RECALLING
THE ACADEMIC & INDUSTRIAL ACHIEVEMENTS OF DR N. U

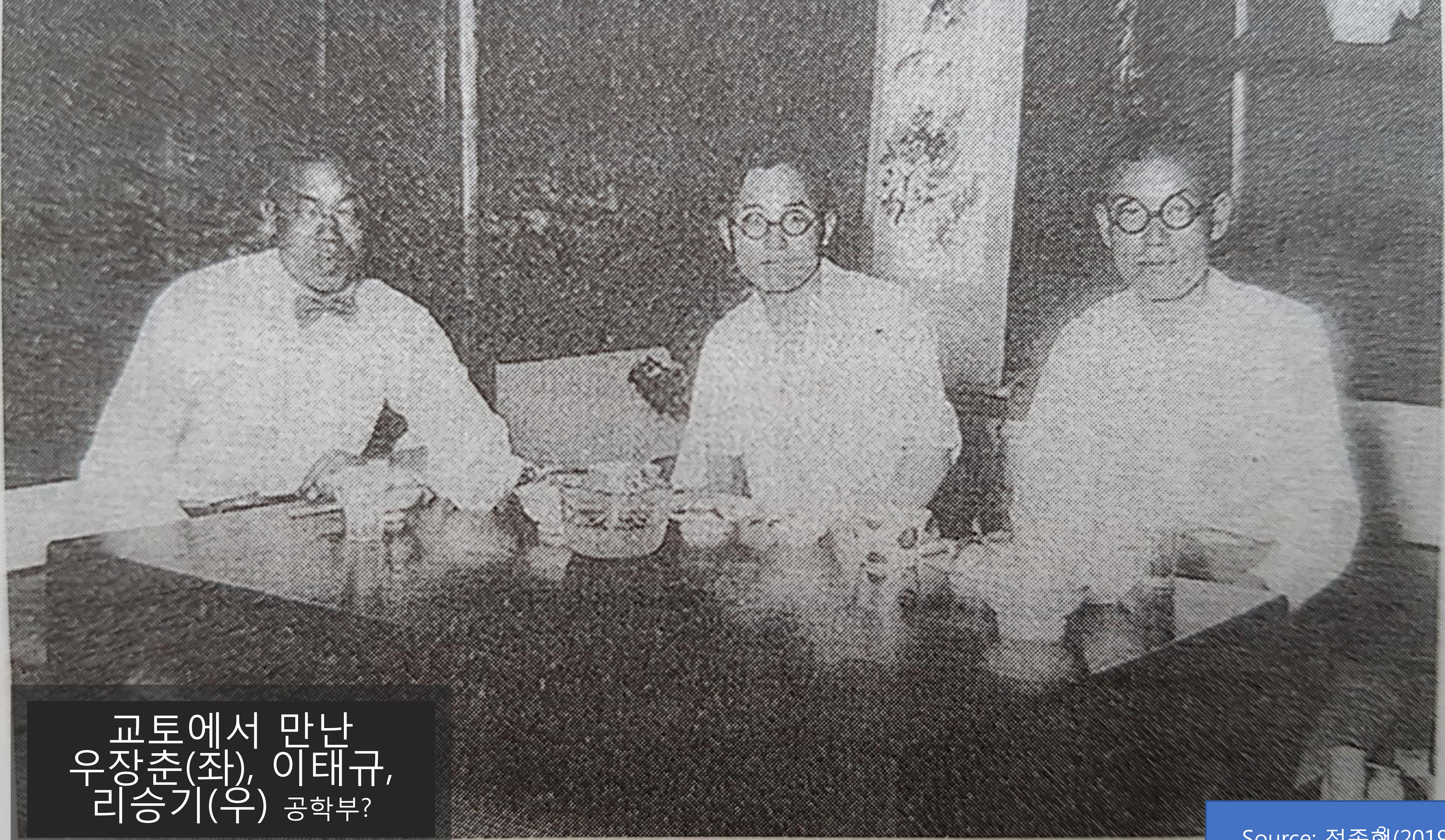
우장춘 박사의
학문적·산업적 성취를 생각한다.

Yoon Jin Young

KSHS Symposium
@ Alpensia Convention
Oct. 24, 2019

Contents

- Doctorial thesis
- Other research theses and reports
- Industrial contribution while in Japan
- Industrial contribution in Korea
- Implications



교토에서 만난
우장춘(좌), 이태규,
리승기(우) 공학부?

Source: 정종현(2019)

Title

Genome analysis in *Brassica*

with special reference to

the experimental formation of *B. napus*

and peculiar mode of fertilization

논문

Backgroun

박사학위 d *(in introduction)*

1. 1929년부터, 현존 종 가운에 일부는 서로 다른 종이 교잡된 후 염색체 배가로 고정되어 임성을 가지게 된 이질배수체라는 것이 증명되었다. (amphi-polyploid species already known)
2. 2, Brassica중 n=17 종(*B. carinata*)에는 n=9 종과 동일한 반수체조가, n=18(*B. juncea*), n=19(*B. napus*)인 종에 n=10인 종과 동일한 반수체조가 들어있다는 것이 알려짐 (In Brassica, inclusion of n=9 set in species with n=17; and n=10 set in species with n=18 or 19 had been known)

Crosses made & F_1 plants therefrom

I B. campestris(10) x B. oleracea(9) →COF1- I, II, III, IV

ii B. napus(19) x B. oleracea(9) →NOF1- I, II, III

iii B. napus(19) x B. campestris(10) →NCF1- I, II, III, IV

iv B. carinata(17) x B. oleracea(9) →CaOF1- I, II

v B. carinata(17) x B. nigra (8) →CaNF1

vi B. napus(19) x B. carinata(17) →NCaF1

vii B. juncea(18) x B. carinata(17) →JCaF1- I, II

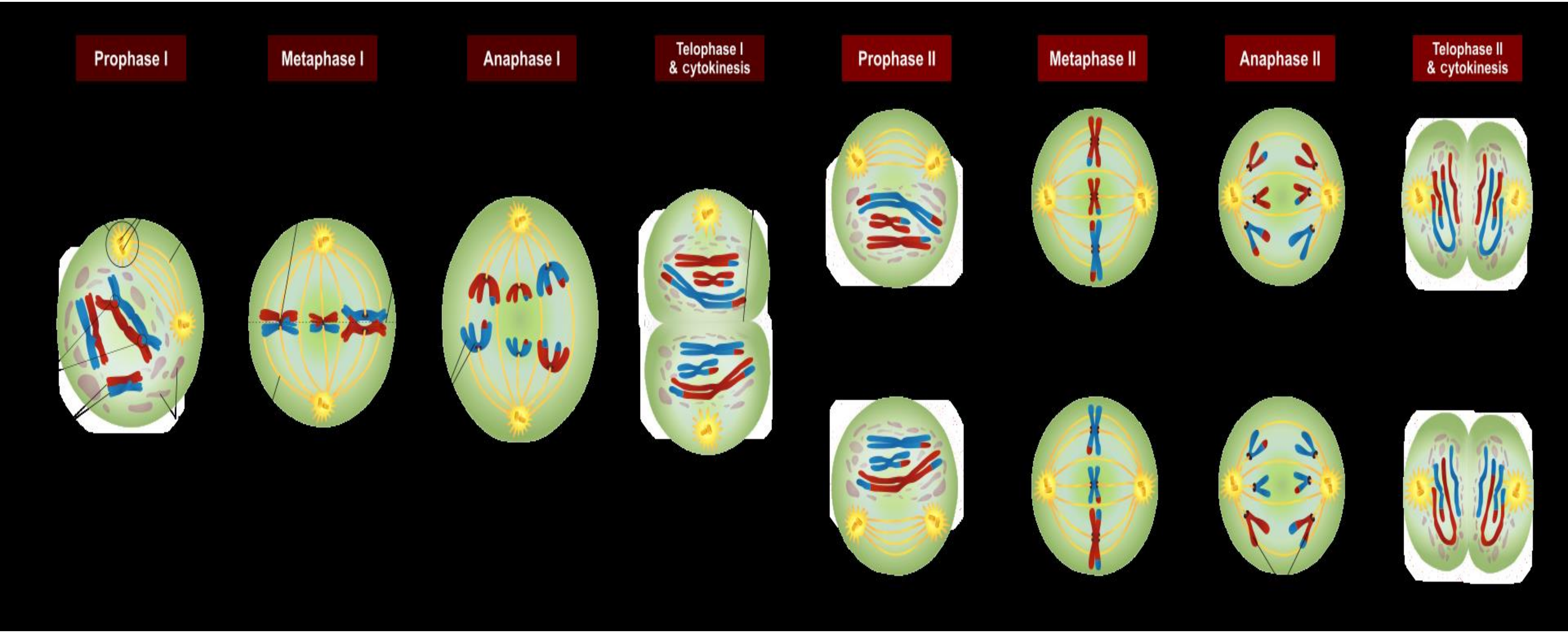
Microscopy

- Somatic chromosome count on root tip
  - Benda fixative or Nawashin fixative

- Meiotic division
  - Flower bud fixation w/ Bouin's fluid (or Allen's modification)
  - Paraffin section of 12 microns
  - Staining with Heidenhain's iron-aceto-alum haematoxylin

- Examination of tetrads and pollens
  by Belling's iron-aceto-carmine method

Meiotic phases(감수분열 전개과정)



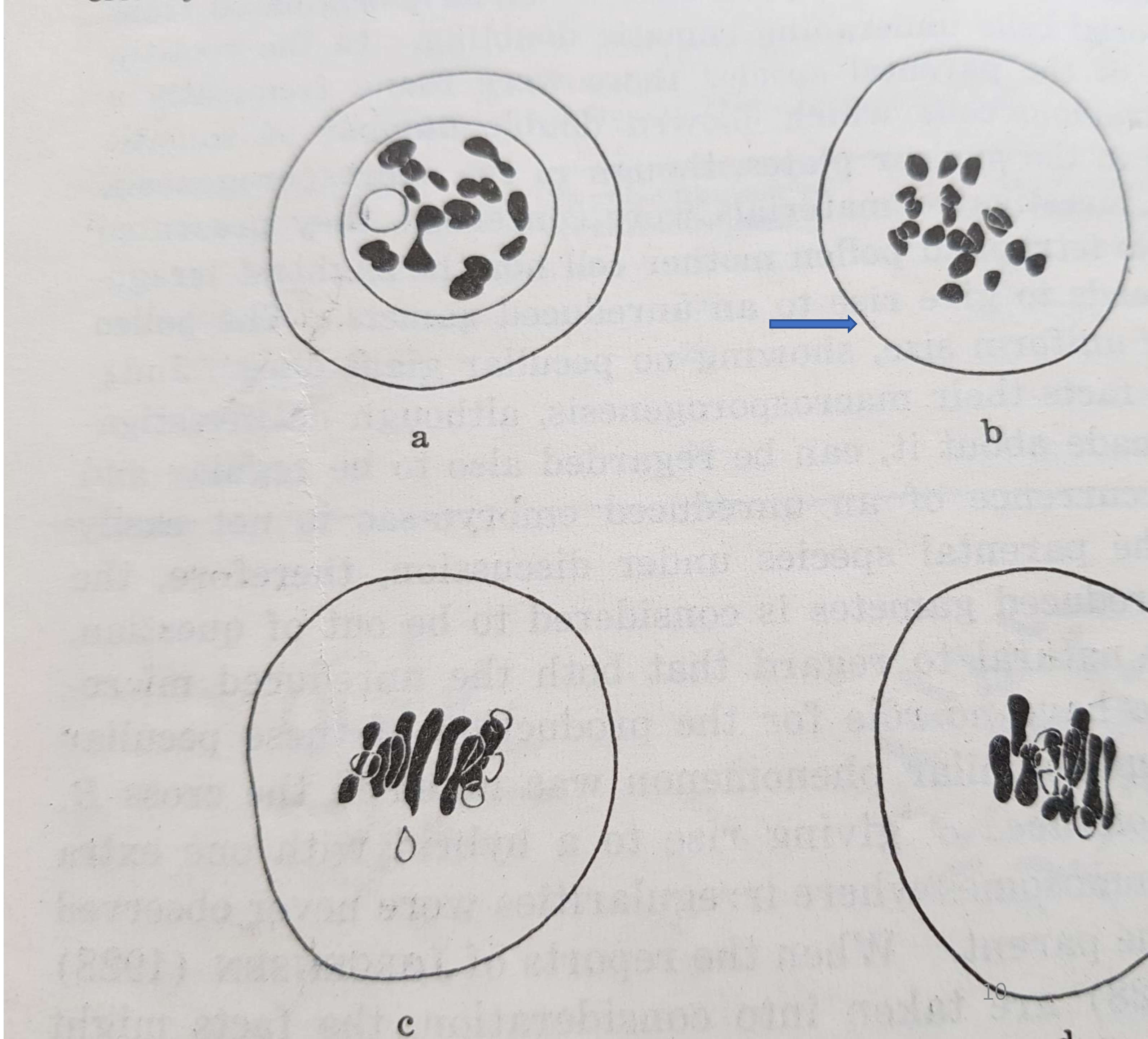
Source: Wikipedia

Zygotic number of chromosomes in COF_1*
campestris x *oleracea* F1개체들의 체세포 염색체 수

F1 Individual	Chromosome Number	No. Extra Chromosomes	Metaphase 1	Relevant figure	Repeated (same as) in
COF_1- I	19	0	19I	Fig 13 b	
COF_1- II	28	9	9II+10I (III)	Fig 15 f	NOF_1
COF_1- III	(29)	10	10II+9I	Fig 17 d, e	NCF_1
COF_1- IV**	38	19	19II	Fig18 b, c	*B. napus*

* Chromosome number of c(*campestris*) and o(*oleracea*) is 10 and 9, respectively. c(n=10) o(n=9)
** Chromosome number is equal to that of *B. napus*, phenotypic characters are in every respect quite similar to those common to *napus* varieties. COF_1- IV는 외견상 B. napus
*** Therefore, it is reasoned that doubling of the cross between *campestris*(aa) and *oleracea*(cc) resulted in amphidiploid *B. napus*(aacc) .

19I
in metaphase 1
of COF_1- I



9(II or III)+10(-α)I in metaphase 1 of COF_1- II

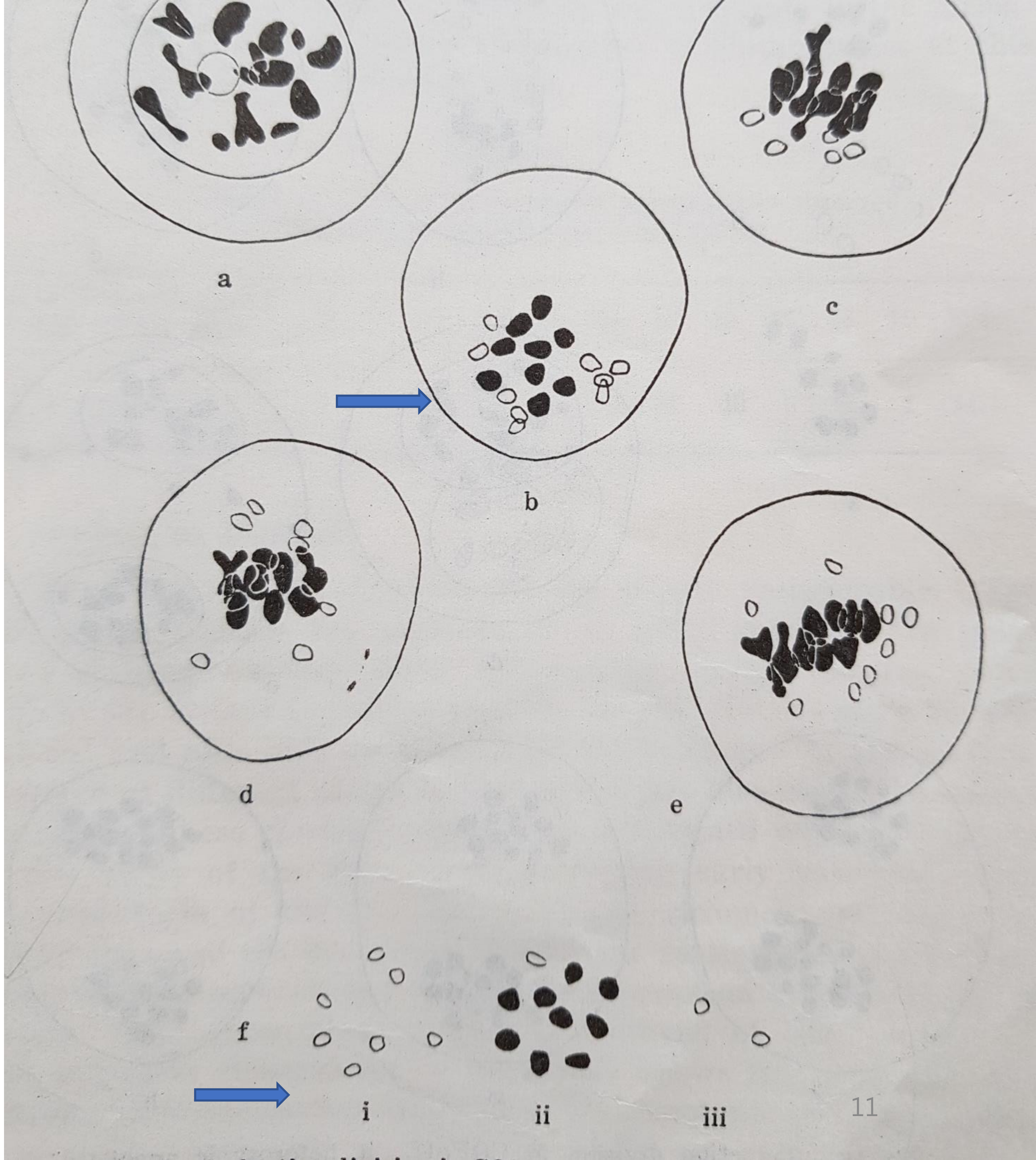
- b = 9II on equatorial plate + scattered univalent
- c, d, e = 5, 7, 8 univalent

  with some trivalents
- f = polar view with different fici.

  i : 7 univalent (upper focus)

  ii : 9 bivalents + 1 univalent (mid focus)

  iii : 2 univalents (lower focus)



Napus(n=19) x *oleracea(n=9)*

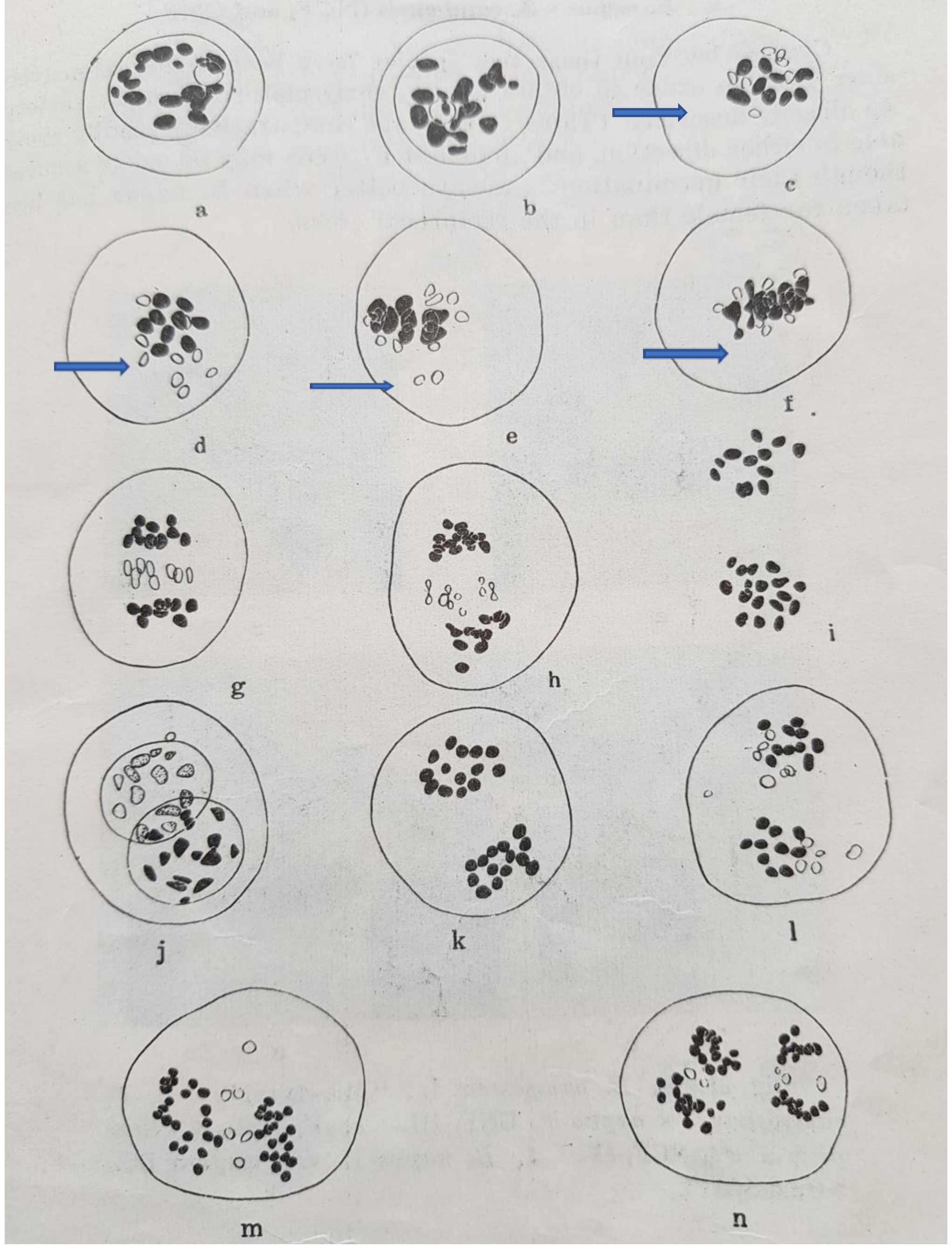
- Metaphase I (NOF$_1$-III)

  9II + 7(c) and 10(d) univalents

  (polar view)

  9II + 7(e) and 10(f) univalents

  (side view)



10II+9I
in metaphase 1 of COF_1- III

- b, c = side and polar view (10 bivale nts and 9 univalent)
- d = with different foci

  i : 4 univalent (upper focus)

  ii : 10 bivalents (mid focus)

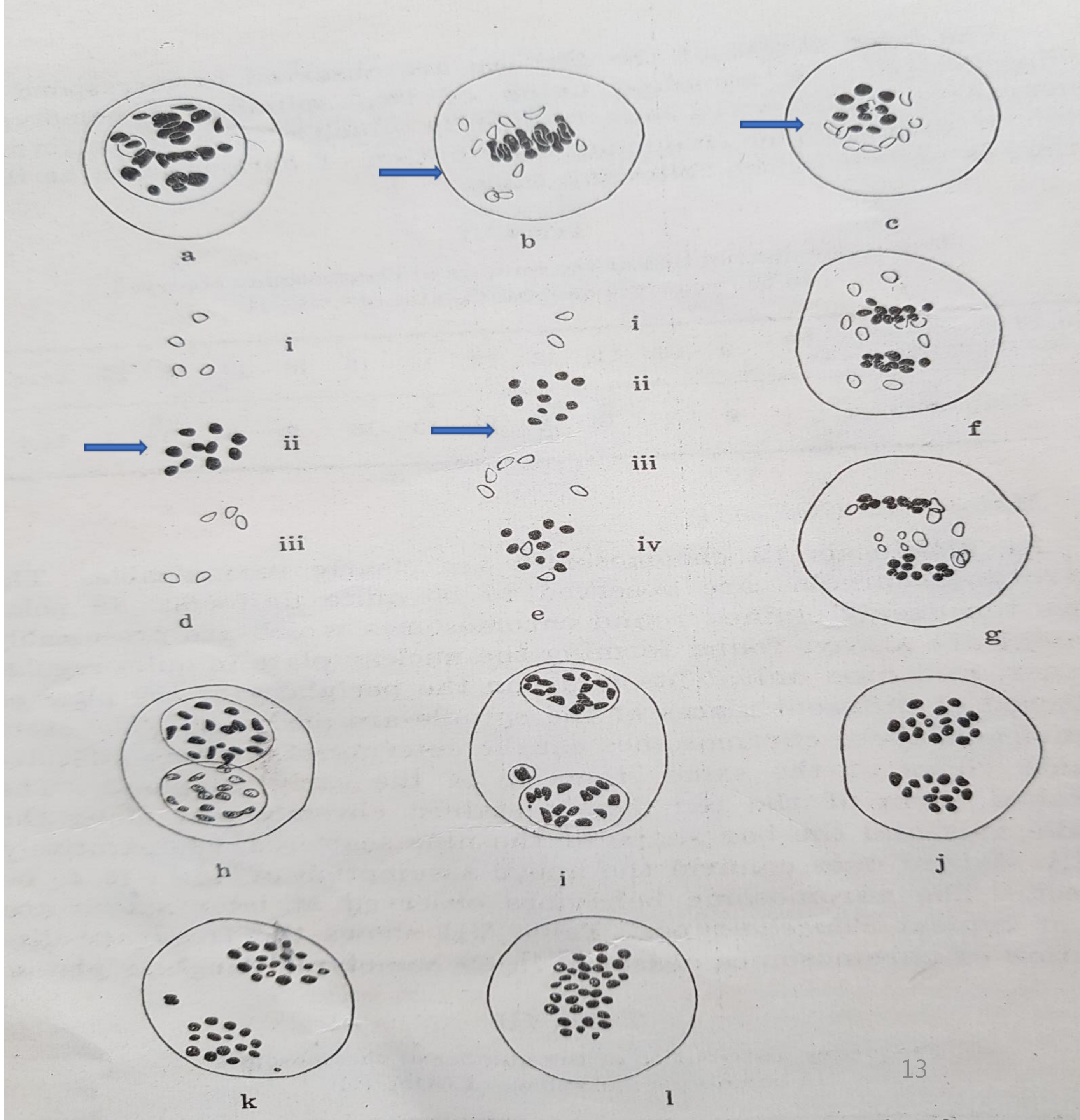
  iii : 5 univalent (low focus)
- e = with different foci

  i : 2 univalent (upper focus)

  ii : 10 disjoined halves of bivalents (mid focus)

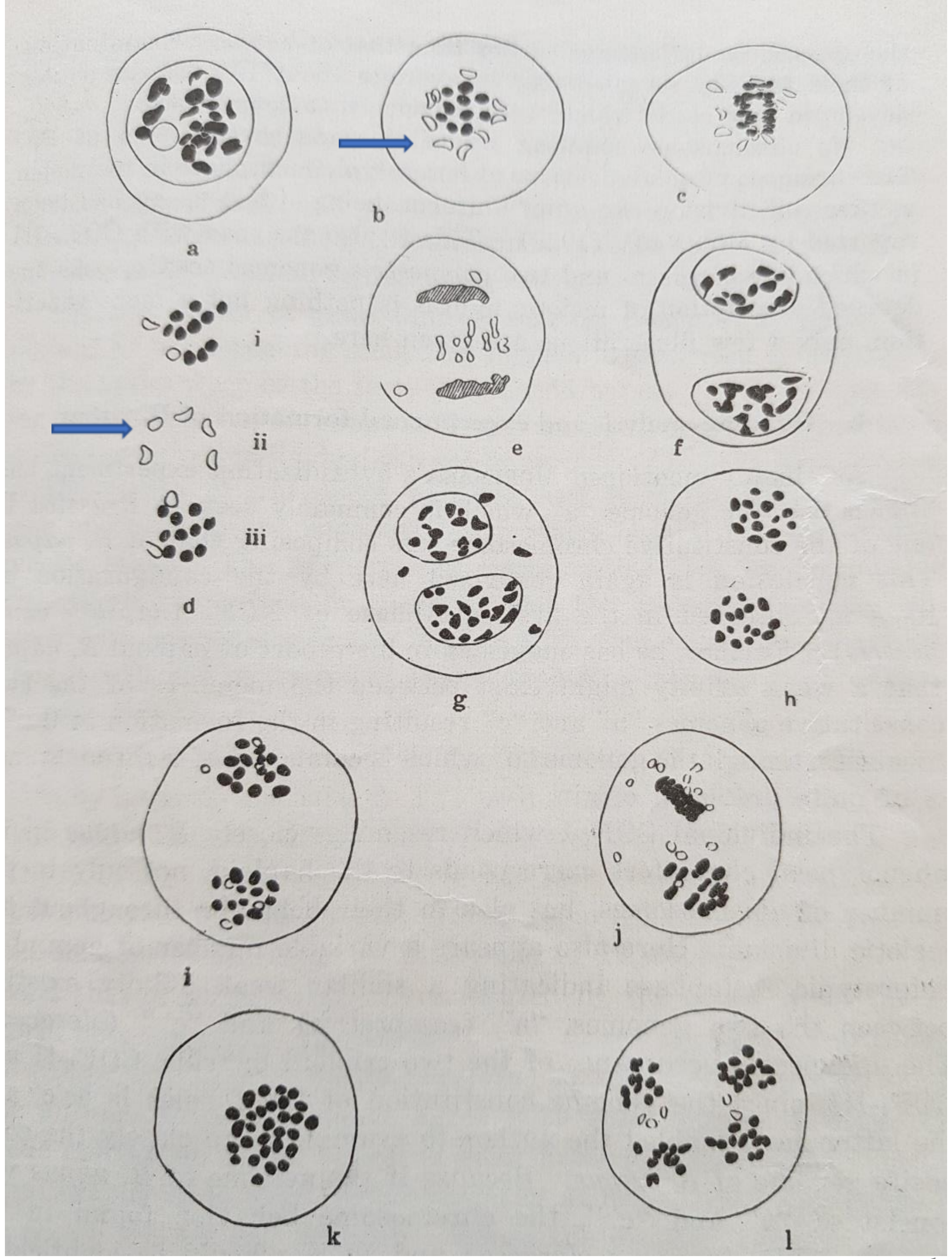
  iii : 5 univalent (low focus)

  iv : 10 disjoined halves of bivalents + 2 univalent



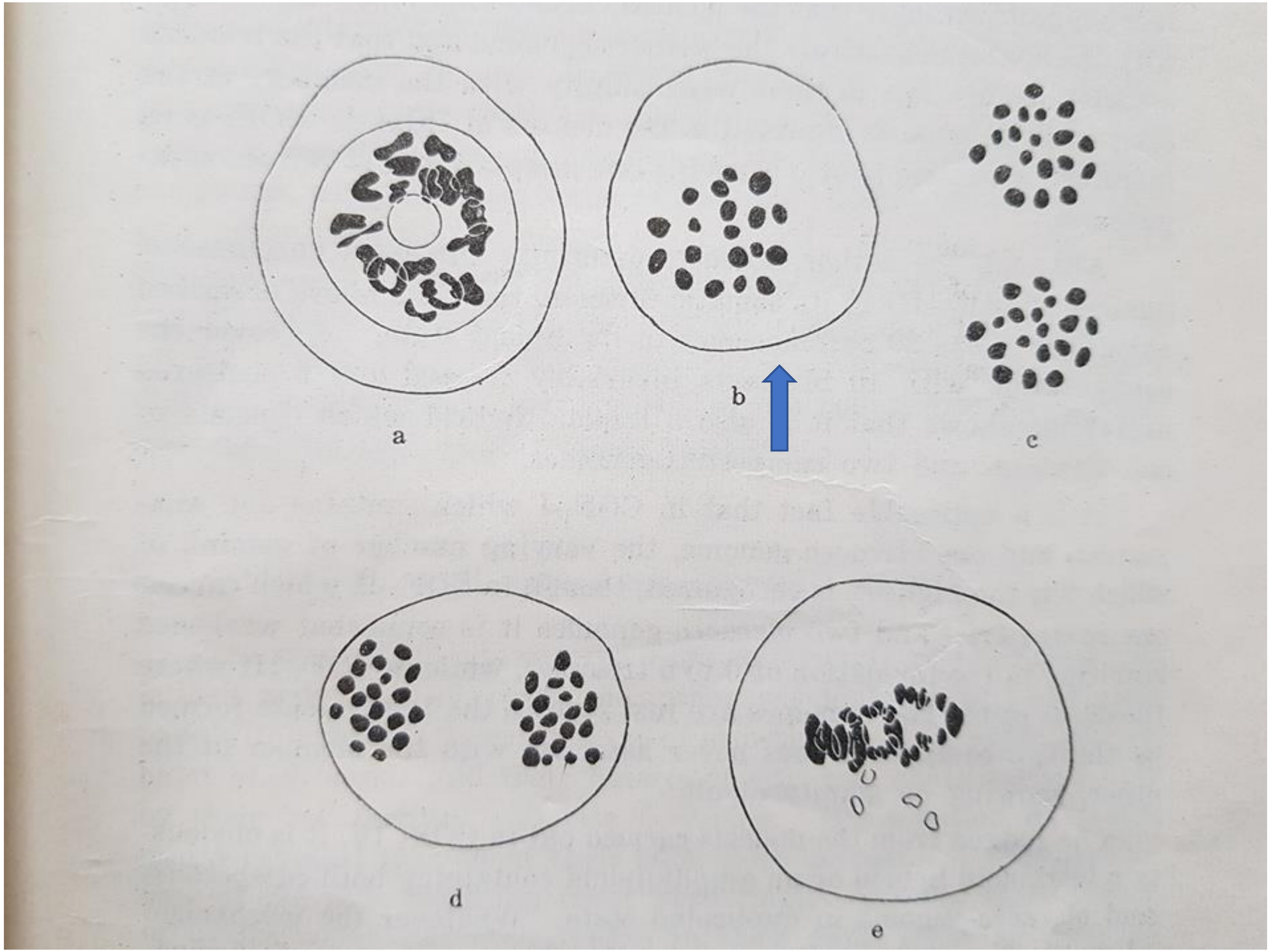
napus(n=19) x campestris(n=10)
campestris(n=10) x napus(n=19)

- b = Polar view of metaphase 1(10II+9I)
- d = anaphase 1
  (observed at 3 different foci)



19II

in metaphase 1 of COF_1- IV



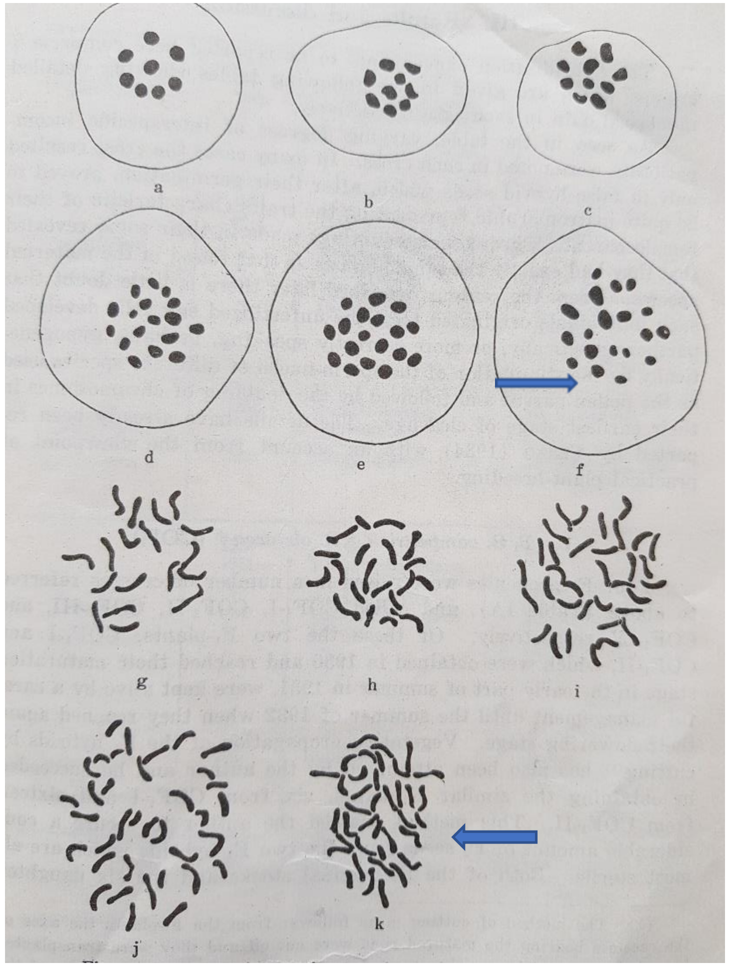
Meiotic and somatic metaphase of parents

- Meiotic meta metaphase 1 of

  B. nigra(a), *B. oleracea*(b), *B. campestris*(c), *B. carinata*(d), *B. juncea*(e) and *B. napus*(f=19II).

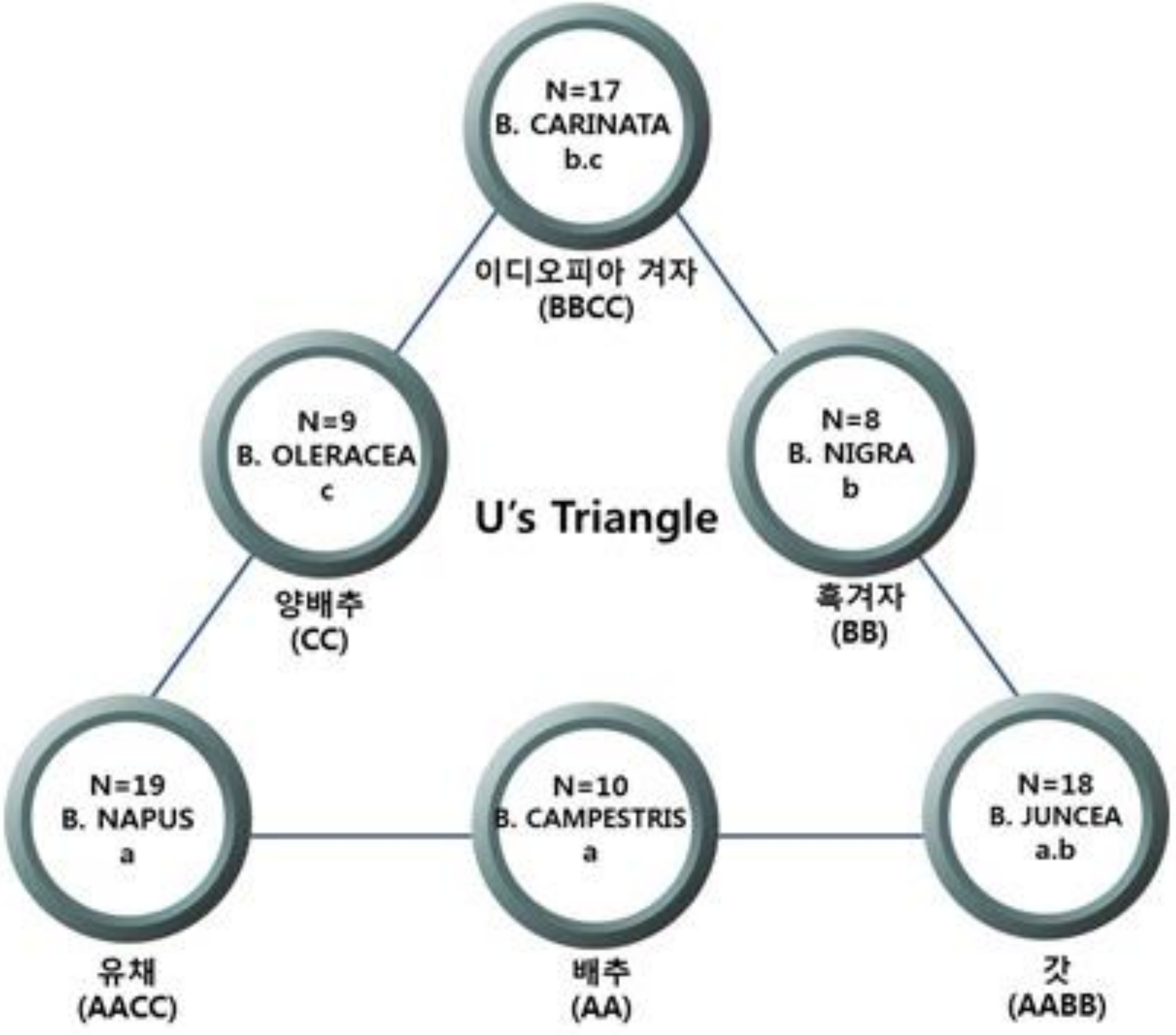
- Somatic metaphase 1 of

  B. oleracea(g), *B. campestris*(h), *B. carinata*(i), *B. juncea*(j) and *B. napus*(k 38chromosomes).



Interpretation and extension to U's Triangle

Plant No.	Chromosome paring	Same as
COF_1-I	19I	
COF_1-II	9II + 10I	*B. napus* x *B. oleracea*
COF_1-III	10II + 9I	*B. napus* x *B. campestris*
COF_1-IV	19II	*B. napus*
∴ COF_1-I = ac, COF_1-II = acc, COF_1-III = aac COF_1-IV = aacc = *B. napus* (observation) therefore it is induced that *B. napus* is amphidiploid between *B. campestris* and *B. oleracea.*		
Further extension led to U's triangle.		



Success factors

- Most recent information
- Good reasoning(hypotheses)
- Nursing and caring the plant materials
- Amazing microscopy, cytology & karyology
- Luck (ex. 4 COF_1 plants have 4 distinct all-possible chromosome constitutions**)

Contribution

- *Brassica* species relationship
- Reconfirm spontaneous amphidiploids formation*
- Providing new tools for taxonomy(paring behavior, karyotype)
- Chromosome no. of *B. napocampestris* (56→58)
- Exploitation of inter- and intra-species variation for breeding (pseudogamy also)

* 현존하는 피자식물 종의 약 40%는 종간 교잡 및 게놈배가로 발생

** 행운은 준비된 자의 것이다.

Other research theses and reports

Ornamental plants (Morning glory)

- Jap. Jour. Genetics. 1926. Seed characters – single recessive
- Jap. Jour. Genetics. 1930. 11 mutations – all appeared in diploid cells and found to be recessive(to wild type).

  * Only those data which had survived fire were reported.

- Jap. Jour. Genetics. 1930. Leaf morphology inheritance : Dragon fly style (A) – Non-mutable fine needles style (a') – Mutable fine needles style (a)

  * detailed data were lost by fire.

- The 3rd Jap. Soc. Genetics Meeting Lecture(1930) -Yellow leaf/white flower x green leaf/red flower

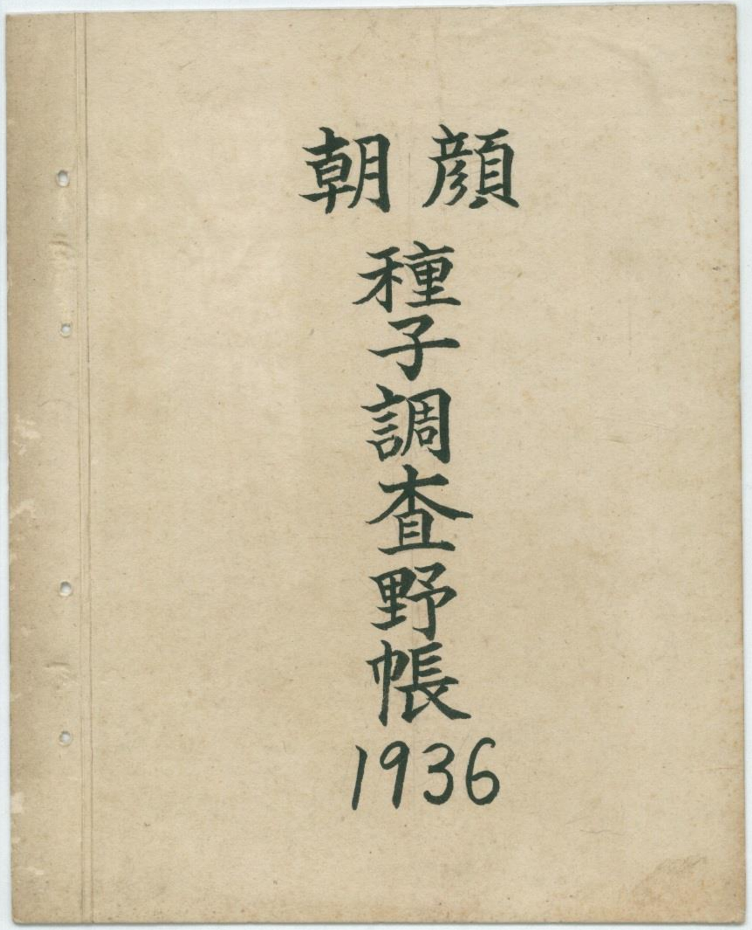
  → 440 green leaf/purple flower

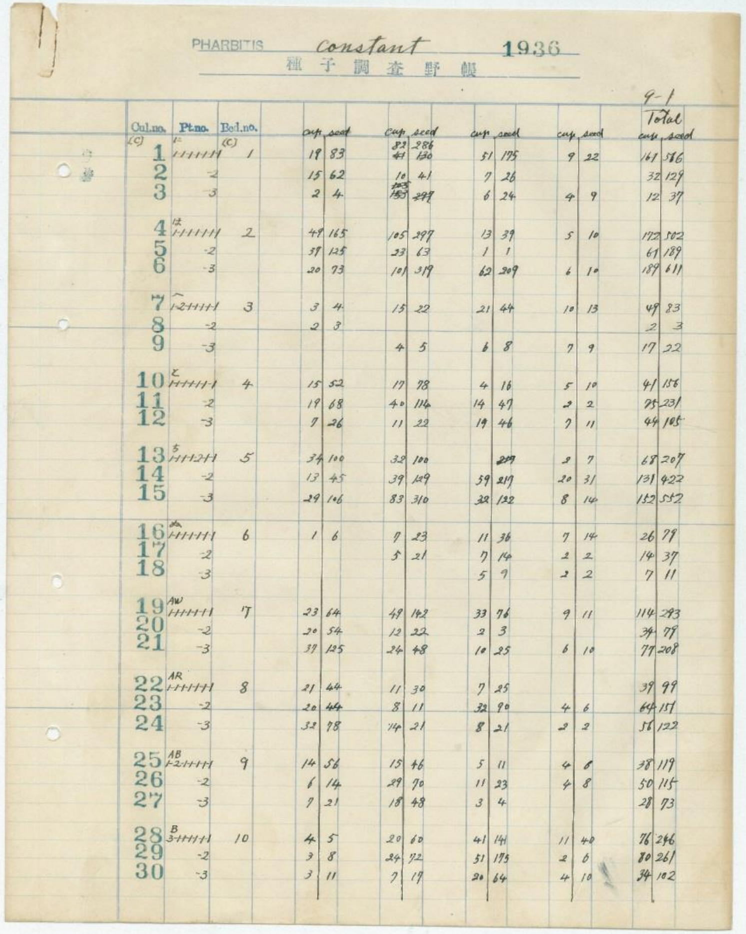
  1 Yellow leaf/white flower (*cytology indicates* pseudogamy-induced)

  * detailed microscopic pictures and drawings were lost by fire.

- Jap. Jour. Botany. 1932. Haploid appearance(cytology; cytogenetics). – reduced size, pollen with high abortion & irregular meiosis, observation on somatic chromosomes & PMC, origin could be apomixis; frequency≒ 1/300

Dr. U's field notebook for morning glory studies





PHARBITIS constant 1936

種子調查野帳

9-1

Cul.no. (C)	Pt.no.	Bed.no. (C)	cup	seed	cup	seed	cup	seed	cup	seed	Total cup	Total seed
1	1-1-1-1-1-1	1	19	83	82 41	286 130	51	175	9	22	161	516
2	-2		15	62	10	41	7	26			32	129
3	-3		2	4	105 153	297	6	24	4	9	12	37
4	1-1-1-1-1-1	2	49	165	105	297	13	39	5	10	172	502
5	-2		37	125	23	63	1	1			61	189
6	-3		20	73	101	319	62	209	6	10	189	611
7	1-2-1-1-1-1	3	3	4	15	22	21	44	10	13	49	83
8	-2		2	3							2	3
9	-3				4	5	6	8	7	9	17	22
10	1-1-1-1-1-1	4	15	52	17	78	4	16	5	10	41	156
11	-2		19	68	40	114	14	47	2	2	75	231
12	-3		7	26	11	22	19	46	7	11	44	105
13	1-1-1-2-1-1	5	34	100	32	100		219	2	7	68	207
14	-2		13	45	39	129	59	217	20	31	131	422
15	-3		29	106	83	310	32	122	8	14	152	552
16	1-1-1-1-1-1	6	1	6	7	23	11	36	7	14	26	79
17	-2				5	21	7	14	2	2	14	37
18	-3						5	9	2	2	7	11
19	1-1-1-1-1-1	7	23	64	49	142	33	76	9	11	114	293
20	-2		20	54	12	22	2	3			34	79
21	-3		37	125	24	48	10	25	6	10	77	208
22	1-1-1-1-1-1	8	21	44	11	30	7	25			39	99
23	-2		20	44	8	11	32	90	4	6	64	151
24	-3		32	78	14	21	8	21	2	2	56	122
25	1-2-1-1-1-1	9	14	56	15	46	5	11	4	6	38	119
26	-2		6	14	29	70	11	23	4	8	50	115
27	-3		7	21	18	48	3	4			28	73
28	3-1-1-1-1-1	10	4	5	20	60	41	141	11	40	76	246
29	-2		3	8	24	72	51	175	2	6	80	261
30	-3		3	11	7	17	20	64	4	10	34	102

Ornamental plants (Petunia & Primula)

- Jap. Jour. Genetics. Vol V-2. 1929. – maternal inheritance of white-margined variegation in leaf
- Jap. Jour. Genetics. Vol V-3. 1929. – allelomorphism of self-incompatibility (s_1, s_2, s_3) (-gametophytic)
- Jap. Jour. Genetics. Vol VI. 1930. – double flower habit is single factor dominant over single flower habit.

  → Sakata Seed

- Jap. Jour. Genetics. Vol XXV. 1950. Karyological observation on 2x x 4x *Primula malacoides* – one plant 2n=36 (fertile), another plant – aneuploid or asynaptic diploid(?)

Karyotyping & inter-specific(generic) relations

- Jap. Jour. Genetics. 1934. Cross between *B. campestris* and *B. oleracea* – obtained 4 plants; one of them fertile *B. napus*.
- Int'nl. Jour. Cytol. Fujii Jubilee. 1937. Bivalents in *Eruca x Brassica* cross could originate from intra-Brassica, intra-Eruca or intergeneric. *B. oleracea*의 구성 = AABBCCDEF(?)
- Int'nl. Jour. Cytol. 1937. *Brassica* x *Raphanus* hybridization. Meiosis observation on F1 RBc(2n=19), F1 BoR(2n=18), F1 RRBc(2n=28); RRBc(2n=28) ← doubled R egg cell and Bc sperm cell.

Rapeseed (Agronomy & botany)

- Jour. Agr. Expt. Sta. 1931. Agronomic and botanical characterization of 137 oleiferous varieties; 83 *B. campestris*, 49 *B. napus* and 5 *B. juncea*.

  (3 field conditions; transplanting vs. direct seeding; 25 traits)
- Jour. Agr. Expt. Sta. 1932. Fertility and natural crossing of *B. napus*(6 vars) and *B. campestris*(10 vars) – natural cross c(76%) > n(9%); self seed setting c < n.
- Agri. & Hort. 1935. To avoid abnormal pith growth, wide spacing and rich fertilization are required in seedling nursery.

Two miscommunications

- New species formation (synthesis; 種의 合成)
  - not true, only repeated the nature.

Dr. U through genome analysis found that

3 mono-genomic *Brassica* species had given rise to 3 amphidiploid species by natural crosses followed by chromosome doubling.

Relationship among 6 Brassica genera clarified as shown in his triangle.

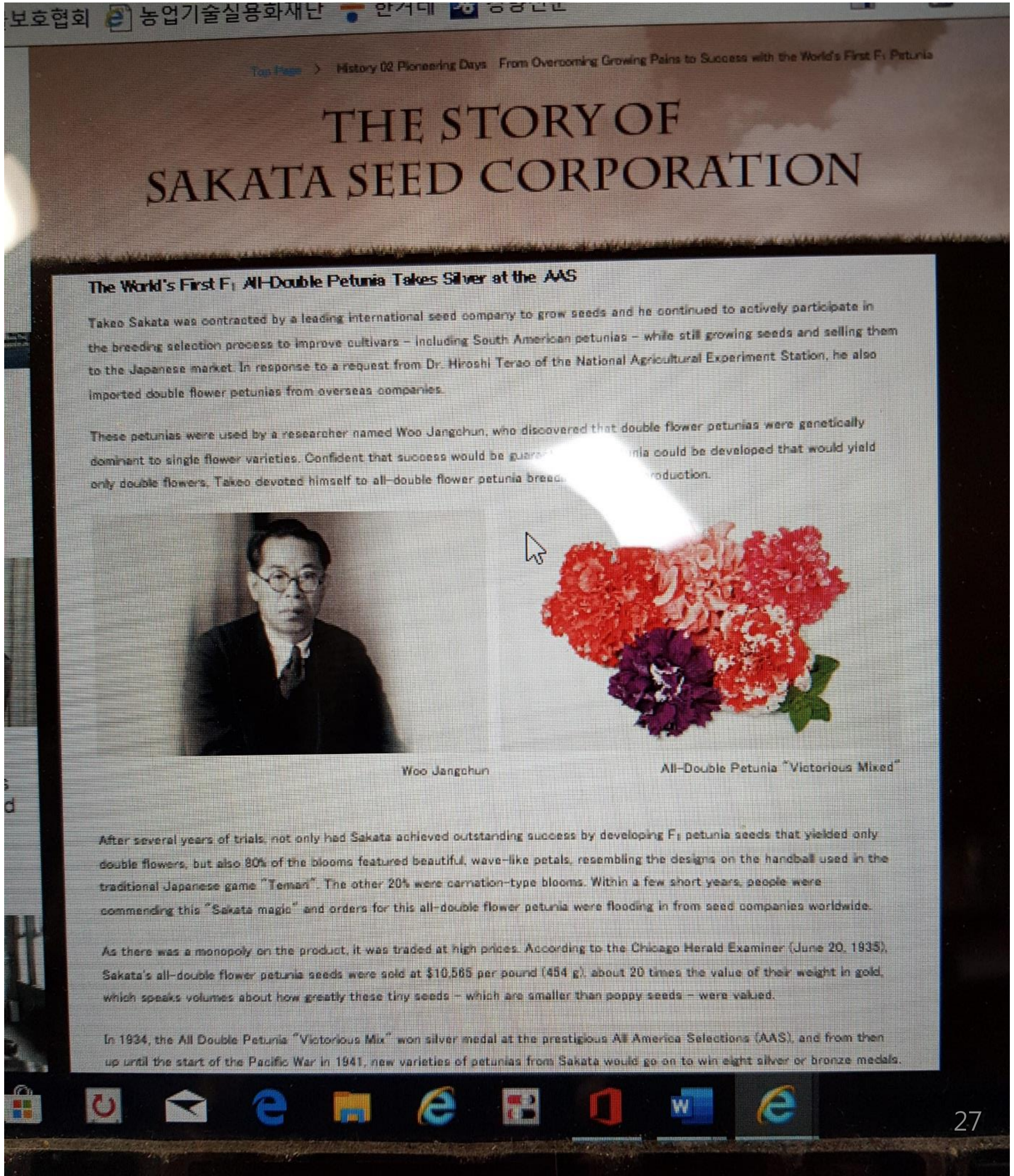
- Seedless watermelon(씨 없는 수박)
  - developed by Kihara, U brought(?) the seed.

Industrial contribution while in Japan

Double Petunia Story

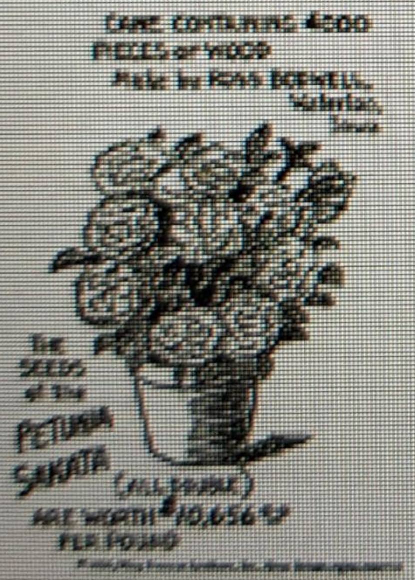
- Takeo Sakata was contracted to a leading intn'l seed company to grow seed and participated in breeding South American petunia, among others.
- Upon request of Hiroshi Terao of NAES, he imported double petunas. (on his return from overseas study trip)
- Dr. U found out that double flower is single dominant over single thus Takeo became able to come up varieties with all double flower.
- In 1934, all double petunia, "Vicotrious Mixed" won silver medal at AAS, until the Pacific War in 1941 double flower vars. won 8 silver or bronze medals in AAS.
- The petunia seeds w sold were at $10,565/pound according to Chicago Herald Examiner (Jan 20, 1935): about 20 times the value of their weight in gold.

http://www.sakata100th.jp/english/story/

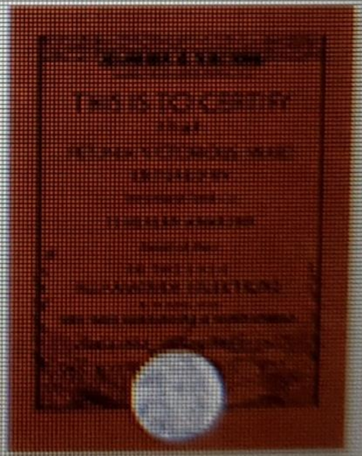


As there was a monopoly on the product, it was traded at high prices. According to the Chicago Herald Examiner (June 20, 1935), Sakata's all-double flower petunia seeds were sold at $10,565 per pound (454 g), about 20 times the value of their weight in gold, which speaks volumes about how greatly these tiny seeds – which are smaller than poppy seeds – were valued.

In 1934, the All Double Petunia "Victorious Mix" won silver medal at the prestigious All America Selections (AAS), and from then up until the start of the Pacific War in 1941, new varieties of petunias from Sakata would go on to win eight silver or bronze medals.



The price of All-Double Petunia published in "Chicago Herald Examiner" (June 20, 1935)



All-Double Petunia "Victorious Mixed" silver prize award

http://www.sakata100th.jp/english/story/

Methods of Vegetable Breeding –Agri. & Hort. 1945-

- JASTA: The 1st Lecture on Breeding

Important points and contents

- If not based on science and technology, no generality nor continuity.
  - Burbank story, farm-bred varieties.
- Common breeding procedures (재료선택, 모본관리, 수분, 영양체보존, 육성연한단축 등등)

- 채소분야 특이 기술-

- Heterosis & inbreeding depression
- Incompatibility –a breeding scheme is proposed. (to be later applied to develop new hybrid Brassica cultivars (in Japan and Korea).

  - based on a theory similar to sporophytic, mono-locus, multi-allele, with dominance-recessive or codominance relationship. (which was proposed and accepted in early 1950s.)

- Intersex
- Male-sterility (Jones and Clarke's report on ASHS Proc. 43 in 1943)


初代農場長
(昭和12年～20年)
農学博士
禹長春


TAKII
TAKII & CO., LTD.

- 1935. Takii Plant Breeding and Experiment Station was established in Nagaokakyo City in Kyoto.

  (Dr. U served as the (1st) director of the Station. 1937)

- 1950. Takii introduced the world's first Brassica F1 Hybrid Chinese Cabbage "No. 1" and Hybrid Cabbage "O-S Cross(AAS Medal in 1951)".

from: http://www.takiiseed.com/about/history/ (2019.10.11)

Industrial contribution in Korea

Self-sufficiency of vegetable seeds

- 1948 – imported 540,000 (3,00x180) liters of radish(궁중) seed
- Essential vegetables: variety introduction, selection, release to private sector (through 농업과학 기술협회), seed production area development (과거 서선농산의 채종지 진도 등)
- Self-sufficiency was achieved by around 1955. (No need for importation was testified in the National Assembly)

* Sources: 한국원예발달사 p.190-196, 한국채소종자산업발달사 p. 415, 456

Courtesy: Dr. GD Koh

한국농업과학연구소 현관에서 채종포 관련자의 기념촬영.
소채원 채종포 수납타합 기념(蔬菜原採種圃收納打合記念)이라고 사진에 새겨져있음
(단기 4286(서기 1953). 8. 20)

Breeding F_1 Hybrid Varieties & Training Breeders

- Dr. U led the breeding programs, but parental lines were released to private companies only after his death.
  - * Chinese cabbage F_1 : Wonye No. 1, Wonye No. 2 (1960)
  - * Cabbage F_1 : Dongchun (1962)
  - **Onion F_1 : Wonye No. 1, Wonye No. 2 (1960)

  * Applying self-incompatibility system

  ** Applying cytoplasmic male-sterility system

  - Sources: 한국원예발달사 p.196
- Training of young breeders – later many of them became key breeders in private seed firms.

1958년 가을 김해시험장의 배추 순도검정.중앙의 코트차림이 정남규 농사원장 왼쪽에서 두번째가 우장춘박사

Courtesy: Dr. GD Koh

Groundwork for healthy potato seed tuber

- 1957(?) : Initiated seed potato research in HES (budget from MOAF, 정운갑장관; 정남규국장_노망 episode)

  (55.11.17-57.06.16)

- 1959(?) : "Daeguanryeong" was decided as the site for seed potato tuber production (changed from Samcheok)

- 1961 : Foundation seed of "Irish Cobbler" was produced on 20ha field. (That was only after Dr. U had passed away)

* Source: 김태욱, 마음속에 살아있는 인간 우장춘 p. 291-298; 한국농업기술사 p. 347

Other contributions

- Hydroponic vegetable production – issued for supply to US military – Dr. U said it was not practical & instead recommended areas having clean land soil and clean water. (수경재배)
- As to breeder seeds of rice varieties, Dr. U suggested to take measures for preventing degeneration. (수도)
- As to tree breeding project, Dr. U emphasized the need a large scale. (임목육종)

  * Source: 우장춘과 원우회 p.57-58, p.117-123; 한국원예발달사 p 15

- As to citrus fruits in Jeju island, Dr. U is known to played a leading role in developing the industry through introduction of new varieties. (but the author was not able to trace relevant records) (감귤)

남해안 지방에서 감귤재배 가능성을 검토하기 위하여 경남 거제에서 겨울철에
가마니를 씌우고월동하는 감귤나무 (1955년)

Courtesy: Dr. GD Koh

감귤재배 가능성 검토를 위하여 거제군에 간
우박사(왼쪽2번째)와 최정일(4번째) (1953. 6)

Courtesy: Dr. GD Koh

Implications(1)

- Nursing material plants ← sound agronomy

  (작물의 정상재배 연후라야 시험연구)

- Observation and data taking with accurate/precise traditional/up-to-date methodology

  (기초적 측정/기록부터 최신 연구 장비/방법까지)

- Follow-up of the most recent academic advancement/findings (최근까지의 연구정보)
- Sound reasoning with forceful hypotheses

  (과감한 가정과 선전한 추론)

Implications(2)

- Research and application (연구와 응용)
- Genetic study and crop breeding

  (한 분이 위 모두를)

- Teamwork (영문번역 등; 다수 증언)
- Cooperation with related sciences

  (육종에 주변학문 활용)
- Multidisciplinary problem solving(농업문제에 학제간 협업)
- Biotechnology vs. crop improvement

  (육종에 적용 않는 생명공학은 왜? 생명공학 없이 좋은 육종 성과?)

  (혼자 못하면 분업/협업이라도!!!)

참고자료

- 고관달. 2019. 우장춘-그는 우리에게 무슨 말을 하고싶을까? Powerpoint 74매.
- 김태욱. 1984. 마음속에 살아있는 인간 우장춘. 343쪽. 신원문화사
- 우장춘박사회갑기념논문집편찬위원회. 1958. 우장춘박사회갑기념논문. 238쪽. 경향신문사
- 원우회. 2013. 우장춘과 원예연구. 204쪽. 국립원예특작과학원.
- 정종현. 2019. 제국대학의 조센징 –대한민국 엘리트의 기원, 그들은 돌아와서 무엇을 하였나? 391쪽. 휴머니스트 출판그룹
- 한국농업기술사편찬위원회. 1983. 한국농업기술사. 87쪽. 정민사.
- 한국농촌경제연구원(편). 1999. 한국농정50년사. 2548쪽. 한국농촌경제연구원.
- 한국원예발달사편찬위원회. 1980. 한국원예발달사. 542쪽. 서울대학교출판부.
- 한국채소종자산업발달사 편찬위원회. 2008. 한국채소종자산업발달사. 607쪽. 서울대학교출판부
- 한창렬. 2009. 우장춘박사 업적의 학술적 재조명. (*in* 우장춘박사 서거 50주기 기념국제심포지엄. 167쪽. 국립원예특작과학원 시설원예시험장)
- http://www.sakata100th.jp/english/story/(2109.09.14)
- http://www.takiiseed.com/about/history/ (2019.10.11)

자료 수집에 도움을 주신 분들께 감사드립니다.

- 변상지사장님 (사카타코리아)
- 유일웅박사님 (삼성종묘)
- 이도현박사님 (타키이코리아)
- 이병서박사님 (농촌진흥청)
- 허윤찬과장 (국립원예특작과학원)

박사학위논문 한글번역본 정오표

우장춘박사의 생애와 학문 –서거 50주기 기념-

쪽	줄	오	정
87	하1	관찰에는 여러	감수분열 관찰을 위한 화뢰 고정에는 여러
101	14	28개의 염색체 중에서	28개이다. 그들 염색체 중에서
101	16	나머지는	나머지 10개는
107	7	간의 친화력이 약한 결과라고	간에 약하나마 친화력이 있기 때문이라고
107	9	유사한 COF1-1의 각 개체는	유사한 개체 COF1-1는
107	10	행동이 그 반수체와	행동이 반수체와
108	하1	배가 안된	감수되지 않은
116	11	후기에서 1가염색체가	후기에 1가염색체가
116	12	모세포뿐이지만 방추체가	모세포뿐이지만, 이경우에는 방추체가
116	하6	핵공	핵강
116	하4	잇따라	잇따른
120	하14	염색체라 할	염색체 수라 할
121	하13	확실하게 했으며	확인할 수 있게 했으며
121	하1	Morinaga(盛永)는 --- 나타냈다.	Morinaga(盛永)는 a게놈과 함께 B. juncea와 B. ceruna를 구성하는, 8개 염색체로 이루어진 미지의 염색체조를 b로 표기했다. 때문에 그에 따르면 이 종의 개놈은 aabb로 표현된다.
124	5	구성하든가	제공했든가
126	3	모계의	부계의
126	하 6~5	이 경우에도 ------거의 같은 결과를 가져왔다.	napus x *campestris*의 경우에도 F1 종자의 발아는 다염색체 종을 모본으로 했을 때에 더 좋았다.
128	하1	3종	3중