大麦の栄養細胞分裂

緒

本研究は大麦の栄養細胞の分裂の模様を知るために行行ったものであるが、特に染色体が如何にして形成せられ如何にして消失するかを知るのに努めた。同時に従来疑問視されて居た小核と染色体又は核縁との関係を明らかにせんと試みた。

材料及び方法

材料は官崎高等農林学校産の大麦二稈種及び六稈種の根端細胞、内顕及び外顕の栄養細胞、前々に発育して将来花粉母細胞となるべき花粉原細胞（花粉母細胞）を含むヘメートキシン法（HEMatoxylin）に依って行われた。又検鏡材料の切片の厚さは二～五μである。

以下の様にして行った実験成績は次の通りであるが、記述の便宜上先づ花粉原細胞分裂のアナフィアレース（Anaphase）
根端細胞
元来に述べた花粉原細胞はその形が比較的小さい為にプロフェーズ（prophase）時代の初期の変化を明瞭に知ることは大変困難であるが、根端細胞はこれに反してその形が大きく、核綱を概して太い。（第十七図）からプロフェーズ

五、メタフェーズ（metaphase）時代
後期に於て、核線は次第に共太さを増すと共に短くなって行くが（第二十四図）、並

大麦の顕微鏡観察に於て観察すると核線と核線とが互に連絡して居るものを見受ける事がある。（第二十四図）斯かる場合に於ては第二十四図に示す様に、核線の内でも直接に核線と連絡して居る部分がこれに附随して居る。
染色体のdoubleの起源

一、染色体のdoubleの起源

既に述べた様にメタフェーズ（metaphase）時代の染色体はdoubleであるが（第二十三図）、此染色体のdoubleの起源に就いては二つの説がある。

一は将来発育して染色体となるべき核線がプロフェーズ（prophase）時代より早くまちにdoubleに分れると言ふ説で、

他はプロフェース（prophase）時代より早く前と生じて、即ちテロフェーズ（telophase）時代に於てdoubleされると云ふ説である。

大麦に於て既に述べた様にテロフェーズ（telophase）時代に於てdoubleになると言ふ説で、

二つに分れる（第二十七図），点から考えると，染色体のdoubleは一部であるが，

時代に於て始まると認められることが出来るが（第九，十及び十七図），プロフェース（prophase）時代に於て染色体が其染色質を失ふ際に，核線に於てdoubleに分れる（第十八図）。此プロフェース（prophase）時代に於ける核線のdoubleより出たものであると考えられる。

但し花粉母細胞に於ては其核が小さく，従つて核線が極めて細い為に斯かる変化を明かに認められることが甚だ困難であるが，

同じ核線細胞である處の核線のdoubleに於てdoubleの形の核線である時に，

此プロフェース（prophase）時代に於ける核線のdoubleより生じたものであると考えられる。
ホルフェース（1926年）時代に於て染色体の染色質が次第に数々に集って遂に球状の小核を形成し、それと同時に染色体の染色質の大部を失って不規則な核網となる事は既に屡々報告された事である。是等の核網はホルフェース（1926年）時代に於て小型の染色体及び花粉原細胞に於ては此染色質が核網の方へ次第に移動して行って染色体を形成するものと考えられるが、根端細胞及び花粉原細胞に於ては此染色質が有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。是等の如き核網と小核との関係は、小核と直接連絡して居る部分が特に多数の染色質を有して色が稍々淡い。は以上の論述より休止時代に於ても小核は核網と互に連絡して居るものと推定する事が出来ない。唯僅かにホルフェース（1926年）時代に於て染色体の染色質は次第に核網の数々に集り、初め不規則な形の大塊となる事が遂に球状となって小核を形成するに至る。
主要文献

(Literature)


Share, L. W., 1943. Some chromosome in Phase Lac Cylindrace.
PL. XIII. (INOUYE)
第九図
インターフェーズ（Interphase）時代（同）
染色質の小粒が核縁の虚々に残って居る。

第十図
同（同）
染色質の小粒が核縁の虚々に残って居る。

第十一図
プロフェーズ（Prophase）の初期（同）
核縁の一部は涎々と太く染まる。

第十二図
同（同）
核縁は涎々と太くなる。

第十三図
同（同）
核縁は涎々と太くなる。

第十四図
同（同）
核縁は涎々と太くなる。

第十五図
同（同）
核縁は涎々と太くなる。

第十六図
インターフェーズ（Interphase）時代（同）
核縁の虚々に涎々と太く染まる。

第十七図
プロフェーズ（Prophase）の初期（同）
核縁は涎々と太くなる。

第十八図
同（同）
核縁は涎々と太くなる。

第十九図
同（同）
核縁の大部分が二本の線に分れて居る。

第二十図
同（同）
核縁の大部分が二本の線に分れて居る。

第二十一図
同（同）
核縁の大部分が二本の線に分れて居る。

第二十二図
同（同）
核縁の大部分が二本の線に分れて居る。

第二十三図
同（同）
核縁の大部分が二本の線に分れて居る。

第二十四図
同（同）
核縁の大部分が二本の線に分れて居る。

核縁が涎々と太くなる。

連絡して居る部分が涎々と太くなる。

小核と核縁とが互に連絡して居る。核縁の内でも小核と直接

連絡して居る部分が涎々と太くなる。

連絡して居る部分が涎々と太くなる。
Fig. 20. Prophase (do). The spireme partially split into two threads.

Fig. 21. Prophase (do). Nearly all the spireme is split into double threads.

Fig. 22. End of the Prophase (do). The nucleolus begins to diminish in size.

Fig. 23. Metaphase (do). Polar view. There are fourteen double chromosomes connected by fine threads.

Fig. 24. Prophase (cell of glume). Some parts of the spireme connected directly with the two nucleoli are dark with much chromatin.
Fig. 3. Telophase (do). Polar view. The chromosomes are separating, though they are still connected with each other by fine threads.

Fig. 4. Telophase (do). Side view. The chromosomes begin to lose their chromatin which concentrates into irregular masses. A vacuole is visible on the chromosomes.

Fig. 5. Telophase (do). Side view. The irregular chromatin masses become somewhat spherical in shape. Chromosomes are connected with these masses at several points.

Fig. 6. Telophase (do). Side view. The chromosomes seem to be split longitudinally.

Fig. 7. Late telophase (do). The chromosomes have gradually changed into irregular threads, single or double, have lost most of their chromatin.

Fig. 8. End of the telophase-interphase (do). The irregular threads of chromosomes become the reticulum.

Fig. 9. Interphase (do). The threads of the reticulum become very fine.

Fig. 10. Interphase (do). Small chromatin granules remain on the reticulum.

Fig. 11. Beginning of the prophase (do). Some parts of the reticulum gradually become thicker and darker.

Fig. 12. Prophase (do). The reticulum gradually changes into a spireme curled irregularly.

Fig. 13. Prophase (do). The spireme becomes thicker.

Fig. 14. Prophase (do). Longitudinal splittings have taken place in some parts of the spireme.

Fig. 15. Prophase (do). The spireme becomes thicker.

Fig. 16. End of the prophase (do). The nuclear membrane becomes obscured, while the spireme increases in thickness.

Fig. 17. Interphase (root-tip cell). Small chromatin masses are scattered on the reticulum.

Fig. 18. Beginning of the prophase (do). The reticulum becomes irregular zigzag threads which are composed in some parts of two fine threads.

Fig. 19. Prophase (do). The zigzag thread gradually loses its uneven thickness to form the smooth spireme.
these masses gradually becomes spherical in shape to form the nucleoli of the interphase.

2. During this movement of chromatin the chromosomes gradually decrease in thickness becoming slender threads as they give up the chromatin, or there appear vacuoles arranged longitudinally on the chromosomes so that the latter seem to be split partially into two threads. And these threads, single or double, together with the fine threads which connect the chromosomes, form the reticulum of the interphase.

3. At the beginning of the prophase, the reticulum gradually changes into a spireme which in places consists of two threads. These double threads may be derived from the splitting chromosomes of the previous telophase.

4. It is observed in the prophase that the nucleolus is connected with the spireme in many places. This fact would suggest that also in the interphase or resting stage the nucleolus is similarly connected with the reticulum in many places.

5. During the prophase the spireme gradually changes into the chromosomes, receiving chromatin directly from the connecting nucleolus.

6. The diploid number of the chromosomes in *Hordeum sativum* is fourteen.

**Explanation of Figures.**

All figures were drawn with the aid of an ABBE camera lucida under a Zeiss apochromatic objective 1.5 mm. with a compensating ocular 20. Magnification about 3,000 diameters, except for figures 17-24, which are about 2,000 diameters.

Fig. 1. Anaphase (archesporial cell). Side view.

Fig. 2. Anaphase—telophase (do). Side view. A nuclear membrane is appearing around the chromosomes which come together into a large irregular mass.
to observe clearly the double nature of the threads early in the prophase, because it has a relatively small nucleus and contains very fine threads (Figs. 11 and 12). But from the fact that in the root-tip cell which belongs to the same somatic cell as the archesporium this phenomenon was definitely observed by the writer, we may assume that it is also true in the case of the archesporial cell.

b. The Relation between the Nucleolus and the Chromosomes

It has been already observed by many investigators that during the somatic cell division the nucleolus is formed from the chromatin of the chromosomes, which concentrates gradually to form a mass of spherical shape, while the chromosomes which have thus lost most of their chromatin become irregular threads of the reticulum in the interphase. With the beginning of the prophase, however, the reticulum gradually changes into a slender spireme which becomes gradually thicker and darker to reform the chromosomes.

According to Fig. 24 it is clearly evident that some parts of the spireme connected directly with the nucleolus are especially dark, containing much chromatin. This would suggest that during the prophase a movement of chromatin takes place from the nucleolus to the connecting spireme to form the chromosomes.

From the above facts we can assume that there must be some connection between the nucleolus and the reticulum in the interphase, though, in practise it is very difficult to tell certainly whether they are actually connected, or whether they are merely touching or one rests on another.

4. Conclusion

1. During the telophase the chromatin of the chromosomes begins to concentrate into irregular masses in the nucleus. And
clearly the connection between the nucleolus and the spireme as shown in Fig. 24.

In this figure it is also evident that some parts of the spireme connected directly with the two nucleoli are dark, containing much chromatin.

3. Discussion

a. The Origin of the Double Chromosomes

As already described in this paper, fourteen double chromosomes are formed from the spireme during the late prophase of the cell division (Figs. 22 and 23).

There are however, two interpretations as to the origin of these double chromosomes: some investigators (Grégoire 1912, Gates 1912, Sharp 1913, etc.) have reported that the spireme from which the chromosomes arise gradually become double during the prophase; while others (Digby 1910, Lundegårdh 1910, etc.) contend that the chromosomes become split into double threads during the telophase as they lose their chromatin to form the reticulum and this is the origin of the double chromosomes which appear in the succeeding prophase.

In Hordeum, it has been observed that the chromosomes gradually lose their chromatin and become partially split into double threads during the telophase (Figs. 5-7). In the meantime, however, during the interphase or resting stage the double nature of the chromosomes has been very much obscured, because they have been transformed into a reticulum (Figs. 9, 10 and 17). But in the following prophase, as the reticulum changes into zigzag threads, their double nature is seen again in some places (Fig. 18): these double threads are perhaps the remains of the splitting chromosomes of the preceding telophase.

In the case of the archesporial cell, however, it is very difficult
1. Archesporial cell: With the beginning of the prophase the threads of the reticulum especially those situated near the nucleolus gradually become thicker and darker (Fig. 11). Meanwhile there appears in the reticulum a slender irregularly curled spireme, which is perhaps produced by the transformation of a portion of the reticulum into slender threads (Fig. 12).

Toward the end of this stage as the spireme becomes gradually smooth and increased in thickness a longitudinal splitting takes place making it double (Figs. 14–16). The nuclear membrane becomes obscured at the end of this stage (Fig. 16).

2. Root-tip cell: Since the root-tip cell is much larger than the archesporial cell, the process by which the reticulum changes to a spireme can be observed more clearly.

In the root-tip cell at the beginning of the prophase the reticulum gradually changes into irregular zigzag threads of uneven thickness which contain an increasing amount of chromatin, and which in places consist of two threads (Fig. 18). These zigzag threads, however, gradually change into smooth spiremes which split into two threads (Figs. 19–21).

e. Metaphase

After continued thickening fourteen double chromosomes connected by fine threads are formed from the spireme in this stage (Figs. 22 and 23).

The nucleolus seems to decrease in size gradually at the end of the prophase (Fig. 22) and disappears completely just before the metaphase.

f. The Connection between the Nucleolus and the Spireme

In the somatic cells of *Hordeum* we can sometimes recognize
At the same time chromatin has begun to withdraw from the chromosomes and to concentrate into irregular masses in the nucleus (Figs. 4–6). These gradually develop into a small number of spherical nucleoli (Figs. 7–9).

Usually there are not more than two nucleoli, though sometimes more are found.

During the movement of chromatin, the chromosomes gradually lose their colour, and vacuoles—portions which have been entirely emptied of chromatin—appear on the chromosomes (Figs. 4 and 5). These vacuoles, gradually increasing in size and number, are generally arranged along the longitudinal axis of the chromosome, so that they seem to split it into double threads (Fig. 6).

In other places, where no vacuole appears, the chromosome grows increasingly slender as it gives up its chromatin. Consequently as the cell division proceeds further, the chromosomes gradually change into irregular threads, single or double, having lost most of their chromatin (Fig. 7). And at the end of this stage, these irregular threads together with the fine threads which connect the chromosomes with one another form the reticulum (Fig. 8).

c. Interphase or Resting Stage

In this stage the network of the telophasic reticulum becomes very delicate (Fig. 9). And, occasionally small chromatin granules are observed remaining on the reticulum (Fig. 10).

d. Prophase

In this stage the irregular network of the reticulum gradually changes into a slender spireme which afterward becomes increasingly thicker splitting into double threads.

The details of the process of the prophaseic transformations observed in the archesporial and root-tip cells are as follows:
SOMATIC MITOSIS IN HORDEUM SATIVUM

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1. Materials and Methods

The materials used in this investigation were the cells of arche- sporium, glume and root-tip of Hordeum sativum, Jess., all of which were fixed in Bouin's solution. Sections were cut at 7-15μ and stained with HEIDENHAIN's iron-alum-haematoxylin.

2. Observation

For the purpose of description we shall begin with the stage of anaphase in which the separation of the daughter chromosomes takes place.

a. Anaphase

In this stage the separating chromosomes gradually approach each pole of the spindle (Fig. 1), fusing finally into a large irregular mass (Fig. 2). At the end of this stage a new nuclear membrane appears around the chromosomes, and the stage of telophase begins (Fig. 2).

b. Telophase

At the beginning of this stage the fused chromosomes, which form a large irregular mass, gradually begin to separate from one another, though connection is still maintained among them by fine threads (Fig. 3).

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