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## REVERSAL OF THE SEXUAL STATE IN CERTAIN TYPES OF MONECIOUS INFLORESCENCES.\*

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The sporophyte of those higher plants which have an antithetic alternation of generations is usually described by morphologists as being nonsexual. This means that the sporophyte generation does not produce gametes directly but spores which develop into the gametophyte generation by ordinary cell division, never showing the property of sexual attraction. It is evident that the term "nonsexual" cannot imply that there can be no morphological difference due to a difference of sexual state in various parts of the sporophyte; for there is such a difference in all of the living heterosporous plants. It would be manifestly unadvisable to ascribe the dimorphism of stamens and carpels, for example, to any other properties or qualities than sexual states of the same fundamental nature as those which produce sexual dimorphism in gametophytes and gametes.

If we consider the sporophyte as "nonsexual" because it does not produce gametes directly but nonsexual spores, we may, nevertheless, consider its cells as all potentially sexual since they give rise farther on in the cell lineage to sexual individuals producing gametes. All homosporous sporophytes, therefore, including those of Liverworts, Mosses, Hornworts, Ferns, Horsetails, and Lycopods, are only potentially sexual and are in a neutral state in respect to sex during their entire life history. No sexual state is ever set up directly in their cells until after the stage of sporogenesis is reached, except in such abnormal species where apospory is present. Every such sporophyte is essentially similar in its morphology to every other sporophyte of the same species. In other words, there is absolutely no sexual dimorphism apparent in any part of the

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body. The Bryophytes and Homosporous Pteridophytes may, therefore, be defined as: Those higher plants which normally show no indication of sexual dimorphism in the sporophyte either in respect to structure or function.

On the other hand, in all of the living heterosporous plants, as intimated above, including the Water-ferns, Quillworts, Selaginellas, Cycads, Ginkgo, Gnetums, Monocotyls, and Dicotyls, there is sexual dimorphism to a greater or less degree and extent in the sporophyte tissues. In the lowest types, this dimorphism does not extend beyond the sporangium and its stalk, but in the extreme diecious species sexual dimorphism may be present to a greater or less degree thruout practically the entire plant. The living heterosporous plants may, therefore, be defined as: Those plants whose sporophytes always show sexual dimorphism to a greater or less extent, at least in the tissues of the sporangia or sporophylls.

Because of the appearance of sexual dimorphism in the vegetative tissues of heterosporous sporophytes, it becomes evident that there must be reversals of sexual states in these tissues, either from a neutral state to one or the other sexual state or in some cases from one sexual state to the other or to a neutral state again during the growth of the tissues. The writer has been making observations for several years on a considerable number of monecious species of the type in which the inflorescence is completely staminate in one part and carpellate in the other. In the present paper only such cases are considered which show a general reversal in the flower cluster from the male state to the female or vice versa. A considerable number of common species show a general distribution or commingling of staminate and carpellate flowers which might also be studied to advantage.

In the cases at hand it becomes self-evident that the growing meristem of the inflorescence axis is either in one sexual state and then passes thru a neutral condition during its growth to the opposite sexual state or that it is constantly in a neutral state but the lateral structures derived from it are thrown into the male or female state depending on the functional activity of the cells at the time. The change from carpellate structures in the lower part of the inflorescence to staminate structures above is apparently much more common than the opposite condition, from staminate to carpellate, notwithstanding the

fact that in the Anthophyta bisporangiate flowers have their stamens below and their carpels above. The reason for this may be that in the comparatively long axis of the inflorescence the outer, later end may usually be in a much less favorable or at least different condition functionally than the lower part, while in the evolution of the flower, the two parts of the flower axis may be more alike or the upper part even better placed for favorable metabolism than the lower part. At least there are strobili and flowers which plainly show a crowding on the lower part of the axis.

Below are given lists of common plants in which a complete change from one sexual state to the other takes place in the inflorescence. Besides the examples of a change from carpellate to staminate or from staminate to carpellate, a few special cases are also cataloged, the most significant of which appear to the writer to be the inflorescences that change from bisporangiate flowers below to staminate flowers above.

#### INFLORESCENCES WHICH ARE CARPELLATE BELOW AND STAMINATE ABOVE.

- |                                                                                               |                                               |
|-----------------------------------------------------------------------------------------------|-----------------------------------------------|
| <i>Sagittaria latifolia</i> Willd.                                                            | <i>Tripsacum dactyloides</i> L.               |
| <i>Sagittaria rigida</i> Pursh.                                                               | <i>Musa sapientum</i> L.                      |
| And other species of <i>Sagittaria</i> .                                                      | <i>Stillingia sylvatica</i> L.                |
| <i>Sparganium eurycarpum</i> Engelm.                                                          | <i>Cnidocolus stimulosus</i> (Mx.) Engelm.    |
| And other species of <i>Sparganium</i> .                                                      | and Gr.                                       |
| <i>Typha latifolia</i> L.                                                                     | <i>Acalypha virginica</i> L.                  |
| <i>Typha angustifolia</i> L.                                                                  | <i>Tragia urens</i> L.                        |
| <i>Peltandra virginica</i> (L.) Kunth.                                                        | <i>Tragia nepetaefolia</i> Cav.               |
| <i>Zantedeschia aethiopica</i> Spreng.                                                        | <i>Tragia ramosa</i> Torr.                    |
| <i>Arisaema dracontium</i> (L.) Schott.                                                       | <i>Tragia macrocarpa</i> Willd.               |
| Monocious individuals.                                                                        | <i>Ditaxis mercurialina</i> (Nutt.) Coult.    |
| <i>Cymophyllum fraseri</i> (Andr.) Mack.                                                      | <i>Croton glandulosus</i> L.                  |
| <i>Carex nardina</i> Fries.                                                                   | <i>Pachysandra procumbens</i> Mx.             |
| <i>Carex capitata</i> L.                                                                      | <i>Myriophyllum spicatum</i> L.               |
| <i>Carex gynocrates</i> Wormsk.                                                               | <i>Myriophyllum heterophyllum</i> Mx.         |
| <i>Carex chordorrhiza</i> Ehrh.                                                               | And other species of <i>Myriophyllum</i> .    |
| <i>Carex arenaria</i> L.                                                                      | <i>Ambrosia trifida</i> L.                    |
| <i>Carex leavenworthii</i> Dew.                                                               | And other species of <i>Ambrosia</i> .        |
| <i>Carex cephaloidea</i> Dew.                                                                 | <i>Gaertneria acanthicarpa</i> (Hook.) Britt. |
| <i>Carex jamesii</i> Schw.                                                                    | <i>Gaertneria discolor</i> (Nutt.) Ktz.       |
| <i>Carex leptalea</i> Wahl.                                                                   | <i>Gaertneria tomentosa</i> (Gr.) Ktz.        |
| <i>Carex rupestris</i> All.                                                                   | <i>Xanthium spinosum</i> L.                   |
| <i>Carex lacustris</i> Willd. Carpellate spikelets below, staminate above.                    | <i>Xanthium pennsylvanicum</i> L.             |
| Many other species of <i>Carex</i> .                                                          | <i>Polymnia wedalia</i> L.                    |
| <i>Carex lupulina</i> Muhl. Several carpellate spikelets below; one staminate spikelet above. | <i>Polymnia canadensis</i> L.                 |
| Other species of <i>Carex</i> .                                                               | <i>Silphium perfoliatum</i> L.                |
| <i>Zizaniopsis miliacea</i> (Mx.) D. & A.                                                     | <i>Silphium integrifolium</i> Mx.             |
|                                                                                               | Other species of <i>Silphium</i> .            |
|                                                                                               | <i>Artemisia caudata</i> Mx.                  |
|                                                                                               | And some other species of <i>Artemisia</i> .  |

### INFLORESCENCES WHICH ARE CARPELLATE ABOVE AND STAMINATE BELOW.

*Carex norvegica* Willd.  
*Carex heleonastes* Ehrh.  
*Carex glareosa* Wahl.  
*Carex canescens* L.  
*Carex brunnescens* (Pers.) Poir.  
*Carex scoparia* Schk.  
*Carex cristatella* Britt.  
*Carex bicknellii* Britt.

*Carex praticola* Rydb.  
*Carex davisii* S. & T.  
*Zizania aquatica* L.  
*Ricinus communis* L.  
*Acalypha ostryaefolia* Ridd.  
*Salix amygdaloides* Anders. Abnormal  
 monocious individuals.

### SPECIAL CASES.

*Lophotocarpus calycinus* (Engelm.) J. G. Smith.

And other species of *Lophotocarpus*. Flowers in the lower part of the inflorescence bisporangiate, in the upper staminate.

*Arisaema dracontium* (L.) Schott.

There are staminate individuals and monocious individuals. The monocious are staminate above and carpellate below.

*Leptamnium virginianum* (L.) Raf.

Lower flowers cleistogamous and fertile; upper flowers perfect and open, but mostly not producing seed.

*Specularia perfoliata* (L.) A. DC.

And other species of *Specularia*.

Lower flowers cleistogamous and carpellate; upper flowers perfect.

*Carex bromoides* Schk.

Some spikelets have both basal and terminal staminate flowers with the carpellate flowers in between.

*Viola papilionacea* Pursh.

And numerous other species of *Viola* have perfect open flowers followed later in the season by cleistogamous, fertile flowers with only the two appendaged stamens developed.

*Zea mays* L.

Occasionally abnormal ears are carpellate below, staminate in the middle, and then carpellate again at the outer end. Also staminate inflorescence may have the main axis with carpellate spikelets in the middle and staminate spikelets below and above.

### STUDY OF SPECIAL SPECIES.

Since there is a functional change during the transition from the one state to the other in the type of inflorescence under discussion, it was thought that an examination of the transition zone would show some interesting peculiarities. Consequently, a rather detailed study has been made of a selected number of species in order to determine the character of the morphological expressions on the transition zone between the staminate and carpellate parts, i. e., on the region between the tissues which are in a male state and those which are in a female state.

**Ricinus communis** L. Castor-oil plant.

The inflorescence of *Ricinus* is a panicle with staminate flowers below and carpellate flowers above. Typically the transition from one type of flower to the other is quite abrupt. There are numerous examples, however, in which a flower on the transition zone is bisporangiate. See Fig. 1. In such a case it is evident that the incipient flower bud is in a neutral condition to a rather late stage. Then the incipient tissue at the base of the flower bud goes into the male state and as a result typical branched stamens develop. The tip of the bud passes into the female state and gives rise to the normal three-carpelled gynecium. In the staminate flowers immediately below, the male state must be established at the very inception of the flower bud or even earlier and thus the entire bud is in the male state which inhibits completely the development of a gynecium. On the other hand, in the carpellate flowers above the transition zone, the female state is established at the inception of the flower bud and this condition inhibits all development of an andrecium.

**Peltandra virginica** (L.) Kunth. Green Arrow-arum.

This plant has a spadix which is carpellate below and staminate above. The carpellate flowers have prominent vestigial stamens while the staminate flowers show no evident vestige of a gynecium. The transition from the carpellate part of the spadix to the staminate is sometimes abrupt, but very frequently there is a transition zone of some width, in which case this area is characterized by flowers showing all gradations from normal gynecia to the merest vestige of a gynecium; and finally, of course, the flowers are purely staminate. Figs. 2, 3 and 4, represent such a series. Fig. 2 is a normal carpellate flower; Fig. 3, a flower with reduced gynecium, the stamens being still vestigial; Fig. 4, a flower from near the staminate side of the zone with a slender, pointed vestige of a gynecium and the stamens still somewhat imperfect. The next flower above was a normal staminate flower with no vestige of the gynecium.

**Typha latifolia** L. Broad-leaf Cat-tail.

In *Typha* the carpellate part of the inflorescence is below and the staminate above. The two parts are usually contiguous in the broad-leaf species and usually some distance apart in

the narrow-leaf species. A specimen was looked for in which there would be an invasion of one area into the other. Such a specimen was readily found. The one studied had a patch of staminate flowers on one side at the top of the carpellate part of the inflorescence. On the transition zone flowers of an intermediate nature were common. Fig. 5 represents a typical carpellate flower with its prominent stigma and Fig. 6 represents a typical staminate flower consisting of one stamen. The staminate flowers have from one to six stamens. Fig. 7 represents one of the intermediate flowers. The ovulary is undeveloped but there is a nearly normal stigma at the top and two imperfect microsporangia with spore tetrads. Fig. 8 is a double structure, the one part being a nearly perfect anther while the other has a microsporangium on one side and an imperfect half stigma on the other.

***Arisæma triphyllum* (L.) Torr.** Jack-in-the-pulpit.

A certain per cent of the inflorescences of Jack-in-the-pulpit are of an intermediate nature being staminate in one part and carpellate in another. The "spotting" of the staminate and carpellate areas is quite diverse. Sometimes the spadix is carpellate below and staminate above; sometimes, the reverse; sometimes, there are irregular spots like in a crazy patch quilt. Such inflorescences are quite favorable objects for the study of the influence of contiguous tissues with male and female states, especially if the two tissues involve parts of the same flower. The flowers of *Arisæma* have very definite positions in spirals, determined by the fundamental heredity, and it frequently happens that the transition line or zone between two tissues of opposite sexual state passes directly thru a flower, in which case the structure is carpellate on one side and staminate on the other. The incept of the flower is organized as a unit in spite of the fact that the cells on the one side are in a female state and on the other in a male state or at least in a condition leading to these states. The hereditary factors which determine the position and unity of the flower have no direct relation to the extent or limits of the sexual states. Sometimes, there is an appreciable neutral zone between the typical staminate and carpellate areas, in which case any flower that falls largely or entirely within this neutral strip will be vestigial or develop as an abnormal vegetative structure.

Fig. 9 represents a carpellate flower with its edge extending into a staminate area. This gynecium is nearly normal but it has an anther growing out of the side near the top. Fig. 10 represents a similar gynecium with two anthers growing out of the side toward the staminate patch. Fig. 11 is a normal gynecium with a large anther at one side near the top. In Fig. 12, a nearly normal stamen is growing out from near the base of the gynecium. Fig. 13 represents a gynecium exactly on the transition line. The ovulary is quite normally shaped. On the side toward the carpellate area there is a normal V-shaped stigmatic surface. In the middle are present a number of abnormal outgrowths, one with a small stigmatic tip. On the side next to the staminate area is one stamen with a double anther and two separate anthers, one of them very close to the stigma. Fig. 14 represents a reduced flower from the transition zone with three anthers growing from the side of the ovulary. Fig. 15 represents a flower so situated that the transition line passes through its center. On the one side is an imperfect ovulary with a two-forked stigma, on the other side of a central depression are two anthers. Fig. 16 represents a small area of flowers carpellate on one side and staminate on the other. On the transition zone there is an imperfect ovulary representing about one-third of a normal structure while two-thirds is transformed into a staminate tissue bearing two anthers. Sometimes the transition zone appears to contain a rather broad strip of neutral tissue. Such a condition is shown in Fig. 17. One ovulary, somewhat to the carpellate side of the zone, is considerably reduced in size. The next one is very rudimentary while the third has developed into a long-horn-like vegetative structure similar to the vegetative projections frequently developed on the neutral part of the spadix above the carpellate part.

***Myriophyllum heterophyllum* Mx. Variant-leaf Water-Milfoil.**

The water-milfoil has a spike which passes rather gradually from the female state below to the male state above. The carpellate flowers have large stigmas and minute petals and stamen vestiges. The staminate flowers above have small, vestigial stigmas, large, normal stamens, and large petals. The small and large petals are sex-limited characters. The carpellate flowers also have somewhat larger sepals than the staminate

and the staminate flowers have vestigial ovules. There is every gradation of size and completeness between the two extremes across the transition zone. Figs. 18-24 represent such a succession. Fig. 18 is a typical carpellate flower. In Fig. 19 the petals and stamens are considerably larger while the stigmas are reduced. Fig. 20 represents a stage somewhat nearer the carpellate flower altho the petals are larger. One of the stamens is considerably more developed than the others while the stigmas are nearly normal. In Fig. 21 the structures are nearly all intermediate between the two extremes. In Fig. 22 the stamens are prominent tho still imperfect, the petals approach the staminate type, while the stigmas are much reduced. Fig. 23 represents a normal staminate flower above the transition zone, just before the petals unfold and the filaments elongate. The petals have been removed. One of them is represented in Fig. 24.

***Zizania aquatica* L. Wild Rice.**

The panicle of the wild rice is staminate below and carpellate above. If one examines a branch on or near the transition zone of the main axis, he finds first staminate spikelets, then bisporangiate spikelets, often with perfect andrecia and gynecia and finally at the tip normal carpellate spikelets. The lemmas of the staminate spikelets are awnless while those of the carpellate ones are long-awned. On the transition zone, one can find spikelets with awns of every conceivable intermediate length. The awn of the wild rice is a prominent sex-limited character and its length depends on the intensity of the staminate or carpellate state present, or on the earliness or lateness of the time that the sexual state is developed in the spikelet or its glumes. Fig. 25 represents a staminate flower with all the stamens removed except one. The gynecium is quite vestigial because of the presence of the male condition. Fig. 26 represents the same gynecium highly magnified. The third vestigial stigma is considerably smaller than the other two. This stigma is vestigial in a phylogenetic sense while the other two are ontogenetically vestigial on account of the inhibitory action of the male state in the flower. Fig. 27 represents a bisporangiate flower from the transition zone. Only one stamen is represented. The gynecium, not quite mature, is normal with typical ovulary and stigmas. Fig. 28 represents the gynecium and



andrecium of a mature carpellate flower. The stamens are vestigial because of the changed sexual state. Figs. 29-34 represent a series of spikelets from the staminate part of a branch to the carpellate part. The length of the awn is determined in the vegetative tissues, depending on the nature of the sexual state present. Sex limited characters of this sort are not due to presence or absence of factors but sexual states present in the tissues during their development.

***Salix amygdaloides* And.** Peach-leaf Willow.

Several years ago the writer discovered a number of remarkable trees of this species in a grove in Kansas.\* The trees in question have monocious catkins, being staminate in the lower part and carpellate in the upper, with a wide transition zone from the one sexual state to the other. As was to be expected under such conditions, the transition part of the axis is covered with all sorts of abnormal flowers. Figs. 35-51 represent some of the gradations and confusions of sexual expressions to be observed. They exhibit something of the remarkable patchwork of small areas of tissues in different sexual states to be observed in many monocious inflorescences. They show that not only is the sexual state reversed from the lower part of the axis of the catkin to the upper part but that an organ may be practically intermediate in morphological expression because the tissue is "spotted" in respect to the sexual state. An ovary may be normally developed in respect to the character of its wall or some of the stigmas and may even have normal ovules which develop into seeds and, at the same time, have certain areas developed into microsporangia. Or a stamen with normal microsporangia may have an imperfect stigma or its stalk may be more or less carpellate in nature, taking on some of the characters of an ovary. The meristematic tissue in the neutral zone was either entirely neutral, in respect to sex, or the sexual state was so weakly developed that reversals were easily brought about. In either case the incepts of the floral structures were developing according to the activity of the hereditary factors present, determining the position, unity, diversity, and other characters of the parts, but the change of the sexual state in local cells and groups of cells of these incip-

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\* SCHAFFNER, JOHN H. The Nature of the Diecious Condition in *Morus alba* and *Salix amygdaloides*. *Ohio Journal of Science*; 19:409-416. 1919.

ient structures caused staminate and carpellate characters to appear in a mosaic. It is even possible that there are no distinct, general staminate and carpellate factors but common dimorphic factors which produce one type of characters under a female state and another type under a male state. Whatever distinctive factors for carpellate or staminate characters are present are rendered latent or active, depending on the sexual state of the cells involved at the time of development.

Altho sexual states must be regarded as fundamental to the living cell, probably, of a chemical or physical nature and brought about by an intimate change of materials held in the meshes of the living structure or some change in the living material itself, it is probable that the reactions of the complex hereditary factors to sexual states is essentially similar to other dimorphic reactions; as for example, the difference in characters caused by youth and senility, by light and darkness, or some of the striking differences accompanying aquatic and aerial environments characteristic of certain species of water plants.

The figures from *Salix* may be briefly explained as follows: Fig. 35 represents a normal staminate flower with five stamens from the lower part of the catkin. Fig. 36 represents a normal carpellate flower with three stigmas and Fig. 37 one with stigmas from the upper part of the catkin. Fig. 38 is a flower from the lower part of the transition zone with two perfect stamens branching off from the lower part of the ovulory and an abnormal stamen coming out of its side. The stalked anthers are the normal yellow after being preserved in alcohol while the sessile anther from the side of the ovulory is of a brownish color partaking of the nature of the ovulory wall. Fig. 39 represents a bisporangiate flower with stamens developed at various levels from the ovulory wall. Fig. 40 shows one stamen with an enlarged filament having carpellate characteristics and an imperfect stigma. This flower was at the base of the transition zone next to the normal staminate flowers. Fig. 41 shows an interesting bisporangiate flower with two stamens and a microsporangium developed near the top of the ovulory. The stigma just above this microsporangium is much reduced because of the influence of the tissue in the male state immediately below. The other stigma is normal. Fig. 42 represents a bisporangiate flower with one stamen and a microsporangium from the side

of the ovulary wall above. Fig. 43 shows a similar flower with two stamens below and three microsporangia on the ovulary below the imperfect stigmas. Fig. 44 shows an abnormal flower containing a complex of abnormal stamens, ovulary and stigmas. Figs. 45, 46, and 47, are three other similar types from the transition zone. Fig. 48 represents an abnormal carpellate flower with two sessile anthers and an imperfect stigma. Fig. 49 represents a carpellate flower from the top of the transition zone with a nearly normal ovulary but with two small microsporangia from its wall near the top and with three imperfect stigmas. Fig. 50 represents a nearly normal gynecium but from the side of the ovulary a short-stalked stamen, an imperfect stigma, and a very small stamen have developed. Finally, Fig. 51 shows a partly matured ovulary with seeds and the remains of two anthers. It will be noted that the side of the ovulary from which the anthers developed failed to enlarge while the opposite side passed thru the normal growth of an ovulary in which seeds are maturing.

What can be said to a series of facts as recounted above? Hundreds, even thousands of pictures might be published each one showing a distinct type or peculiarity of sexual expression with the accompanying confusion of staminate and carpellate characters. The examples given show one thing conclusively, that sexuality is something fundamentally different from the ordinary Mendelian hereditary factors, and that sex determination and sex reversal take place in small contiguous areas of vegetative cells with absolutely no relation to segregation or association of Mendelian factors. It behooves those botanists who have been carried away into an ultra-simple explanation of sexual phenomena as being due to the segregation and association of homozygous or heterozygous sex factors or homozygous or heterozygous "sex chromosomes" to reconsider the foundations of their faith and adopt an explanation that will, at least, not contradict the great body of complex phenomena of sexual expressions as they actually occur in plants, and in animals also.

#### CONCLUSIONS.

The foregoing study shows that in plants sex is due to a state or condition; that in the same general tissue system some cells may be in the female state (+), some in the male state (-),

and some in the neutral state; and that each state is quantitative, exhibiting a greater or less degree of intensity. The sexual state has no direct relation whatever to a segregation or association of chromosomes with a possible homozygous or heterozygous relation to hypothetical sex factors. Such an hypothesis is not only impossible but to the writer it would appear as the height of absurdity to even suggest it as an explanation of the phenomena described. It is plain to any one familiar with sexuality in the plant kingdom in general, that sexual states usually arise during the vegetative growth of the cells or tissues, that they must in most cases, at least, come from neutral states, and that they are often easily reversible, the female to the male or the male to the female. The phenomena of maleness, femaleness, and neutrality of cells, tissues, organs, or entire individuals do not come under the category of hereditary units or factors in the ordinary sense and are certainly not Mendelian, altho when their determination coincides with fertilization or reduction they may have a superficial resemblance to normal Mendelian phenomena. Sexuality will probably find its final explanation in relation to the somewhat similar physical and chemical phenomena, as electricity, magnetism, ionization, electrons, and the like.

It is remarkable that the opposite types of sexual states may arise in small contiguous areas of a common vegetative tissue; and that if the line of demarkation passes thru a unit structure, like the flower of *Arisæma triphyllum*, the one side should be staminate and the other side carpellate. The very organs in which the factors become active for the expression of sexual characters may thus become tissue mosaics in respect to these characters. Since maleness, femaleness, and neutrality are states plainly reversible during vegetative growth under different metabolic levels of the tissues or organs of the individual, it becomes evident that sex can not only be controlled but that it can be changed in any organism of indeterminate growth or in any part of an organism of determinate growth which possesses tissues that reproduce or regenerate themselves. It is even possible that cells which have completed their ontogeny might be reversed in sexual state, altho such reversal could probably only show itself functionally by the production of certain chemical bodies and not morphologically.

Columbus, Ohio, Dec. 6, 1920.

## EXPLANATION OF PLATES I AND II.

All the drawings were originally magnified and then reduced in the reproduction of the plates.

***Ricinus communis* L.**

- Fig. 1. Bisporangiate flower from the transition zone between the staminate and carpellate parts of the inflorescence.

***Peltandra virginica* (L.) Kunth.**

- Fig. 2. A normal carpellate flower showing the character of the gynecium and the prominent vestigial stamens.  
 Fig. 3. A flower from the transition zone showing the gynecium greatly reduced.  
 Fig. 4. A flower from the transition zone, near the staminate part of the inflorescence, showing a small vestigial gynecium with an elongated tip and 4 vestigial stamens. The normal staminate flowers have no vestige of carpels.

***Typha latifolia* L.**

- Fig. 5. Normal carpellate flower, showing the leaf-like stigma.  
 Fig. 6. A normal stamen. Staminate flowers may have two or more stamens on a common pedicel.  
 Fig. 7. A flower from the edge of a staminate area invading the carpellate part of the inflorescence, showing a stigma-like structure with two imperfect pollen sacs containing microspore tetrads.  
 Fig. 8. A stamen-carpel complex from the edge of a staminate patch in the carpellate part, showing one anther and a twin structure which has a pollen sac on one side and a stigma-like structure on the other.

***Arisaema triphyllum* (L.) Torr.**

- Fig. 9. Carpellate flower or gynecium from the edge of a staminate area in a carpellate inflorescence showing an anther growing out of one side.  
 Fig. 10. Gynecium from the edge of the transition zone between the lower carpellate area and the upper staminate, showing two anthers growing from its side.  
 Fig. 11. Gynecium from the top of a carpellate inflorescence with an anther on its side. Otherwise the inflorescence was completely carpellate.  
 Fig. 12. Gynecium somewhat rudimentary with a stamen growing from the side lying next to or partly within the staminate spot of the inflorescence.  
 Fig. 13. Flower from transition zone between the staminate and carpellate parts of an inflorescence, showing a stigma on one side and four anthers and irregular stigmatic and distorted masses on the other.  
 Fig. 14. Flower from the transition zone consisting of a small rudimentary gynecium with three pollen-sacs growing out of the side next to the staminate patch of the inflorescence.  
 Fig. 15. A flower on the line dividing the staminate and carpellate parts of an inflorescence showing a carpellate structure with stigma on one side and a staminate structure with two pollen-sacs on the other.  
 Fig. 16. A number of flowers on the transition zone; one with a rudimentary stigma and ovulary from which two large anthers have developed.  
 Fig. 17. An area on the transition zone showing two normal carpellate flowers on one side and two staminate flowers on the other with three rudimentary gynecia; one a normal gynecium but considerably reduced, the middle one vestigial, and the third one developed as a long, horn-like neutral structure.

***Myriophyllum heterophyllum* Mx.**

- Fig. 18. A carpellate flower from the lower part of the inflorescence, showing the large stigmas, minute vestigial stamens, and very small petals.  
 Fig. 19. A flower from near the base of the transition zone of the inflorescence, showing petals and vestigial stamens much larger than in the carpellate flowers below and having the stigmas somewhat reduced.  
 Fig. 20. A flower from near the base of the transition zone with apparently normal stigmas, with intermediate petals and enlarged vestigial stamens, one stamen being considerably longer than the other three.

- Fig. 21. A flower from the middle of the transition zone of the inflorescence showing petals of intermediate size, somewhat reduced stigmas, and the vestigial stamens considerably enlarged.
- Fig. 22. A flower from near the top of the transition zone next to the typical staminate part, showing rather large petals, stigmas decidedly reduced, and stamens of an intermediate size between the vestiges of the carpellate flowers and the typical stamens of the staminate flowers.
- Fig. 23. A staminate flower from above the transition zone of the inflorescence just before the petals open and the filaments elongate, showing normal stamens and vestigial stigmas. The larger petals have been removed.
- Fig. 24. A single petal from the staminate flower of Fig. 23, showing its large size when compared with the vestigial petals of the carpellate flowers.

## PLATE II.

*Zizania aquatica* L.

- Fig. 25. A stamen and vestigial gynecium of a flower from the lower or staminate part of the panicle.
- Fig. 26. The vestigial gynecium from Fig. 25 highly magnified, showing the three vestigial stigmas, the one much smaller than the other two.
- Fig. 27. A bisporangiate flower from the transition zone of the panicle showing a gynecium with stigmas of nearly normal size and character and normal stamen. Five similar stamens were removed. The spikelet had an awn of half length.
- Fig. 28. Gynecium and andrecium of mature carpellate flower from the upper, carpellate part of the panicle, showing the vestigial stamens and the normal stigmas.
- Figs. 29-34. Spikelets from the staminate part of the inflorescence thru the transition zone to the carpellate part, showing the sex limited nature of the awn, 29 and 30 are staminate, 31 and 32 are bisporangiate, and 33 and 34 are carpellate.

*Salix amygdaloides* And.

- Fig. 35. A typical staminate flower from the lower, staminate part of the catkin.
- Fig. 36. A normal gynecium with three stigmas from the upper, carpellate part of the catkin.
- Fig. 37. A normal gynecium with two stigmas.
- Fig. 38. A bisporangiate flower from the broad transition zone between the staminate and carpellate parts of the catkin. The anthers on filaments are yellow, while the anther growing out of the side of the ovary is of a brownish color characteristic of the preserved ovary.
- Fig. 39. A bisporangiate flower from the transition zone.
- Fig. 40. A flower from the top of the staminate part or at the base of the transition zone, showing four normal stamens and an elongated structure with a dark color, with two microsporangia near the tip.
- Fig. 41. A bisporangiate flower with one normal stigma and one stigma much reduced because of the presence of a microsporangium immediately below it.
- Fig. 42. A bisporangiate flower from the transition zone of a catkin, showing a microsporangium on the side near the top of the ovary and a stamen below.
- Fig. 43. A bisporangiate flower with two short stamens arising from near the base of the ovary and three microsporangia just below the stigmas.
- Fig. 44. A structure, part carpellate and part staminate, from the transition zone.
- Fig. 45. An abnormal flower with a confusion of staminate and carpellate parts.
- Fig. 46. A flower showing distorted staminate and carpellate structures.
- Fig. 47. A distorted structure, partly staminate and partly carpellate.
- Fig. 48. A carpel-like structure with an imperfect stigma and two abnormal anthers near the top.
- Fig. 49. An imperfect carpellate flower from the top of the transition zone, showing three imperfect stigmas and two small microsporangia.
- Fig. 50. A carpellate flower from the top of the transition zone, showing two small stamens and an abnormal stigma from the side of the ovary.
- Fig. 51. A partly matured ovary with seeds and with dried-up anthers on one side. From the base of the carpellate part of the catkin.



