more completely occupied by grasses than any other great stretch of grassland, except possibly in Siberia. In the South American grasslands there are scattered shrubs and low trees; the same is true in Africa and the other regions. Much of our plains for miles were almost a solid turf of buffalo-grass, grama-grass, and other low perennials, without a tree in sight. There is no other region of like area that has a larger number of highly specialized grasses than has the United States. Aegopogon, Buchloë, Cathestecum, Munroa, Blepharidachne, Elyonurus, Heteropogon, and many others with curious specializations, make an agrostologist sorry for Europeans. The grasses of Europe seem so simple and commonplace-sweet vernal-grass is, I think, the most highly specialized grass in the British Isles. In the north as a whole the more primitive types (except bamboos) prevail. Bromus, Festuca, Poa, Puccinellia, Calamagrostis, Agrostis, and Catabrosa are circumpolar.

Grasses are the dominant family in the vegetation

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### FIRST BOOK OF GRASSES

Grasses have been so successful in the struggle for existence that they have a wider range than any other plant family, and they occupy all parts of the earth. They reach the limits of vegetation (except for lichens and algae) in the polar regions and on mountain tops. They endure both cold and torrid desert conditions; form the main part of the vegetation of vast prairies, plains, savannas, and steppes of both hemispheres; and occupy great stretches of marsh and tidal flats, where they are steadily building up the land. Bamboos, the largest of grasses, form extensive forests and dense jungles.

Mostly low in stature and relatively inconspicuous, grasses attract but little attention—but they are the meek that inherit the earth. They form the third largest family of flowering plants, exceeded in number of species only by the aster family and the orchids. But in the number of individual plants, grasses far outnumber all others and have a wider range than any other family of flowering plants.

Grasses love sunlight and are the dominant plants in open country; only in dense forests are they scarce. A few broadleaved species carpet the floors of our Florida hammocks and of coffee plantations, and a few hide here and there in dense forests.

The great grass areas of the world are our own Great Plains and prairies from the Mexican plateau to the Arctic tundra and from the prairies of Illinois to the foothills of the Rockies; the semiarid llanos of

are dominant, while bamboos form extensive forests in Asia and the East Indies. In the mountains of tropical America and Africa certain bamboos occupy a zone above timber-line and below the short-grass areas of the alpine regions. In Brazil these "chusquales" are as difficult to get through as is chaparral in California. Some bamboos are vinelike, their slender culms pushing up through the jungle along trails and streams until they reach the sunlight. Whorls of spreading branches develop and, lying outstretched on the branches of the trees, support the main culm as it ascends, repeatedly branching, until the whole mass falls like a lacy green curtain from the treetops. A steep slope or a riverside so draped is one of the most enchanting sights in the world. The West Indies and Central and South America have more of these climbers than the Old World, and none are so slender and lacy as ours.

The grasses seem to have appeared on the earth during the Upper Cretaceous, at least the earliest fossils recognized as grasses belong to that period. In the first quarter of this century, Dr. Maxim Elias, formerly State geologist of Nebraska, found in the Miocene of Nebraska and Colorado great numbers of fossilized grass fruits (so called "seeds") obviously related to living Stipa and allied genera, and some strikingly like Panicum and Setaria. I think these are the first real fossils of grass florets ever found. The earlier fossils are carbonized impressions of leaves or culms or bits of inflorescence not identifiable

### FIRST BOOK OF GRASSES

of the cold regions (mixed with sedges in wet ground), but they consist of vast numbers of relatively few species. Some, especially the Poas (blue-grasses), are sorely puzzling, but that is because they seem to be fluid, flowing under or through all specific limitations any agrostologist can set up. In the tropics and subtropics are great numbers of highly specialized genera and species.

In the United States are two grasses with spikelets on underground branches, their flowers close-fertilized and producing very large grains, and several others with close-fertilized spikelets hidden in the sheaths. The latter were discovered as recently as the early part of this century, but the birds found them long before we did. In winter a common grass of moist wood borders, *Panicum clandestinum*, is seen to have its numerous sheaths shredded. I have watched chickadees splitting the sheaths and eating the plump grains hidden in them.

In some of our grasses the spikelets are curiously shaped, decorated with bristles and silvery hairs. In some the male and female spikelets are on separate plants and are strikingly different. In the subtropics and tropics are the more curious and highly specialized grasses, and the greater number of species. In the cold north the grasses are simpler in structure, the species fewer, but with vast numbers of those few.

Besides the great grasslands there are smaller prairies, savannas, and mountain meadows where grasses

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Some seeds are enclosed in the watertight corky joints of the rachis. The joints of Parapholis, a low seaside species, may be seen piled above high tide on the coast of Oregon, like tiny logs of drift wood. The most curious watertight package is that of Thuarea of the South Seas. The short, broad, ribbon-like rachis bears staminate spikelets above and pistillate below. Toward maturity the staminate fall off, the rachis folds up around the fruiting spikelets, and the end closes down over, like a tiny fist, the whole becoming hard and corky, safely floating to distant lands. It is a strand plant all over Micronesia.

Spinifex of the East Indies and Australia has enormous spiny balls of pistillate spikelets, which roll over the sands of the coasts, scattering their spikelets, each attached to the base of a long strong branchlet. The staminate spikelets are borne on separate plants.

#### GRASSES IN RELATION TO MAN

Man like other animals is wholly dependent for his living on the Plant Kingdom, and of all plants the grasses are most important to him. All our breadstuffs, wheat, corn, oats, rye, barley, and rice, as well as sugar-cane, are grasses, and grasses form the principal food of the animals that furnish meat and milk. Bamboos are grasses, and so are the Kentucky bluegrass and the creeping bent of our lawns and the timothy and redtop of our meadows. If such dif-

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with certainty. I think Dr. Elias rather doubts that the earlier "fossil" grasses are truly grasses. He worked over his collections at the Smithsonian's Grass Herbarium. Many of them are beautifully preserved.<sup>1</sup>

Grasses have developed many ways of scattering their seed, but some long-lived perennials with vigorous vegetative reproduction produce very little good seed. Some grasses of regions having very short growing seasons produce tiny plantlets in the spikelets instead of florets—these are the so called proliferous spikelets. *Poa bulbosa* is a good example. It is not known to produce seed, but the bulblets are sold as "seed."

Dissemination of seeds by wind is the commonest method. In many the florets bear cottony or silky tufts, or crowns of feathery awns. A few years ago an entomologist turned over to the Department of Agriculture plant material that was captured in insect traps on airplane flights. More than half of all the seed was those of grasses. They were caught at altitudes up to 5,000 feet.

The panicles of some grasses break off and roll before the wind scattering their seeds as they go. Those of *Eragrostis spectabilis* may be seen in the fall piled up against hedges or shrubs. Barbed spines such as those of Stipa and Aristida attach many seeds to the hair of animals.

<sup>1</sup>Elias, Maxim. Tertiary prairie grasses and other herbs from the high plains. Geol. Soc. America Special Paper 41. 176 pp. 1942.

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ferent looking plants as bamboo, corn, and timothy are all grasses, what is it that characterizes a grass? It is the structure of the plant. All grasses have stems with solid joints and 2-ranked leaves, one at each joint, the leaves consisting of two parts, the sheath, fitting around the stem like a split tube, and the blade, commonly long and narrow. No other plant family has just this structure. Clover and alfalfa, built on a very different plan, are not grasses.

Grasses, like sunlight, air, and water, are taken for granted. For more than a generation scientists in the Department of Agriculture had been preaching to deaf ears the dangers of overgrazing. For thousands of years our Great Plains maintained countless herds of bison, which provided meat and clothing for hundreds of generations of Indians. Then came the white man, and in two generations the plains, which had been richly clothed in grass, were reduced to semidesert, because overgrazing had destroyed the thick mat of sod that held the rain and melting snows and prevented erosion. With expanding population semiarid land was plowed that should have been left as grazing land. Dust storms and floods, the rapid run-off from denuded land, have taught us a lesson and erosion-control work is now going ahead in earnest. In the work of revegetation, grasses are of first importance for these areas. We have many excellent native soil binders, grasses with stout rootstocks that form a network below the surface. Grasses from Asia and elsewhere are being tried also.

Two from Siberia, Agropyron cristatum (L.) Gaertn. and A. desertorum (Fisch.) Schult., are making rapid progress in the Dakotas.

Not only do grasses hold the soil, some of them built up the soil in the first place. One of the cordgrasses (Spartina pectinata Link) has filled up miles of marshland in the Middle West, converting it into rich black prairie. Two others, S. alterniflora Lois. and S. cynosuroides (L.) Roth, on the Atlantic coast, and S. foliosa Trin., on the Pacific, have reclaimed many miles of salt marsh. Much of rich tidewater Virginia was built up through the ages by cordgrasses.

Dr. A. P. Dachnowski, for many years peat specialist in the United States Department of Agriculture, found that all the peat deposits from the Appalachians to the Rocky Mountains were formed of *Phragmites communis* Trin., the common reed, which today occupies marshes across this country, extends across Europe and Asia, and south through Argentina.

Phragmites communis is not only a land builder. In the National Geographic Magazine for February 1958 is an account of the part played by this worldwide reed in southern Iraq. Not only does it form the low land on which the people build their tentlike dwellings, but also it furnishes the material from which the dwellings themselves are constructed. Lacking wood the marsh dwellers turn for building material to the giant reed, which grows to 20 feet high in the marshes. The reeds are tied, overlapping,

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in long bundles and set up in great arches to form pillars and roofs of their dwellings.

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The other great land builders are species of Spartina. On mud flats and tidal estuaries such as those in the Gulf of St. Lawrence, Chesapeake Bay, and San Francisco Bay, Spartinas are building up dry land. These grasses thrive in the soft mud submerged at high tide, their stout rhizomes forming a dense firm network, ever pushing seaward. The coarse grass impedes the oncoming waves, protecting the shore while causing the water to drop its burden of silt or sand, thus building up the floor until it becomes first marsh meadow, then dry land, when Spartina dies out, leaving the land ready for cultivation. This land-building by Spartina has been going on along our coasts for ages, and it is going on today on a gigantic scale along the English Channel and the North Sea. The traveler on a ship entering Southampton will see vast green meadows of Spartina stretching into the sea. Eighty years ago these were bare mud flats. Spartina townsendii H. & J. Groves, a species closely related to S. alterniflora Lois., of the North American coasts, was first observed on the Southampton salt marshes in 1870. It now occupies tidal flats for about 150 miles along the south coast of England. At the suggestion of Prof. F. W. Oliver it was transplanted to other mud flats and now occupies the tidal flats along the Baie de la Seine on the French coast, and the straits of Dover,

and was planted on the tidal flats to protect the sea walls of Essex.

In 1924 this species was planted in Holland on the tidal mud of the Sloe, opening into the West Scheldt, and later along the East Scheldt also. The plants were set outside the dikes, in rows at right angles to them. The force of the waves was thus divided and conquered, where crosswise plantings might have been uprooted and washed away. Within a few years the tufts had spread to form a solid meadow. By 1938 Professor Oliver found the deposit of soil up to 6 feet in 10 years.

The most striking work of this grass is seen in the Netherlands. In a letter of June 10, 1951, Professor Oliver, wrote:

"The recent history of Spartina townsendii is full of interest. As long ago as 1923 I became interested in this plant on account of the marvelous amount of silt which it fixes in coastal waters and estuaries. I approached our Ministry of Agriculture in the matter (1923), but they took no interest. So I turned to my Dutch friends, whose country depends greatly on the reclamation of tidal lands, so that their agriculture may keep pace with their expanding population. They just jumped at it, and took tens or hundreds of thousands of sets from Poole Harbour (W. of Southampton) which by that time was half filled with the plant. These were planted out on the salt marshes between Flushing and Bergenop-Zoom in backwaters of the Scheldt—also in several other localities. From

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1928 up to last year I kept in touch with the plantations-except for the period of the war. This Spartina raised the level of the tidal marshes at an average of 3 feet in 5 years-slowing down somewhat as the level approached tidal limits. By 1940 these Spartina areas had risen about 7 feet, and after the war the Dutch banked in a first Spartina polder. This polder I visited in September 1950-about 2 square miles. It was carrying its first crop after ploughing-mostly of carrots! The Dutch experts tell me that the silt accreted by Spartina makes the best soil in Holland, and, as the plant has run wild over most of the marshes in that part of Holland, there will shortly be some 80 square miles ready to reclaim and bank in, whilst in the future it may extend to 100 or more square miles. Doubtless the success of the Dutch enterprise will stimulate other countries, with suitable climates and seaboard to follow their example. Perhaps even the U.S.A. in another century, when the population has trebled, may themselves follow the Dutch example and import millions of sets of S. townsendii for their own requirements! One fact let me stress-sets are much more reliable than seed. The latter, once it gets dry, has a very poor germination, of 10 percent or less. Our local agent at Poole was able to export hundreds of thousands of sets, which, properly packed and stored in cool parts of ships, would reach even the antipodes in good condition. The agent charged his clients 12/6 (about \$3) per 100, and some years would earn up to £400 for

his services. He was a most intelligent fisherman, and prior to exporting Spartina on any scale made many preliminary experiments in packing and storing at various temperatures. It was vital, he told me, that they should be stored on board ship well away from the engines, as heat promoted fermentation.

"Nor is the Spartina story by any means ended. One of my former students (E. H. Chater), now lecturer in botany at Aberystwyth in Wales, where plantings were made 25 or more years ago, discovered last year two forms of mutants-one with variegated leaves like ribbon grass; the other is dwarfish and contains a good deal of brown pigment. These probably will not be economically valuable, but their appearance suggests that further mutants may appear somewhere. So far as I know the Dutch have found nothing of the kind, or Mr. Verhoeven, now Minister of Reclamation for all Holland, would have told me immediately. Chater had a preliminary note in Nature last autumn, and is now working out the details of nuclear cytology of these new forms. I went over the ground at Aberystwyth last autumn and found these mutations to be frequent on the area under Spartina."

Later Spartina townsendii was planted in the shallow borders of Zuider Zee, the inland sea that occupies on the maps so great a part of Holland's scant territory. Early in 1958 it was announced in the newspapers that the former Zuider Zee was opened to cultivation. In some 35 years many square miles of arable land had been added to the Netherlands.

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So little do people appreciate what grasses have done to make a habitable earth that they frequently want to destroy these bulwarks and land builders. Some years ago real-estate promoters wrote the Department of Agriculture in distress. They had cleared away the "coarse grass" on the sandhills and developed a summer resort on the western shore of Cape Cod Bay, and now the sand was blowing up around the cottages. What could they do? They could only be told to transplant that coarse grass (Ammophila) on the sandhills again and do it without making large openings anywhere in the line of defense, or blowouts would develop. It must have cost a small fortune to fix the dunes again—if they succeeded in doing it.

Not a summer passes but letters are received asking how to get rid of Ammophila or of Spartina. A woman complained that the grass she sent for identification (*Spartina alterniflora*) was very deep rooted, impossible to dig up. It spoiled the bathing beach and she wanted to know how it could be destroyed. She was told that her land (on Chesapeake Bay) had been built up by that grass through thousands of years—that if she could destroy it her land would wash out to sea.

Man's first attempts to control his fate, to provide for future need instead of remaining the victim of droughts or other untoward circumstances, must have been on grasslands where the young calves, lambs, and kids he caught and tamed could find forage. It was on grasslands, too, that primitive man developed most rapidly. The earliest known records of human culture are found in the Nile Valley and in southwestern Asia, open country of scanty rainfall.

It is not known when man began to cultivate the grains, for at the dawn of history wheat and barley were already in cultivation in Egypt and to the east of the Mediterranean. Rice has been cultivated in eastern Asia since prehistoric time. Rye and oats came into cultivation later. Sorghum, the millets, and other grass seeds (or grain) form the breadstuffs of many peoples in Asia and Africa.

In the Western Hemisphere American Indians developed a culture about maize or Indian corn. The Inca, Maya, Aztec, and Pueblo civilizations were based upon it, and it was cultivated by the North American Indians over much of what is now the United States. The hungry Pilgrim Fathers, we are told, found a buried hoard of Indian corn during their first terrible winter in the New World and thankfully appropriated it. The Indians taught the Pilgrims how to plant maize, or corn, as it was called by the English settlers.

Grasses are the greatest single source of wealth in the world, for they not only furnish the breadstuffs but are the principal constituent of pastures, whereas meat and dairy products, leather, and wool, are secondary products of grass.

Besides food, grasses furnish endless other necessities. More than a hundred commercial products are

now made from maize (or corn) from alcohol to wall board, from the gum on your postage stamp to your "rubber" hot-water bottle, for so-called "red rubber" erasers, rings for fruit jars, sponges, bathmats are not rubber but a byproduct of corn. The amber head of your umbrella is very likely derived from cornstalks, and now furfural, made also from cornstalks, is being used in the construction of roads, making the cement more durable. It would take pages just to name the uses of grasses.

So large and important a family as the grasses necessarily requires critical study. From the time of Dr. George Vasey, in the 1880's, the United States Department of Agriculture maintained specialists on grasses. In 1939 the Grass Herbarium was made a part of the United States National Herbarium, Smithsonian Institution, forming probably the most nearly complete collection of grasses in the world. Students have come from all over this country, from South American countries, China, the Philippines, and elsewhere to study in this herbarium and in the library and bibliographic index connected with it. A herbarium is to the study of plants what a dictionary is to literature; it enables us to use names in the same sense, to communicate knowledge with precision.

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