HOMOGENEOUS AND HETEROGENEOUS RAYS

THEIR CHARACTERISTICS AND A KEY FOR THEIR IDENTIFICATION

BY

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Mededelingen van de Landbouwhogeschool
Deel 49 — Verhandeling 6

H. VEENMAN & ZONEN — WAGENINGEN — 1949

581.824.1

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(Received for publication on March 28th 1949)

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INHOUD

§ 1. INTRODUCTION

MOLL and JANSSONIUS (9, vol. I, p. 59), dutch wood anatomists who published in german, classified rays in 1906 merely as *einfache Markstrahlen* and *zusammengesetzte Markstrahlen*. Markstrahlen means rays. As long as this classification was used *einfache Markstrahlen* were rays composed of either upright (square) cells (fig. 1) or procumbent cells (fig. 2). These rays are termed in dutch: *enkelvoudige mergstralen* or *homogene mergstralen*, see REINDERS (14). In english and american literature (2, 5, 12, 13) they are known as *homogeneous* where they are composed of procumbent cells (fig. 2) and *heterogeneous* (fig. 1) when the cells are upright (square). Unfortunately these terms are not always used in the same sense even in american literature, thus being one example of many discrepancies between the terminology of various wood anatomists.

A third type of rays in MOLL and JANSSONIUS's classification were *zusammengesetzte Markstrahlen* (fig. 3), rays consisting of alternating tiers of upright and procumbent cells, in dutch: *samengestelde mergstralen*, in the „*Glossary*" (5): *heterogeneous*. So in english the same term comprises different types of rays, not only rays composed exclusively of upright cells, but also rays composed of both upright and procumbent cells.

The simple classification of 1906 was used by JANSSONIUS in his first studies (vol. I–III) of javanese woods (9). But in the first families examined for volume IV, the grouping appeared to be much too simple. Rays seldom are so plain in structure as those depicted in fig. 1, 2 and 3. They often are composed of both upright and procumbent cells, yet in such cases they may not always be designated as „zusammengesetzt". Why not, will be explained in due sequence. The presence of two types of cells within a ray is frequently notable in the type of fig. 2, but appears also in the type of fig. 1. During the progress of his work JANSSONIUS therefore altered the classification. The revision proved successful, but is by no means easily read nor easily applied.

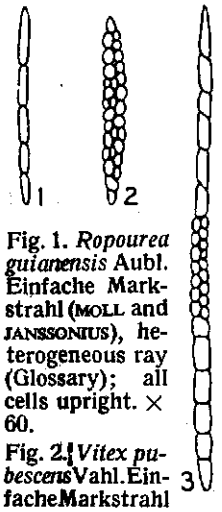


Fig. 1. *Ropourea guianensis* Aubl. Einfache Markstrahl (MOLL and JANSSONIUS), heterogeneous ray (Glossary); all cells upright. × 60.

Fig. 2. *Vitex pubescens* Vahl. Einfache Markstrahl (M. and JS), homogeneous ray (Glossary); all cells procumbent. × 90.

Fig. 3. *Sarcocephalus cordatus* Miq. Zusammengesetzte Markstrahl (M. and JS), heterogeneous ray (Glossary); the enlarged tier consisting of procumbent cells, the marginal tiers containing upright cells. × 60.

The new definition of a „zusammengesetzte" ray is fully cited in § 3 (p. 220). A part of it reads: „the enlarged tier or tiers are *commonly* multiseriate". But when the addition „commonly" has to be applied is not told by JANSSONIUS. So we can not tell beforehand whether a uniseriate ray as depicted in fig. 4 is a „zusammengesetzte", although its middle part is composed of procumbent cells. This is, however, of importance because JANSSONIUS uses the feature for segregation purposes in the Key on javanese woods (7). More details about the first and the revised definition will be mentioned in § 2 (p. 218) and in § 3 (p. 220).

Since JANSSONIUS did not mention characteristics by which to determine whether a ray were to be called *zusammengesetzt* or *einfach*, the present author tried and

Fig. 4. *Sarcocephalus cordatus* Miq. See text. × 60.

looked for such characteristics in JANSSONIUS's work. Due to the attention paid to details by Dr JANSSONIUS such features could be obtained from his descriptions of woods. They are told in § 6 (p. 223).

To establish these characteristics is one purpose of this paper. As will appear from subsequent paragraphs the identification of a ray is not always easily done, since the process sometimes involves a study not only of the structure of the ray type in question but also of all of the types in the sample.

The second purpose of this paper regards the division of rays into *kinds*. As the present author wrote in a previous paper (15) such a classification corresponds mostly, but not always to a division into *sizes*. It is discussed why a classification of rays based on kinds is to be preferred to a division based on size, see § 4 (p. 221) and § 8 (p. 228).

The illustrations in this paper depict the rays as they are seen on tangential face. This suffices for the purpose in view as the author checked cell shape on radial face where necessary. The drawings are the work of Dr JETSKE DE ZEEUW; the author gratefully acknowledges this help.

§ 2. THE FIRST RAY CLASSIFICATION OF MOLL AND JANSSONIUS

The full text of 1906 (vol. I, p. 59) reads: „Die Markstrahlen sind, je nach ihrer Differenzierung":

„1*a* einfach: nicht aus verschiedenen, senkrecht über einander gestellten Teilen zusammengesetzt",

„1*b* zusammengesetzt: aus in senkrechter Richtung über einander gestellten, *regelmässig abwechselnden ein- und mehrschichtigen Teilen* zusammengesetzt. Die einschichtigen Teile fast immer aus aufrechten Zellen aufgebaut; stets das oberste und unterste Stockwerck bildend. Die mehrschichtigen Teile fast immer aus liegenden Zellen aufgebaut,"

in english: rays „einfach", where consisting of one type of cells either upright or procumbent,

„zusammengesetzt", where consisting of *alternating tiers of uniseriate and multiseriate parts*. Uniseriate parts virtually always composed of upright cells, always on the upper and lower margin of the ray; multiseriate parts virtually always composed of procumbent cells.

According to this definition the rays depicted in fig. 1 and in fig. 2 are „einfache", the ray in fig. 3 is a „zusammengesetzte". In the „zusammengesetzte" rays the tiers composed of upright cells are uniseriate, those composed of procumbent cells are multiseriate. In the latter rays there may be many tiers, when rows of procumbent cells are alternating more than once with rows of upright cells; thus rays may be composed of 3 (fig. 5*a*), of 5 (fig. 5*b*) or of more tiers. The seriation of the multiseriate tiers may range from 2–several cells.

The definition sufficed for the classification of the rays of the woods which belong to the families enlisted into the vol. I–III, as for example the *Leguminosae*, but failed with the *Rubiaceae* and other families in later volumes. The first trouble regards the *uniseriate* rays that are composed of different parts. Are these parts tiers and thus the rays „zusammengesetzt" or are they not and may the rays be called „einfache"? From an examination of ray structure in the nearest rela-

tives JANSSONIUS concluded that in some of the cases such rays may be called „zusammengesetzt" (fig. 6) but in other cases „einfach" (fig. 7). Now neither of these classifications was possible but for a revision of the ray definition; the rays of fig. 6 can not be called „zusammengesetzt" because of their being uniseriate all over; the rays of fig. 7 can not be termed „einfach" because they contain two types of cells.

A revision of the ray definition was necessary as well from another point of view. Some woods not only possess uniseriate rays composed as those of fig. 8*a* and fig. 8*b*, but also multiseriate rays with uniseriate parts on the upper and lower margin (fig. 8*c* and fig. 8*d*). In fig. 8*c* the upper and lower tier are formed by the ray type of fig. 8*a*; according to the definition cited in this paragraph a ray of the type of fig. 8*a* is an „einfache" ray and the ray of fig. 8*c* is „zusammengesetzt". But in this wood two other types are present. One of them is represented by fig. 8*b*, a uniseriate ray that is partially composed of procumbent cells, the other one by fig. 8*d*. None of the latter ones might be satisfactorily classified regarding the definitions cited in this paragraph. The marginal parts of fig. 8*d*, particularly the lower one closely resemble the ray of fig. 8*b*. JANSSONIUS obviously percieved the analogy between the types of fig. 8*a* and 8*b* both of which are constituting the uniseriate marginal parts of rays that are for the rest multiseriate; in any case he designated the rays of fig. 8*d* as „zusammengesetzte" and those of fig. 8*b* as „einfache". Thus in *Alstonia* and in other genera, two types of „zusammengesetzte" and two types of „einfache" rays are present, the latter ones composing the upper and/or lower margin of the „zusammengesetzte" rays. The question is treated again in § 3 and in § 7 (p. 227). In classifying thus and not creating new terms for the peculiar types of rays, JANSSONIUS did justice to the relationship with other representatives of the families, where only two types of rays, those of fig. 8*a* and fig. 8*c* are present.

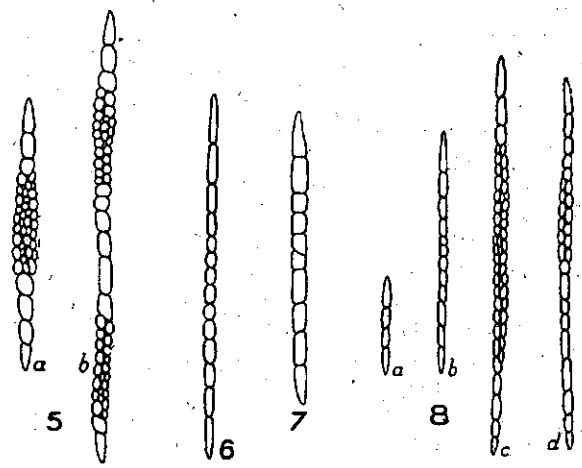


Fig. 5. *Wrightia javanica* A. DC. All × 90.
a. 3-storied heterogeneous ray.
b. 5-storied heterogeneous ray.

Fig. 6. *Ropourea guianensis* Aubl., „zusammengesetzte" ray. × 60.

Fig. 7. *Sarcocephalus cordatus* Miq., „einfache" ray. × 60.

Fig. 8. *Alstonia scholaris* R.Br. All × 60.
a. Ray „einfach", cells upright.
b. Ray „einfach", containing upright cells with radial rows of procumbent cells.
c. Ray „zusammengesetzt", the uniseriate tiers similar to ray 8a, the multiseriate tier consisting of procumbent cells.
d. Ray „zusammengesetzt", the uniseriate tiers similar to ray 8b, the multiseriate tier consisting of procumbent cells.

Fig. 9. *Wrightia javanica* A.DC. Ray „einfach" with one uniseriate row of upright cells at the margins. × 90.

Approximately the same trouble as in these uniseriate rays is encountered in the multiseriate type shown by fig. 2. This type is virtually never constituted of procumbent cells only; the upper and/or lower one or two marginal rows [1]) often contain upright or square cells (fig. 9). Yet JANSSONIUS terms these rays as „einfache"; according, however, to the definition they should have been called „zusammengesetzte".

JANSSONIUS was aware of the fact that a classification of rays could not be satisfactorily established but for his altering the definitions. The new definitions had to serve two purposes, first of all they should not interfere with the characterizations of rays in the volumes of the „Mikrographie" already issued, secondly they should mitigate the qualifications of seriation.

§ 3. THE REVISED CLASSIFICATION OF RAYS

In vol. IV, p. 403 JANSSONIUS (9) informs us of a revised definition of the term „zusammengesetzte" rays. It reads in german: „aus in senkrechter Richtung übereinander gestellten, *voneinander verschiedenen Teilen* zusammengesetzt. Die eine Art dieser Stockwerke, 1-schichtige oder schmale genannt, fast immer 1-schichtig und aus aufrechten Zellen gebildet, meistens der Markstrahl oben und unten abschliessend. Die andere Art, mehrschichtige oder breite Stockwerke genannt, fast immer mehrschichtig und grösstenteils oder ganz aus liegenden Zellen gebildet, der Regel nach den Markstrahl nicht oben oder unten abschliessend." It reads in english:

„zusammengesetzte" rays are rays composed of alternating narrow and enlarged tiers. The narrow tiers virtually always are uniseriate and are commonly composed exclusively of upright cells and generally present at the upper and lower margins of the ray. The enlarged tiers commonly are multiseriate, they are either entirely or for the most part constituted of procumbent cells; they generally do not occur at the margins.

The difference between the two definitions appears to be: no longer a „zusammengesetzte" ray needs to be composed of alternating narrow and enlarged tiers, but it may be uniseriate down its whole length.

JANSSONIUS does not give an altered definition of „einfache" rays. The revision, however, is not only apparent from the text of the definition of the „zusammengesetzte" rays cited here but also from the descriptions of woods in vol. IV of the *Mikrographie des Holzes*: an „einfache" ray no longer needs to be composed exclusively of one type of cells; inspection of ray figures 7, 8*b* and 9 may serve to show that „einfache" rays may contain both upright and procumbent cells. How their definition should be is spoken about in § 5 on p. 222.

In the revised definition the word „commonly" renders the definition vague. Sometimes as in the case of fig. 10, an examination of many species of the same *family* taught JANSSONIUS how to apply the words *commonly* and *virtually always* of his definition; sometimes an examination of all of the ray types within the same *wood* sufficed, as in the case of fig. 11. The ray of *Ropourea* (fig. 10) has to be

[1]) Only the uppermost and lowermost row are uniseriate, the other rows are multiseriate and so belong to the multiseriate part of the ray.

called a „zusammengesetzte" ray since in the allied species of *Ropourea* [1]), rays of the type of fig. 10 are biseriate procumbent in the places where they are uniseriate procumbent in *Ropourea*. In *Ficus* the uniseriate ray (fig. 11*a*) is similar to the marginal tier in the ray of fig. 11*b* of the same species. The latter, therefore, is a „zusammengesetzte" ray and the uniseriate ray is called „einfach", although it contains (as does the „zusammengesetzte" ray in fig. 10) procumbent *and* upright parts. For the same reasons the ray of fig. 6 is „zusammengesetzt" and the rays of fig. 7 and fig. 8*b* are „einfache" rays.

If, however, allied species are unknown or if some of the ray types are rare, a determination and designation of rays should yet be possible or JANSSONIUS's classification of rays would be of no importance. As was mentioned in the introduction the present author succeeded in collecting the features wanted, from JANSSONIUS's wood descriptions; they will be recounted in § 6 (p. 223).

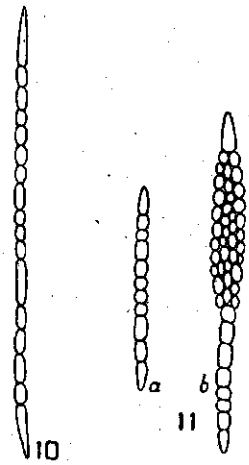


Fig. 10. *Ropourea guianensis* Aubl. „Zusammengesetzte" ray. × 60.

Fig. 11. Ficus L. spec. All × 90.
a. „Einfache" ray containing upright and procumbent cells.
b. „Zusammengesetzte" ray, 2-storied; the lower tier similar to ray 11a.

§ 4. KINDS OF RAYS

In vol. I and II of the work of MOLL and JANSSONIUS (9) rays were not yet divided into „kinds", but only into „einfache" and „zusammengesetzte" rays. In vol. III JANSSONIUS distinguishes two kinds but only with regard to size and uses the terms narrow and enlarged. But soon it was recognized that the structure of rays if to be used for diagnostical purposes was too complicated to have classification depended on size only; seriation and types of cells had to enter into the classification. JANSSONIUS never wrote about the new grouping: the new classification appeared for the first time in vol. IV in all of the descriptions; from here on it is constantly used and apparently reads:

I. Rays of the *first kind*, when composed exclusively of upright cells or of such cells mingled with radial rows of procumbent cells.

II. Rays of the *second kind*:

a. „zusammengesetzte" rays (revised definition, see p. 220),

b. „einfache" rays composed exclusively of procumbent cells or with one or two or three rows of upright cells at the upper and lower margin, the upper and lower row uniseriate, the other one(s) multiseriate and so belonging to the multiseriate part of the ray.

Since JANSSONIUS classified rays intuitively in this way it might be asked why he grouped thus and why he did not place for example rays of the second kind b into the group „rays of the first kind" and had this first group fall into two sub-

[1]) According to REINDERS-GOUWENTAK and STAHEL (16) *Ropourea* is a representative of the *Ebenaceae*. The name *Ropourea guianensis* Aubl. has to be replaced to all probability by *Diospyros Martini* R. Ben. (AMSHOFF (1)).

groups. That such a classification would not have been a natural one might already be evident from paragraph 3. Further, rays composed of procumbent cells often have rows of upright cells at the upper or lower margin and so differ only from „zusammengesetzte" rays through the number of the uniseriate rows of upright cells. As soon as this number is two or more on one or both margins, the ray becomes a „zusammengesetzte" of either two or three tiers. So there is more difference between a ray composed of upright cells (a ray of the first kind) and a „zusammengesetzte" ray than between the two types of the second kind.

In wood anatomical descriptions and keys rays often are classified according to *size* (RECORD and HESS (13), RECORD (11), HESS (6)); in that case the structure of rays is only considered by a mere statement of the presence of upright or procumbent cells or both of them. On the other hand, as may be remembered from the information given in the preceeding paragraph the structure of rays is far more complicated; treated in the way as it is by JANSSONIUS, structure is a valuable feature from a taxonomical point of view. To this feature full justice is only done if rays are divided into *kinds* [1]) and not if they are classified according to size (see also KRIBS (8)). Within both kinds various sizes may occur. The question is further discussed in § 8 (p. 228).

§ 5. SUGGESTIONS FOR TERMINOLOGY

RECORD and CHATTAWAY (12) propose the term *homogeneous* for rays composed of procumbent cells only (admitting sporadic upright/square cells). The present author suggests to extend this term that it might also cover rays composed of procumbent cells with 1–3 *marginal rows* of upright cells, the upper and lower row *uni*seriate, the other one(s) belonging to the *multi*seriate part of the ray. These rays only differ from homogeneous (in the sense as it is used by RECORD and CHATTAWAY) rays composed of procumbent cells through the presence of these marginal row(s) of upright cells.

Further, RECORD and CHATTAWAY propose the term *heterogeneous* for rays composed of upright (square) cells only and also for those composed of both upright (square) and procumbent cells. Since, however, these two types of „heterogeneous" rays are decidedly different, one of them, as has been shown in § 3, functioning as tiers in the other type, the present author suggests to restrict the term *heterogeneous* to rays composed of alternating *tiers* of upright (square) and procumbent cells („zusammengesetzte Markstrahlen", „samengestelde mergstralen"). To rays composed exclusively of upright (square) cells, the term *homogeneous* should be applied.

Note, that now the term *homogeneous* is applied to two types of rays, as RECORD and CHATTAWAY did with heterogeneous, but this time the types have the same anatomical function, since they compose each of them the upright or procumbent tiers of the heterogeneous ray. Justice is done to their different *structure* by placing them into different categories called *kinds*[1]). In terms of JANSSONIUS's characterizations classification of rays becomes in english:

1. Rays of the *first kind*:

Homogeneous, virtually always uniseriate, composed of upright (square) cells or sometimes of upright (square) cells with radial rows of procumbent cells scattered between (fig. 1, fig. 4).

[1]) The term *type* would have been preferred by the present author but it was already used in another sense by KRIBS (8).

2. Rays of the *second kind*:

2*a*. *Heterogeneous*, rays composed of alternating narrow and enlarged tiers. The narrow tiers virtually always uniseriate and virtually always composed exclusively of upright cells, commonly also occurring at the upper and lower margin of the ray. The enlarged tiers virtually always multiseriate and entirely or for the most part consisting of procumbent cells, commonly not occurring at the margins.

2*b*. *Homogeneous*, virtually always multiseriate, entirely or for the most part (fig. 12) composed of procumbent cells, sometimes with a few rows of upright cells at the upper and/or lower margin in which case the upper and lower row of upright cells are uniseriate and the other one or two rows of upright cells are multiseriate and belong to the enlarged part of the ray.

But unless there are easily recognizable categories of rays the scheme cannot serve as a means of separating homogeneous and heterogeneous rays, since the words „commonly" and „virtually always" included in the definitions render a classification impossible. Now neither in the wood descriptions nor in his books JANSSONIUS informs the reader when for example a ray that is also uniseriate in its „enlarged" part has to be called homogeneous according to its seriation or heterogeneous according to its being composed of upright and procumbent cells. Yet, the presence of such information within JANSSONIUS's descriptions seemed highly probable. As has been stated previously in the text this proved to be the case. The result is recorded in the next paragraph and for ease of manipulation has been incorporated into a key where information is arranged by following a dichotomous plan.

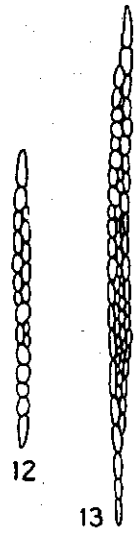


Fig. 12. *Ropourea guianensis* Aubl. Homogeneous ray of the second kind with one row of upright cells at the margins. × 60.

Fig. 13. *Glochidion philippicum* Robinson. Three-storied heterogeneous ray with sheath cells on the flanks. × 60.

It is well to make note of the fact that heterogeneous rays occur in the second kind only. Homogeneous rays are present in both first and second kind. Where homogeneous rays of the second kind are not composed exclusively of procumbent cells but contain upright cells at the margin(s) they are yet different from *three*-storied heterogeneous rays through the number of the uniseriate rows of upright cells at the margins. Only when one uniseriate row of upright cells is present the ray is still to be called homogeneous (fig. 12).

Sheath cells, upright cells situated on the flanks of heterogeneous rays (fig. 13) are merely accessory features and are of no significance with regard to the classification of rays, see also CHATTAWAY (3).

§ 6. KEY FOR IDENTIFICATION OF HOMOGENEOUS AND HETEROGENEOUS RAYS

1	Rays composed of one type of cells only	2
	Rays composed of two types of cells [1])	7
2	Rays composed of upright cells only, uniseriate or multiseriate	3
	Rays composed of procumbent cells only	4

[1]) Note only whether upright (square) and procumbent cells are present; rays with tile cells being peculiar enough in themselves do not fall within the province of the key.

3 Rays uniseriate or locally biseriate.

a. Homogeneous of the first kind (fig. 14).

Rays multiseriate [1]) (rare, for example: *Urticaceae*).

b_1. Homogeneous of the second kind.

4 Multiseriate or multiseriate with uniseriate extension(s) 5
Uniseriate 6

5 Multiseriate all over

b_2. Homogeneous of the second kind (fig. 15, 17*b*).

Multiseriate with uniseriate extension(s)

c. Heterogeneous (fig. 16*b*)

6 The uniseriate rays similar to the marginal extension(s) of partly multiseriate (fig. 16*b*) rays. In this case the uniseriate rays are

d. Homogeneous of the first kind (fig. 16*a*).

No such partly multiseriate rays present. Multiseriate rays without marginal extensions present (fig. 17*b*) or absent. In this case the uniseriate rays are

e. Homogeneous of the second kind (fig. 17*a*)

7 Partly multiseriate 8
Uniseriate all over 10

8 Composed of 5 or more alternating uniseriate and multiseriate parts of upright and procumbent cells. The upright tiers may be mingled with radial rows of procumbent cells (fig. 20*b*) and are commonly present also at the upper and/or lower margin (fig. 18*c*). The tiers may be of different height, ranging from 1–many cells.

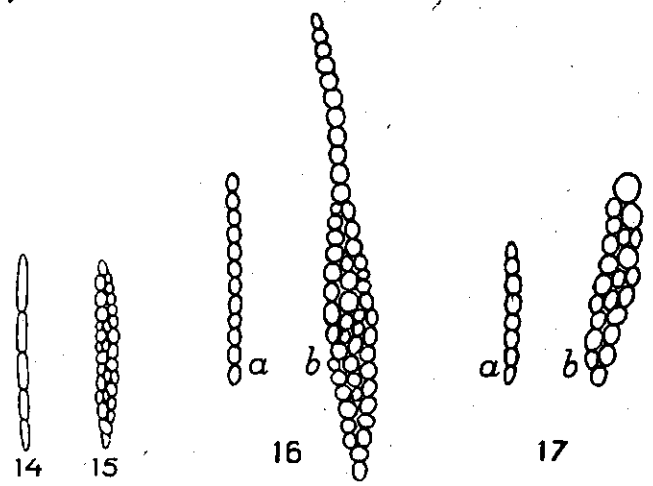


Fig. 14. *Ropourea guianensis* Aubl. Homogeneous ray of the first kind; all cells upright. × 60.

Fig. 15. *Vitex pubescens* Vahl. Homogeneous ray of the second kind, entirely consisting of procumbent cells. × 90.

Fig. 16. *Acer campestre* L. All × 180.
a. Homogeneous ray of the first kind, consisting of procumbent cells.
b. Heterogeneous ray composed of two tiers; one multiseriate and one uniseriate tier, both consisting of procumbent cells.

Fig. 17. *Cassia javanica* L. All × 180.
a. Homogeneous ray of the second kind, uniseriate, consisting entirely of procumbent cells.
b. Homogeneous ray of the second kind, also consisting entirely of procumbent cells, but multiseriate.

[1]) JANSSONIUS designates as homogeneous rays also the multiseriate rays with long uniseriate extensions which very rarely occur in the *Urticaceae*, but he states in a footnote that these rays might be called heterogeneous. – Is probably better!

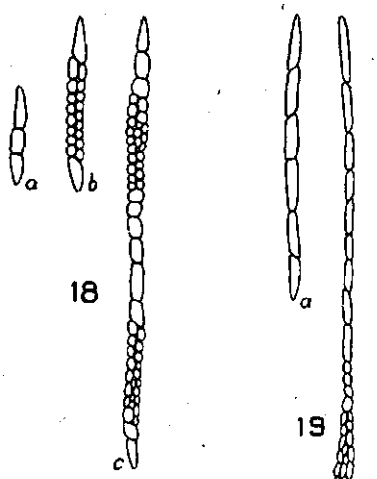


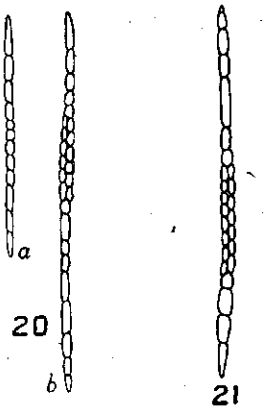
Fig. 18. *Wrightia javanica* A. DC. All × 90.

a. Homogeneous ray of the first kind, consisting of upright cells.

b. Homogeneous ray of the second kind; the multiseriate part consisting of procumbent cells the top rows containing also upright cells; the uniseriate marginal parts consisting of upright cells one cell in height.

c. Heterogeneous ray, composed of two multiseriate tiers of procumbent cells and three uniseriate tiers of upright cells (5-storied).

Fig. 19. *Dillenia aurea* Smith. All × 60.



a. Homogeneous ray of the first kind consisting exclusively of upright cells.

b. Heterogeneous ray, composed of three tiers; one multiseriate tier of procumbent cells, two high marginal tiers of upright cells, in one of which the rows next to the multiseriate part consist of procumbent cells.

Fig. 20. *Alstonia scholaris* R.Br. All × 60.

a. Homogeneous ray of the first kind, consisting of upright cells with radial rows of procumbent cells.

b. Three-storied heterogeneous ray. The marginal tiers composed as the ray in fig. 20*a*.

Fig. 21. *Alstonia scholaris* R.Br. Heterogeneous ray; the uniseriate marginal tiers are of different height. × 60.

f. Heterogeneous (fig. 18*c*) [1]

Composed of 3 or 2 alternating parts i.e. 2 or 1 *uniseriate* (sometimes locally biseriate) part(s) of upright (square) cells or upright (square) cells mingled with procumbent cells, and one *multiseriate* part of procumbent cells [2]. The upright tiers commonly restricted to the upper and/or lower margin and 1–many cells in height 9

9 Marginal part(s) formed by uniseriate extension(s) composed of upright (square) cells and identical with the rays *a* of the key in the same sample (fig. 19*a*) or formed by uniseriate extension(s) composed of upright (square) cells with rows of procumbent cells scattered between (fig. 20*a*), which are also present as separate rays (the rays *k* of the key)

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[1]) The upper and/or lower radial row or rows of the *multi*seriate part(s) may be also composed of upright cells (fig. 28*f*).

[2]) The multiseriate part may be composed of upright cells with scarce rows of procumbent cells in the middle (some species of the *Urticaceae*).

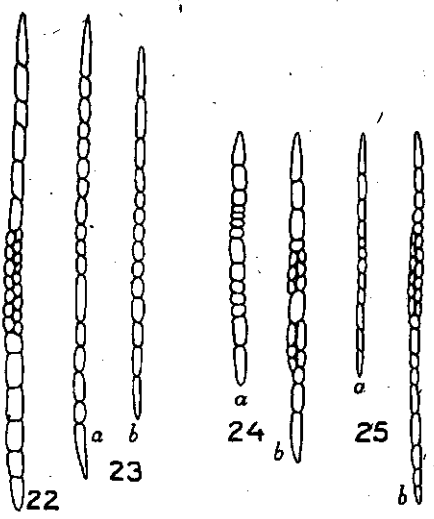

Fig. 22. *Sarcocephalus cordatus* Miq. Heterogeneous ray composed of three tiers, one multiseriate tier of procumbent cells, two tiers of upright cells. × 60

Fig. 23. *Ropourea guianensis* Aubl. All × 60.
a. Heterogeneous ray, uniseriate all over and composed of many tiers.
b. Heterogeneous ray, uniseriate all over, composed of three tiers.

Fig. 24. *Nauclea* L. *spec.* All × 90.
a. Heterogeneous ray, uniseriate all over, composed of 5 tiers.
b. Heterogeneous ray, partly multiseriate, composed of 5 tiers.

Fig. 25. *Alstonia scholaris* R.Br. All × 60.
a. Homogeneous ray of the first kind, composed of upright cells with a radial part of procumbent cells.
b. Heterogeneous ray composed of a multiseriate tier of procumbent cells and two uniseriate tiers of upright cells with radial rows of procumbent cells.

g. Heterogeneous (fig. 19*b*, 20*b*, 22) [1])

Marginal part(s) consisting of 1 *uni*seriate radial row of upright cells only.

h. Homogeneous of the second kind (fig. 18*b*) [1], [2])

If the marginal parts of a ray are identical with the homogeneous rays of the first kind and the (enlarged) body or bodies with the homogeneous rays of the second kind, the parts are called *tiers*. The marginal tiers may be of different height (fig. 21), variations being the same as in the homogeneous rays of the first kind (fig. 14). Such rays are called two-storied, three-storied rays etc. Authors who do not distinguish tiers *within* a ray use the term storied rays for rays arranged so as to occasion ripple marks. Where the marginal parts are unlike the homogeneous rays of the first kind regarding height or cell shape the term tier may not be used: see the ray in fig. 18*b*.

10 (coming from 7) Partly multiseriate rays which are heterogeneous according to *f* (fig. 18*c*) or *g* (fig. 19*b*, 22) absent, then the uniseriate rays are

i. Heterogeneous (fig. 23*a*, 23*b*)

Partly multiseriate rays heterogeneous according to *f* or *g* present (fig. 18*c*, 22) 11

11 The uniseriate rays only differing from the multiseriate rays present in being uniseriate (fig. 24*a*) in the places where the enlarged rays are multi- (usually bi-)seriate (fig. 24*b*).

j. Heterogeneous (fig. 24*a*)

All other uniseriate rays; these rays often similar to the marginal tiers of some of the rays called heterogeneous according to *f* or *g* (fig. 25*b*).

k. Homogeneous of the first kind, composed of upright cells with radial rows or a radial part of procumbent cells (fig. 25*a*).

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[1]) The upper and/or lower radial row or rows of the *multi*seriate part(s) may be also composed of upright cells (fig. 28*f*).

[2]) The multiseriate part may be composed of upright cells with scarce rows of procumbent cells in the middle (some species of the *Urticaceae*).

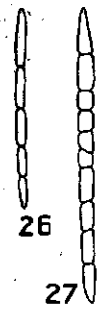

Fig. 26. *Ropourea guianensis* Aubl. Homogeneous ray of exclusively upright cells. × 60.

Fig. 27. *Sarcocephalus cordatus* Miq. Homogeneous ray of upright cells with radial rows of procumbent cells. × 60.

§ 7. COMMENTS IN ADDITION TO THE KEY

When heterogeneous rays are present, whether uniseriate or multiseriate, homogeneous rays of the first kind also occur (fig. 19*a*, 19*b*). Exceptions are scarce: *Cordia suaveolens* BLUME (MOLL and JANSSONIUS vol. IV, p. 691) has no homogeneous rays of the first kind although (scanty!) heterogeneous rays composed of 2 or 3 tiers are present.

In all other cases homogeneous rays of the first kind were present, composed exclusively of upright cells (fig. 26), of upright cells with radial rows of procumbent cells (*Sarcocephalus*, fig. 27) or of procumbent cells only (*Acer*, fig. 16*a*). The marginal tiers of the heterogeneous rays are formed by the type or types of homogeneous rays of the first kind present in the same species. Sometimes as in *Sarcocephalus*, the type of heterogeneous rays with the marginal part of the ray of fig. 26 is present in abundance, but the type formed with the ray of fig. 27 is rare, although both types of homogeneous rays of the first kind are present. In other woods, for example in *Ficus* or in *Alstonia* (fig. 28), both types of homogeneous rays and of heterogeneous rays are present.

The ray picture of *Alstonia* is interesting enough to be particularly mentioned. This species actually possesses 5 à 6 different types viz. two types of uniseriate rays (fig. 28*a* and 28*b*), two types of heterogeneous rays (fig. 28*c* and 28*d*) and the type of fig. 28*e* and 28*f*. The rays of fig. 28*a* are uniseriate and composed of upright cells only and so are *homogeneous* of the first kind (the ray *a* on p. 224 of the key). The rays of fig. 28*c* are partly multiseriate rays and composed of one portion of procumbent cells and two parts of upright cells. As the marginal parts are identical with the homogeneous rays of the first kind (fig. 28*a*), the rays are *heterogeneous* according to the ray *g* on p. 226. The rays of fig. 28*b* are uniseriate, composed of 3 parts; yet they are *homogenous of the first kind*, because they (see ray *k* on p. 226) appear to compose the marginal tiers of the ray in fig. 28*d*. For the same reasons as those of fig. 28*c* the latter ones are to be called *heterogeneous*, the upper marginal tier being identical with fig. 28*a*, the lower margin with fig. 28*b*. Fig. 28*e* and 28*f* are *homogeneous* rays according to ray *h* of the key. In fig.

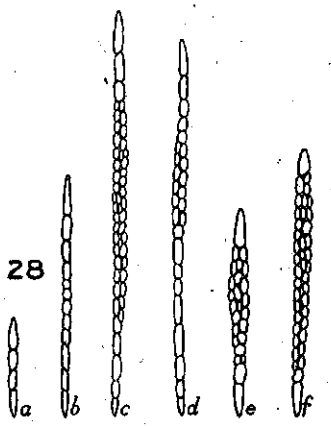

Fig. 28. *Alstonia scholaris* R.Br. All × 60.

a. Homogeneous ray of the first kind. Upright cells only.
b. Homogeneous ray of the first kind. Upright cells and radial rows of procumbent cells.
c. Heterogeneous ray. The uniseriate tiers composed as 28*a*.
d. Heterogeneous ray. The uniseriate tiers with radial rows of procumbent cells (as 28*b*).
e. Homogeneous ray of the second kind with one uniseriate row of upright cells at the margins; see text.
f. Homogeneous ray of the second kind with one uniseriate row of upright cells at the margins; one of the uppermost radial rows of the multiseriate part with an upright cell on tg. face.

28*e* only the upper and lower row are composed of upright cells [1]); in fig. 28*f* one of the uppermost radial rows of the *multi*seriate part contains upright and procumbent cells (cf. note 1 on p. 226 and definition of ray 2*b* on p. 223).

§ 8. DISCUSSION

As was mentioned in paragraph 4 rays may be classified according to seriation and cell shape or according to their structure. A choice in favour of the latter has been suggested, being the only one of the two classifications taking all characteristics of rays into consideration. An accurate knowledge of ray structure not only reveals more facts for segregation purposes as it increases the number of wood characters available, but will also permit of understanding thoroughly the mutual connection existing between the types of rays within the specimen and the botanical affinity between genera.

1. *Increase of feature number*. Compared with the abundance of morphological characters taxonomy has the disposal of, wood anatomy does not possess many diagnostical features. From a mere practical point of view this is an argument not to neglect any feature available. It would be desirable to analyze the structure of rays in future more elaborately than it has been generally done up to the present. Wood specimens are continually increasing in number and as many features as may be obtained will be wanted for their separation. Particularly when an unknown wood has to be identified as much information as may be obtained about structure will be necessary. Only then a correct determination may be insured; citing DADSWELL and RECORD (4): „The correct determination of a specimen requires consideration of every possibility residing in more than 3000 genera of over 230 families".

2. *Mutual connection*. The various types of rays present in the same sample are often mutually connected with respect to structure. The uniseriate rays of upright cells in *Sarcocephalus cordatus* MIQ. and also those composed of both upright and procumbent cells (fig. 27) are functioning as the upright tiers of the heterogeneous rays in the same species. The same striking connection exists between the ray types of *Alstonia scholaris* R.BR. depicted in fig. 28*a*, *b*, *c*, *d*, *e*, *f*. The uniseriate extension of the ray in fig. 28*c* possesses the same structure as the *ray* of fig. 28*a*; the same holds as between fig. 28*d* and 28*b*. The identity of the enlarged portion of the ray in fig. 28*e* and 28*f* and the multiseriate tiers of the heterogeneous rays of fig. 28*c* and fig. 28*d* is evident. A classification which takes structure into consideration sees the connection between these rays, between those of fig. 16*a* and 16*b*, between those of fig. 17*a* and 17*b* and between the various types of fig. 32 to be spoken of in due course. Because it sees, the rays of fig. 16*a*, fig. 32*a* and fig. 32*c* are called homogeneous rays of the *first kind*, whereas those of fig. 17*a* are called homogeneous of the *second kind*, although for example the rays of fig. 16*a* and of fig. 17*a* *in themselves* are identical. The same may be said of the ray of fig. 28*b* and of fig. 23*b*. These rays are quite identical with regard to cell shape, but one of them has to be called *heterogeneous* (fig. 23*b*) and the other one (fig. 28*b*)

[1]) The second lowermost cell being on tg. face a transition between a square and a procumbent cell, the ray cannot be designated indisputably. It might be a heterogeneous one. Yet *Alstonia* has got plenty of rays with typical procumbent cells in this particular row.

homogeneous. Classification regarding only size and shape of cells does not see these phenomena. It stops at stating seriation variations and at mentioning *homocellularity* or *heterocellularity* within the types, that is it states only whether cells are procumbent or upright or whether both types of cells occur within the same ray, see KRIBS (8) for the introduction of these terms.

3. *Botanical affinity*. Within a family sometimes several types of rays are present different in structure and/or size. To group rays according to size and to acknowledge only whether they are composed of upright and/or procumbent cells appeared to be a too simple doing and not to guarantee a natural classification. Within the genus *Diospyros* L. some species possess uniseriate rays of upright cells (fig. 29*a*) and biseriate heterogeneous rays; in other species the uniseriate homogeneous rays (fig. 29*a*) are present accompanied by rays uniseriate also but containing upright and procumbent parts (fig. 29*b*), whereas biseriate or locally biseriate heterogeneous rays are scarce (JANSSONIUS (9)). To obtain a grouping in which justice is done to morphological relationship as much as possible JANSSONIUS also designated the uniseriate rays of the *Diospyros* species where upright cells are mingled with procumbent cells as heterogeneous rays. These uniseriate heterogeneous rays differ from the biseriate heterogeneous rays only by being uniseriate in the spots where the other ones are biseriate. In *Ropourea* AUBL. biseriate heterogeneous rays have not been found at all (16). Since in this species of the *Ebenaceae* no multiseriate heterogeneous rays of different structure have been found, there is no objection to consider the uniseriate rays of fig. 29*b* as to be uniseriate also in the places where the rays of other *Ebenaceae* are biseriate and to call them heterogeneous too.

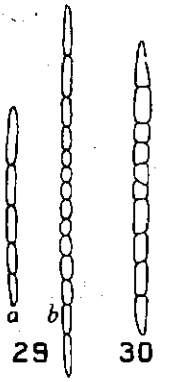

Fig. 29. *Ropourea guianensis* Aubl. All × 60.
a. Homogeneous ray of the first kind.
b. Heterogeneous ray, uniseriate and composed of 3 tiers.

Fig. 30. *Sarcocephalus cordatus* Miq. × 60. Homogeneous ray of the first kind with radial rows of procumbent cells.

Sarcocephalus cordatus MIQ. (fig. 30) has uniseriate rays similar to the heterogeneous ones of fig. 29*b*, but here these rays are called homogeneous of the first kind, since in *Sarcocephalus* and in several other species of the *Rubiaceae* multiseriate heterogeneous rays occur, in which the uniseriate rays sometimes appear as the marginal tiers. Because of botanical affinity these uniseriate rays in all the genera of the *Rubiaceae* should be designated in the same way; because of their connection with the multiseriate rays within the same species, the most appropriate designation is that of homogeneous of the first kind. In grouping rays as he did JANSSONIUS made woodanatomical and taxonomical classification agree. The fact that a *key* to rays could be prepared on his characterizations substantiates the truth in JANSSONIUS's conception of ray structure. The present writer has not encountered more than two exceptions to the rules of the key of § 6, that are *Litsea confusa* KOORD. et VALET. and *Litsea brachystachya* BOERL. At first sight it seems as if there are more exceptions: *Sarcocephalus cordatus* MIQ. and other *Rubiaceae*, *Compositae* etc., *Nyssa sessiliflora* HOOK. f. et THOMS.[1])

[1]) The name is outlawed, see for example WASSCHER in VAN STEENIS (17) *Flora malesiana;* the tree's botanical name ought to be *Nyssa javanica* (Bl.) Wang.

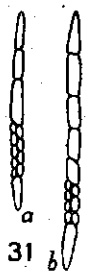

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Fig. 31. *Sarcocephalus cordatus* Miq. All × 60.

a. Heterogeneous ray composed of two tiers, The uniseriate tier of upright cells is short.

b. As *a*, but the uniseriate tier is longer.

Gelonium glomerulatum Hassk. and *Homalanthus* Juss.; as will be shown subsequently, in fact these species are no exceptions, but due to the fact that Janssonius had not yet perfectioned his conception of ray structure. Fortunately discrepancies are of little importance, since both ray types concerned are present – the homogeneous rays of the second kind and the heterogeneous – and so only the boundary between the two types will have to be drawn elsewhere.

Sarcocephalus cordatus Miq. (9, vol. IV). Janssonius describes among other types of rays a type with a multiseriate procumbent part and an upper *or* lower part which is 3–many cells high. According to the key in § 6 these rays (fig. 31*a* and 31*b*) are heterogeneous rays consisting of two tiers. At the time when he examined *Sarcocephalus* (vol. IV, p. 46) Janssonius did not distinguish two-storied rays and so called these rays homogeneous of the second kind.[1]) In later days he would certainly have designated these rays of *Sarcocephalus* as two-storied heterogeneous rays. The disparity, however, does not interfere with classification as three- and more-storied heterogeneous rays are also present in *Sarcocephalus*.

The same trouble as in *Sarcocephalus* is encountered in other genera of the *Rubiaceae*, in *Nyssa sessiliflora* Hook. f. et Thoms. and in other families where one marginal part ranges between 2–25 cells: so these rays also are two-storied heterogeneous rays.

Gelonium glomerulatum Hassk. (9, vol. V, p. 781). According to Janssonius the rays belong to almost one kind; the author describes uniseriate rays, 2–3 seriate rays and uniseriate rays that are partly 2- or 3-seriate. The bi(3)-seriate rays or parts of rays contain procumbent cells, the uniseriate rays and parts of rays are often composed of procumbent cells, but also of upright and procumbent cells. In a note at the bottom of the page Janssonius informs us he might have called the hetero*cellular* rays heterogeneous. It appears advisable to obey the footnote; and to all probability Janssonius would have done this too, if he had realized himself the classification rules of the key in § 6 of this paper. There is no objection with regard to the allied species of the group II of the *Euphorbiaceae* (see vol. V, p. 467).

The same is the case with *Homalanthus populneus* Kuntze and *H. giganteus* Zoll. et Mor. (vol. V, p. 789 and p. 796), but here these heterogeneous rays are rare. The genus is closely related to *Excoecaria* L. which possesses homogeneous uniseriate rays of the second kind.

Litsea confusa Koord. et Valet. and *Litsea brachystachya* Boerl. Here the multiseriate heterogeneous rays present in other *Litsea* species are lacking. The species only possess homogeneous rays of the first kind composed of upright cells, rays x composed of upright cells with radial rows of procumbent cells scattered between and homogeneous rays of the second kind. According to the rays *i* of

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[1]) Once Janssonius had got a conception of 2-storied rays, such queer phenomena as a ray being homogeneous when it has one wing of 2–3 cells (cf. fig. 31*a*) but heterogeneous when it has two such wings, disappeared and both rays were called heterogeneous (cf. *Vernonia*, vol. IV, p. 253 and *Ehretia*, vol. IV, p. 699).

the key in § 6 the rays x must be called heterogeneous, as multiseriate heterogeneous rays are absent. But with regard to ray types in other *Litsea* species, this will not do, as it is not in keeping with botanical affinity. In other words, in the case of *Litsea confusa* KOORD. et VALET. and *Litsea brachystachya* BOERL. the key in § 6 does not work satisfactorily. Yet, it did not seem worth while to try and alter the key in § 6 for the benefit of the two species. The question is besides that a purely academical one since the *Litsea* species have not been separated in the keys on laurineous woods (7, 9, 15) by using the character about presence or absence of heterogeneous rays and so no mistake in identification of the species will result.

Rays may be studied and examined from at least three different points of view:

1. by an examination of each ray without comparing it with other rays,
2. by an examination of all of the ray types within the species, eventually within the genus or family, and comparing them,
3. by treating all ray types within the species as a whole.

The 1st point of view has been taken by those authors, for example the „Glossary", who only state the shape of cells within each ray and then designate the ray as either a homogeneous ray if only procumbent cells are present, or a heterogeneous ray if upright (square) cells exclusively or both these and procumbent cells are present. KRIBS (8) suggests for rays composed of one kind of cells the term *homocellular*, for those that contain two kinds of cells the term *heterocellular*. The terms are worthy of attention.

The 3rd point of view has been taken by KRIBS (8). This author starts with the examination what rays are present in the sample. If only homocellular rays are present, the wood is said to possess a *homogeneous type* of rays. If also heterocellular rays are present, then ray structure represents a *heterogeneous type*. So KRIBS uses these terms for specific *ray combinations*.

From the 2nd point of view the work published in the present paper has been done. In the woods described by JANSSONIUS even more structural types were found than KRIBS admitted. The present author does not use the terms *homogeneous ray* and *heterogeneous ray* with regard to homo*cellularity* or hetero*cellularity*, but as seen from a structural point of view. Thus a homogeneous ray may be heterocellular and a heterogeneous ray may be homocellular.

The work of KRIBS (8) and the ray classification as it appears from the present paper will now be compared. KRIBS recognizes 6 different types: the heterogeneous type I, the heterogeneous type II, the homogeneous type I, the homogeneous type II, the heterogeneous type III (only uniseriate rays present) and the homogeneous type III (only uniseriate rays present). They will be compared now with the present authors classification; the letters *a*, *b* etc. refer to the key in § 6. All combinations recognized by KRIBS and even more may be found in JANSSONIUS's wood descriptions. Fig. 33 on p. 233 may be used for illustration of the following text.

The heterogeneous type I of KRIBS comprises our heterogeneous rays g_1 in combination with our homogeneous rays *a*.

The heterogeneous type II is divided into two subtypes. Subtype A comprises the rays g_2 and *a* and to the present authors opinion must also comprise *f*. The marginal tiers of g_2 are considerably lower than in the preceeding type I and some-

times only one cell high, the latter then being our type *h*. The uniseriate rays of subtype B are described to contain either upright cells (our rays *a*) or ± procumbent cells. The multiseriate rays are our rays g_2 but with only two upright cells at the margins, or our ray *h*, but also our rays g_2 with square instead of upright cells at the margins. What are the rays composed of cells bearing resemblance to procumbent cells? Most probably our type *d*, but the text is not illustrative enough to permit of deciding and no photomicrograph is present of this type.

The homogeneous type I as depicted in the photomicrograph, in KRIBS's paper, of *Acer mandshuricum* MAXIM. to our opinion is not a homogeneous but a heterogeneous type, since text and photomicrograph in KRIBS's paper show rays with a uniseriate wing of procumbent cells. The present writer saw the same type in for example *Acer campestre* L. of the slide collection of the laboratory. This wood possesses, as does *Acer mandshuricum* MAXIM., uniseriate rays of procumbent cells (fig. 32*a*) and multiseriate rays also composed of procumbent cells (fig. 2). But it has besides these rays multiseriate rays with a wing of uniseriate procumbent cells (fig. 32*b*). If one kind of a ray serves as the marginal part of another ray, the latter is to be called a *heterogeneous ray*. *Acer campestre* L. possesses also uniseriate rays of procumbent cells with upright cells scattered between (fig. 32*c*) and multiseriate rays with a wing where procumbent cells and upright cells are present and even upright cells only (fig. 32*d*). In other *Acer* species of our collection we found the same phenomena: *Acer platanoides* L. and *Acer saccharinum* L. with rays from the type of fig. 2, fig. 32*a* and fig. 32*b*. The multiseriate rays of *Acer pseudoplatanus* L. usually possess no wings, but where they are present they are short and contain square cells; the uniseriate rays are composed of procumbent cells but some of them contain upright or square cells. If he had seen the ray picture of these *Acer* species KRIBS certainly would have called the type a heterogeneous one even in *Acer mandshuricum* where evidently upright cells are absent.

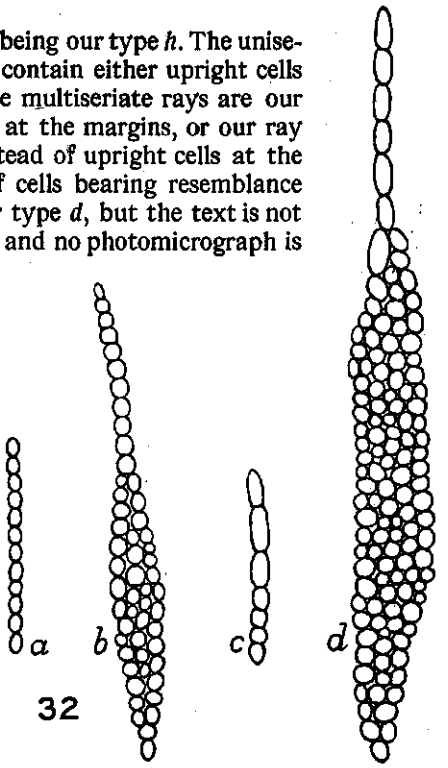
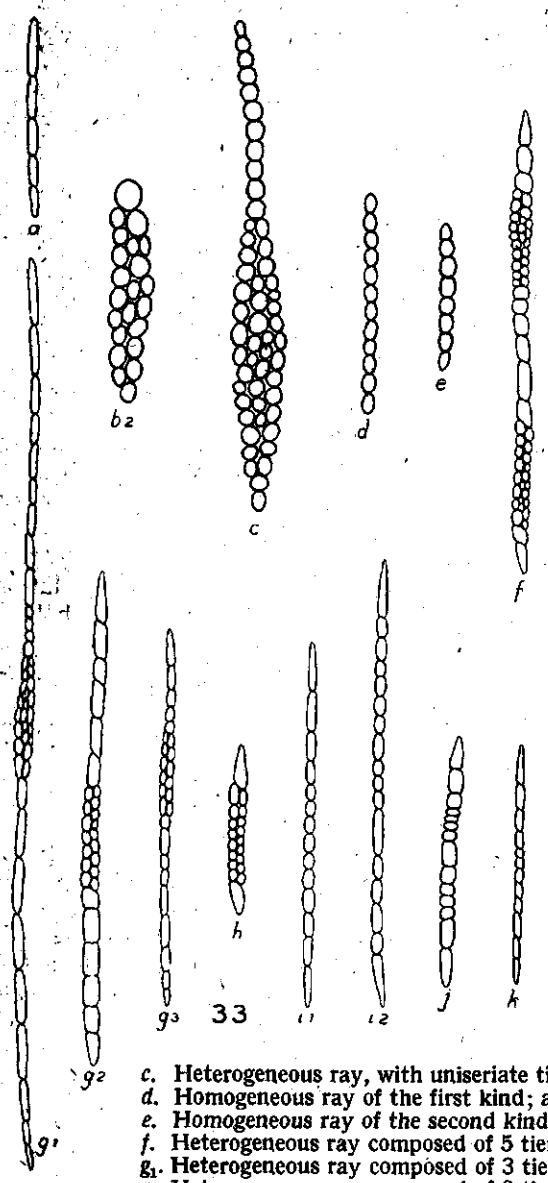


Fig. 32. *Acer campestre* L. All × 180.
a. Homogeneous ray of the first kind but composed of procumbent cells.
b. Heterogeneous ray, the uniseriate tier composed of procumbent cells ast he ray of 32*a*.
c. Homogeneous ray of the first kind, composed of upright cells with radial rows of procumbent cells.
d. Heterogeneous ray, the uniseriate tier composed of upright cells.

Although to the present authors opinion *Acer mandshuricum* does not belong to the homogeneous type I, yet this type exists and is represented for example by *Tamarindus indica* L. which possesses rays of the sorts portrayed in fig. 17*a* and 17*b*. The homogeneous type I of KRIBS then represents our rays $b_2 + e$ (fig. 33).



The homogeneous type II is our ray b_2 alone or in combination with very short and scarce rays *e*.

The heterogeneous type III and the homogeneous type III are present in wood samples which possess exclusively uniseriate rays. The heterogeneous type III comprises our rays *i* (fig. 33). The present author supposes uniseriate rays composed exclusively of upright cells to be always present too, this type then being a combination of the rays *a* and *i*. The homogeneous type III is our ray *e*.

Apparently some of the rays the present paper deals with, were lacking in the wood species KRIBS examined. These are (fig. 33) the heterogeneous rays *f*, g_3 (the combination of a multise-

Fig. 33. *a*, g_1, g_2, g_3, i_1, i_2, *j*, *k*: × 60.
b_2, *c*, *d*, *e*: × 180.
f, *h*: × 90.
Rays collected from the key.

a. Homogeneous ray of the first kind; all cells upright.
b_2. Homogeneous ray of the second kind; all cells procumbent.
c. Heterogeneous ray, with uniseriate tier of procumbent cells.
d. Homogeneous ray of the first kind; all cells procumbent. [1])
e. Homogeneous ray of the second kind; all cells procumbent. [1])
f. Heterogeneous ray composed of 5 tiers.
g_1. Heterogeneous ray composed of 3 tiers; the uniseriate tiers very high.
g_2. Heterogeneous ray composed of 3 tiers; the uniseriate tiers lower.
g_3. Heterogeneous ray composed of 3 tiers; the uniseriate tiers with radial rows of procumbent cells.
h. Homogeneous ray of the second kind. See also note 1 on p. [14].
i_1. Heterogeneous uniseriate ray of 3 tiers. [1])
i_2. Heterogeneous uniseriate ray of many tiers.
j. Heterogeneous uniseriate ray of 5 tiers.
k. Homogeneous uniseriate ray of the first kind [2]) with radial rows of procumbent cells.

[1]) The rays *d* and *e* are quite identical and so are the rays i_1 and *k*, but an examination of all ray types in the same sample shows them to belong to different kinds: *d* occurs with *c*, *e* with b_2; *k* with g_3, i_1 not with g_3.

riate tier and marginal tiers of upright cells mingled with procumbent cells), i_2 and j (j belonging structurally to the multiseriate heterogeneous rays), the homogeneous *multiseriate* ray b_1 (composed of upright cells only) and the combinations of b_1 with g_4 and h_1, where g_4 and h_1 (both not depicted) are respectively a heterogeneous and a homogeneous ray containing a *multi*seriate part of *upright* cells (see footnote 2 on p. 226); the homogeneous combination $b_2 + e$, where e is not rare, is not mentioned either by KRIBS.

With the exception of the ray b_1 and its combinations with g_4 and h_1 we may try and correlate the results from JANSSONIUS's ray descriptions and KRIBS's type classification. Then we come to the following conclusions (cf. fig. 33):

The combination rays $a + g_1$ or $k + g_1$ (wings with or without procumbent cells) of our key in § 6 is KRIBS's heterogeneous type I (wings are long).

The combination (a or k) + (g_2 or g_3) (or f) with or without j and with or without b_2 or/and h: heterogeneous type II A (wings are short).

The heterogeneous type II B appears to be the combination a + rays bearing resemblance to d, + g_2 (but wings of g_2 only two cells high and composed as a) with or without b_2 or/and h, or/and + rays bearing resemblance to c (wings longer and composed about as d).

The homogeneous type I rather is the combination $b_2 + e$ (e not scarce) than KRIBS's $d + c$, with or without h. To the present author's meaning the latter combination ($d + c$ with or without h) is the heterogeneous type of which II B (see above) is the prototype; from this prototype to the heterogeneous type $d + c$ there has been a change from the hetero*cellular* to the homo*cellular condition*, but not yet from the hetero*geneous type* to the *homogeneous type*.

The presence of rays b_2 (without e) or b_2 in combination with scanty and short rays e is the homogeneous type II.

The combination $a + i_1$, i_2 is the heterogeneous type III.

Only rays e present is the homogeneous type III.

PFEIFFER and VAROSSIEAU (10) established schemes for classification of wood features. In the summary of their paper the authors write that their classification schemes refer to features visible with the naked eye and handlens. The paper, therefore, would not have been mentioned here, if it were not for the fact that some of the data gathered by JANSSONIUS on ray structure in more than thirty years of wood anatomical studies are also visible with the handlens. Though PFEIFFER and VAROSSIEAU discuss the work of MOLL and JANSSONIUS (9) they did not grasp the invaluable information presented there.

SUMMARY

1. The author discusses the first and the revised definition of homogeneous („einfache", „enkelvoudige") and heterogeneous („zusammengesetzte", „samengestelde") rays in MOLL and JANSSONIUS's *Mikrographie des Holzes*, vol. I, p. 59 and vol. IV, p. 403.
2. The characteristics by which rays may be classified as homogeneous of the first kind or of the second kind, or as heterogeneous have been compiled and to insure ease of manipulation have been recorded in key form (§ 6).
3. The identification of one type of ray is not always possible without an examination of all of the ray types of the sample.

4. A classification of rays into kinds after JANSSONIUS, is preferable to a classification according to size since only the former takes all structural features into consideration.
5. KRIBS's terms *homocellular* and *heterocellular* are excellent for the designation of cell types. KRIBS suggests the term *homocellular* for rays composed of either upright or procumbent cells, *heterocellular* where both cell types are present within the same ray.
   The terms *homogeneous* ray and *heterogeneous* ray are proposed in this paper to indicate the structural appearance of a ray resulting from the examination of all of the ray types of the species, and in certain instances of a whole genus or family. The various types of homogeneous rays of the first kind have been recorded in *a*, *d* and *k* of the key in § 6, those of the homogeneous rays of the second kind in b_1, b_2, *e* and *h*, and the types of heterogeneous rays in *c*, *f*, *g*, *i* and *j*.
   KRIBS's terms *homogeneous type* and *heterogeneous type* indicate the presence of a special combination of homogeneous rays and heterogeneous rays in the specimen.
6. That the multiseriate rays of *Acer* with wings of uniseriate rays of procumbent cells have to be called heterogeneous rays is indicated by the occasional presence of upright cells within the wings. Thus the rays of *Acer* belong to a heterogeneous type also when they are homocellular.

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