A Diploid Plant with only One Nucleolus and its Bearing on the Balance Hypothesis of Nucleolar Chromosome.¹⁾

By

Dyuhei Satô.

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The relation between nucleoli and chromosomes has been an object of many cytological investigations. HEITZ's hypothesis of sat-chromosomes was modified or extended by McCLINTOCK (1934) and MATSUURA (1938) to fit the recent investigations of nucleolar chromosomes. The nucleoli condense at the stalk of sat-chromosome and at the position of nucleolus-organizing body or 'a distal end of a definite (nucleolar) chromosome, and the nucleolar substance seems to originate in a matrix substance of whole chromosomes. The differential capacity for nucleolus organization of the chromosomes in a complement is assumed in order to explain the differential amphiplasty (disappearance of a satellite of one parental plant in a certain hybrids). Bearing such balance of nucleolar chromosomes with differential capacity in mind, we can explain the relation between nucleoli and nucleolar chromosomes in hybrids and polyploids.

In *Scilla japonica* ($2n=16, 18, 26, 34, 35, 43$) the writer (1940) found only two nucleoli at telophase in polyploid series with following combinations of basikaryotypes, i.e., 18 ($\kappa=B_2B_2$), 26 ($\kappa=B_1B_2B_2$), and 34 ($\kappa=B_1B_1B_2B_2$), where κ is karyotype, B_1 basikaryotype with 8 chromosomes and B_2 basikaryotype with 9 chromosomes. This fact was explained by the existence of two sat-chromosomes derived from B_2 and of no nucleolar chromosomes from B_1 . While four nucleoli and corresponding four sat-chromosomes were found in a plant with 35 chromosomes ($\kappa=B_1B_2B_2B_2$), containing one sat-chromosome with a secondary constriction at the distal end besides three characteristic sat-chromosomes of B_2 . This special sat-chromosome seems to be derived from karyotype alteration such as translocation rather than directly from B_1 . According to this explanation the balance of nucleolar chromosomes between B_1 and B_2 remains in a constant condition, that is, the sat-chromosome from B_2 has greater activity for the nucleolus organization than the nucleolar chromosome from B_1 , and normally utilizes

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the available material for production of a nucleolus in advance, so that the latter chromosome has no opportunity to function, unless the capacity of the nucleolus-organization of the nucleolar chromosomes is changed by a karyotype alteration such as translocation (cf. SATÔ 1936 a, b in *Scilla permixta* and *S. ughii*).

TABLE 1. The relation between nucleolus and sat-chromosome in *Scilla japonica*.

Chromosome number	Combination of basikaryotype	Sat-chromosomes	Nucleoli
18	B ₂ B ₂	2M ^a	2
26	B ₁ B ₂ B ₂	2M ^a	2
34	B ₁ B ₁ B ₂ B ₂	2M ^a	2
35	B ₁ B ₂ B ₂ B ₂	3M ^s + 1M ^{s*}	4

* This SAT-chromosome seems to be derived from translocation.

According to the balance hypothesis of nucleolar chromosome diploid hybrids or heterozygous plants with one nucleolus have been expected to exist. As a result of studying further a number of species especially lacking of sat-chromosomes, *Brodiaea uniflora* has been found to fulfil the expectation above mentioned. But such plants could so far be found neither actually nor in literature (cf. GATES 1937; RESENDE 1938; etc.). For instance *Paris hexaphylla* is triploid and has 15 somatic chromosomes including one sat-chromosome (Fig. 1), but three nucleoli in maximum

Figs. 1, 2, Root-tip cells in *Paris hexaphylla* ($2n = 15$). 1, mitotic metaphase showing one sat- and two nucleolar chromosomes (S' , S''). 2, three nucleoli in the resting stage one of which attaches to a satellite(t) consisted of heterochromatin. Fixed with NAVASHIN's solution and stained with gentian violet. $\times 1450$.

number are found in the telophase and resting stages (Fig. 2). This fact clearly indicates the existence of terminal type of nucleolar chromosomes (cf. HAGA 1940). The satellite consists of heterochromatin and is located on the surface of one somewhat large nucleolus (Fig. 2). This suggests that the satellite in *Paris* is genetically inert. Such coexistence of terminal and interstitial types of nucleolar chromosomes is reported by SINOTÔ(1937) in *Rumex* and by SATÔ (1939) in *Tricyrtis*.

Brodiaea uniflora has 12 somatic chromosomes and regularly one nucleolus in the telophase and resting stages, although the karyotype clearly indicates a diploid nature. One sat-chromosome with an extremely long stalk (S^t) is clearly distinguished and this corresponds to one nucleolus. When FLEMING's solution is employed as a fixative, nucleolar material possibly derived from chromosome matrix shows a greenish colour and accumulates as one definite nucleolus at the position of sat-constriction. This sat-chromosome alone is attached to the surface of the nucleolus at mid- and late prophases, though many chromosomes also are attached to this nucleolus in the early prophase. So it may be surmised that this sat-chromosome has so great capacity for the nucleolus organization that the other chromosomes are made inactive in function. This discovery of the diploid plant with only one nucleolus may give a favourable evidence to the balance hypothesis of nucleolar chromosome.

Figs. 3-6. Somatic mitosis of *Brodiaea uniflora* ($2n=12$) especially showing one sat-chromosome with extremely long stalk. 3-5, material from Tôkyô Nosan Syôkai. 6, material from Koisikawa Botanic Garden of the Tôkyô Imperial University. Fixed with NAVASHIN's solution (3-5) or Bonn's modification of FLEMING's fixative and stained with gentian violet. $\times 1900$.

Summary.

1) The relation between nucleolus and nucleolar chromosomes in polyploid series of *Scilla japonica* ($18=B_2B_2$, $26=B_1B_2B_2$, $34=B_1B_1B_2B_2$, $35=B_1B_2B_2B_2$) was explained by the balance hypothesis of nucleolar chromosome.

2) *Paris heraphylla* ($2n=15$) is triploid and has one sat- and two nucleolar chromosomes, corresponding to three nucleoli at telophase. The satellite in *Paris* consists of heterochromatin and seems to be genetically inert.

3) *Brodiaea uniflora* ($2n=12$) is diploid and has only one nucleolus,

corresponding to one sat-chromosome with a long stalk. This fact seems favourable for the balance hypothesis of nucleolar chromosome.

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Division of Genetics, Botanical Institute,
Faculty of Science, Tôkyô Imperial University.

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一個ノ仁ヲ有スルニ倍性植物ト仁染色體ノ平衡說ニ 對スル關係 (和文摘要)

佐 藤 重 平

仁染色體ノ平衡說トハ或雜種ニ於テ一方ノ親ノ附隨體ガ消失スル場合ガアルガ、ソレヲ説明スル爲ニ兩方ノ親カラ來タ仁染色體ガ仁形成能力ニ差異ヲ有シ、ソノ大ナル方ダケガ仁形成ニ關與スルトノ說デアル。例ヘバつるば *Scilla japonica* ($2n=16, 18, 26, 34, 35, 43$) デハ 8 個ノ染色體カラ成ル基本核型 B_1 ト 9 個ノ染色體カラ

ナル基本核型 B_2 トノ組合セカラナル倍數體ガアル。 $18=B_2B_2$, $26=B_1B_2B_2$, $34=B_1B_1B_2B_2$ ノ組合セニ於テハ B_2 カラ來タ M^s 染色體ガ 2 個アリ仁モ亦 2 個存在シ, B_1 カラ來タ仁染色體ハ仁形成ニハ關與シナイ。然ルニ $35=B_1B_1B_2B_2$ デハ B_2 カラ來タ M^s 染色體 3 個ノ他ニ端部ニ二次狹窄ヲ有スル SAT 染色體ガ 1 個アリ, 都合 4 個デ 4 個ノ仁ガ終期デ見ラレル。コノ特別ナ 1 個ノ SAT 染色體ハ B_1 ヨリ直接來タノデハナク轉座等ノ核型變化ニヨツテ生ジタモノラシイ。カカル説明ニヨレバ, つるばニ於テハ B_2 ノ仁染色體ハ B_1 ノソレヨリ仁形成能力ガ大デアルカラ, 轉座等ノ核型變化ガナケレバ, 規則正シク B_2 ノ仁染色體ダケガ仁形成ニ關與スル。

カクノ如ク仁染色體ノ平衡說ニヨレバ, 二倍性雜種又ハヘテロ接合體ニハ 1 個ノ仁ヲ有スル植物ガアル筈デアル。ソレデ特ニ SAT 染色體ヲ缺除スル種類ヲ檢ベタ。くるまばつくばねさう (*Paris hexaphylla*) ($2n=15$) デハ 1 個ノ SAT 染色體ト 2 個ノ附隨體ノナイ仁染色體ガアリ 3 個ノ仁ガ終期デ形成サレル。之ハ明カニ末端型ノ仁染色體デアル。はなニラ (*Brodiaea uniflora*) ($2n=12$) デハ核型ハ明カニ二倍性デアルガ, 仁ハ 1 個ダケシカデキズ, ソレニ對應スル連結絲ノ非常ニ長イ SAT 染色體ガ 1 本アル。カカル 1 個ノ仁ダケヲ有スル二倍體ノ存在ハ仁染色體ノ平衡說ニ都合ノヨイ證據ヲアタヘルト考ヘラレル。

(東京帝國大學理學部植物學教室)

On the Minimum Concentration of Manganese Necessary for the Growth of Lemnaceae Plants.

By

Fuji Yoshimura.

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Introduction.

Recently it has been reported by some authors that Mn is essential for the culture of Lemnaceae.¹⁾ According to those authors the following characteristic symptoms of Mn-deficiency appear. In the beginning the young fronds remain very small, and the growth of root is retarded. Then the youngest frond becomes brown and dies first, and the older ones are similarly fated in order according to the age. The larger older fronds, which have accomplished their development, are most resistant against the Mn-deficiency, but at last died from it. Soon after Mn is added in trace

1) HOPKINS (1934), MCHARGUE and CALFEE (1932), CLARK, (1933), SAEGER (1933).