WHEAT INFORMATION SERVICE

a b c d

No. 1 **October, 1954**

Laboratory of Genetics
Biological Institute, Kyoto University
Kyoto, Japan

Explanation of the figures on the cover

(KIHARA, H.)

a. *Triticum persicum stramineum*
b. *Aegilops squarrosa*
c. A synthesized hexaploid from the cross,
T. persicum stramineum × *Ae. squarrosa*
d. *T. vulgare erythrospermum* (natural hexaploid)

No. 1 WIS October, 1954

CONTENTS

I. Foreword

On the occasion of the 9th International Congress of Genetics held at Bellagio, Italy, August 29, 1953, twenty six geneticists, representatives of nineteen different countries, who are interested in wheat genetics, met to discuss important problems regarding wheat genetics with Dr. H. KIHARA, Kyoto University, Kyoto, Japan, as chairman. Their names are listed on pages 2—3.

The main decisions of the meeting were as follows:

(1) WIS (Wheat Information Service) will be published from the Laboratory of Genetics, Biological Institute, Kyoto University, Japan, as a medium of information and exchange of methods, materials and stocks, results and ideas for the promotion of the international cooperation in wheat genetics.

(2) Plant Industry Station, U.S.D.A., Beltsville, Maryland, U. S. A,. will be the center, where genetic wheat material will be collected and maintained, and the Laboratory of Genetics, Kyoto University, Japan will be the corresponding center for *Aegilops*.

(3) International Wheat Symposium will be held in 1956, if possible, in Japan.

The present issue of WIS is one of the results of the Bellagio meeting. It includes: (1) informations on genetic stocks of *Triticum, Aegilops* and *Agropyron* at Kyoto University; (2) proposed rules for nomenclature and symbolization of genes, and standardized system of gene symbols in wheats; (3) information on a film, "Origin of Wheat", and other items.

At the present time there are no definite enrolled members of WIS. Anyone who is interested in wheat genetics may subscribe without membership fee for the publications from No. 1 through No. 4, which will be published biennally. For further publications, your co-operation is greatly appreciated. The number of copies prepared for the present issue is 1,000, and they will be distributed upon request.

The cost of the present publication has been defrayed by contributions by the following Japanese organizations, for which we wish to express our sincere thanks.

Flour Millers Association, Tokyo, Japan
Nisshin Flour Milling Co. Ltd., Tokyo, Japan
Nippon Flour Mills Co. Ltd., Tokyo, Japan
Showa Sangyo Co. Ltd., Tokyo, Japan
Nitto Flour Milling Co. Ltd., Tokyo, Japan
Chiyoda Chemical Engineering and Construction Co. Ltd., Tokyo, Japan
The Iyenohikari Association, Tokyo, Japan.

II. Geneticists who met at a special meeting in Bellagio, Italy

(At the Hotel Grande Bretagne, August 29, 1953)

* ÅKERMAN, A.: Svalöf (Sweden)

* BECKMAN, I.: Caixa Postal 189, Bagé, R.G.S. (Brazil)

BURNHAM, C.R.: University of Minnesota, University Farm, St. Paul, Minn. (U.S.A.)

CAMARA, A.: Estação Agronòmica Nacional, Sacavém (Portugal)

COVAS, G.: Aviador Koehl 429, El Palomar, Bs. As. (Argentina)

ESPOSITO Seu MARGHERITE, M.: Istituto Nazionale de Genetica per la Cerealicultura, Via Cassia 176, Roma (Italia)

FISCHER, G. J.: Instituto Fitotecnico y Semillero Nacional "La Estanzuela", Estanzuela (Uruguay)

FRANKEL, O.H.: Commonwealth Scientific and Industrial Research Organization, Division of Plant Industry, P.O. Box 109, City Canberra, A.C.T. (Australia)

GRILLOT, G.: Service de la Recherche Agronomique au Maroc, 67 Avenue de Témara, Rabat (Morocco)

KIHARA, H.: Laboratory of Genetics, Dept. of Agriculture, Kyoto University (Japan)

KUMP, M.: College of Agriculture, Zagreb (Yugoslavia)

LARSON, R.I.: Science Service Laboratories, Box 270, Lethbrige, Alberta (Canada)

MACKEY, J.: Sveriges Utsadesforening, Svalöf (Sweden)

MALIAHI, C.: Istituto de Tecnica, Lonigo, Vicenza (Italia)

MAYER, R.: Station Centrale de Génétique et d'Amélioration des Plantes, Versailles, S. et O. (France)

MAZOTI, L.B.: Calle I. Arias 2853, Castelar FCNDFS, Bs. As. (Argentina)

MONTEVECCHI, P.: Istituto Nazionale de Genetica per la Cerealicultura, Via Cassia 176, Roma (Italia)

MÜNTZING, A.: Institute of Genetics, Lund (Sweden)

OEHLER, E.: Station Fédérale d'essais et de controle de semences, Lausanne, Mont Calme (Switzerland)

PATHAK, C.H.: P.O. Box 4456, College Station, Texas (U.S.A.)

PESOLA, V.A.: Agricultural Research Center, Dept. of Plant Breeding, Jokioinen (Finland)

* Not present, but their present representatives assured us of their interest in joining our organization.

Pienaar, R. de V.: 22 Greenhill Road, Emmarentia, Johannesburg, (South Africa)

* Rutishauser, A.: Sommatt Str. 5, Schaffhausen (Switzerland)

* Sachs, L.: Dept. of Experimental Biology, Weizmann Institute of Science, Rehovoth (Israel)

Sanches-Monge, E.: Estacion Experimental de Aula Dei, Apartado 202, Zaragoza (Spain)

Schiemann, E.: Institut f. Geschichte der Kulturpflanzen, Faradayweg 16, Berlin-Dahlem (Germany)

Simonet, M.: Station Centrale de Génétique et d'Amélioration des Plantes, Versailles, S. et O. (France)

Staudt, G.: Institut f. Geschichte der Kulturpflanzen, Faradayweg 16, Berlin-Dahlem (Germany)

Tavcar, A.: Institute for Plant Breeding and Genetics, Faculty of Agriculture, University, Zagreb (Yugoslavia)

Volpe, E.: Istituto Nazionale de Genetica per la Cerealicultura, Via Cassia 176, Roma (Italia)

Wagner, S.: Eidgen. Landw. Versuchsanstalt, Zürlich-Oerlikon (Switzerland)

III. Announcement for issue No. 2

WIS No. 2 will be ready for publication in April, 1955. It is open to all contributions dealing with informations on methods, materials and stocks, ideas and research notes related to wheat genetics and cytology, including *Triticum*, *Aegilops*, *Agropyron*, *Secale* and *Haynaldia*.

Contributions should be typewritten in English. The authors are cordially requested to present their manuscripts, not exceeding two printed pages with the exception of the lists of stocks, and not later than February 28, 1955.

Manuscripts and communications regarding editorial matters should be addressed to Dr. K. Yamashita. The address of the Editorial and Business Office of the WIS is as follows:

Laboratory of Genetics, Biological Institute
Kyoto University
Kyoto, Japan

* Not present, but their present representatives assured us of their interest in joining our organization.

IV. Genetic Stocks
at
Laboratory of Genetics, Kyoto University, Japan

* * *

Since 1918, when KIHARA began his genetic research on wheat and its related genera, a great numbers of species and varieties, including *Triticum, Aegilops, Secale, Agropyron* and *Haynaldia,* have been collected from all over the world. They have been maintained by the financial support of the Ministry of Education.

The numbers of collected species, strains and also artificially induced autopolyploids and amphidiploids, are as follows:

	Species	Strains	Artificial autopolyploids & amphidiploids	
Triticum	16	183	2	1
Triticum and *Aegilops*				8
Aegilops	22	63	7	5
Secale	2	6		
Triticum and *Secale*				17
Agropyron	23	49		
Haynaldia	1	1		

The collected stocks have been maintained by selfing from generation to generation. One of the difficulties of maintaining these stocks has been that the flowering time of most of them coincides with the rainy season in Kyoto. For this reason some of the valuable stocks of diploid species were often lost and had to be replaced. In compliance with requests we shall be able to supply the seeds obtained by open pollination of all but some diploid species of *Aegilops.*

Ae. squarrosa L. var. *Meyeri* Griseb. and var. *anathera* Eig and also ssp. *strangulata* Eig are missing from our collection and we would appreciate any contribution to complete our stock.

1. Species and varieties of *Triticum*

Species or variety [1]	Source (Original cultural No.)	Sender (Year)
T. aegilopoides Bal.		
var. *boeoticum* Perc.		College of Agric., Hokkaido Univ., Japan (1927)
var. 〃 (Leningrad)	Balaklava, Crimea (reproduced in Grandja)	Vavilov (1930)
var. *Larionowi* Flaksb.	Balaklava, Crimea (reproduced in Otrada, Kanioskaia, North Caucasia)	Vavilov (1930)
T. monococcum L.		
var. *vulgare* Körn.		College of Agric., Hokkaido Univ., Japan (1927)
var. *flavescens* Körn. (French 67)		Agricultural Experiment Station, Himeji, Japan.
var. *Hornemanni* Körn.		O'Mara (1953)
T. Timopheevi Zhuk. No. 1		Zhukowsky (1931)
〃 No. 2		Briggs (1948)
〃 No. 3		Cillis (1954)
T. dicoccoides Körn.		
var. *Kotschyanum* Schulz		—
var. *spontaneo-nigrum* Flaksb.	Palestine	Vavilov (1930)
var. *Straussianum* Schulz	Suburbs of Tiberia, Palestine	Vavilov (1930)
T. dicoccum Schübl.		
var. *liguliforme* Körn.		College of Agric, Hokkaido Univ., Japan (1927)
var. — (Emmer)		Agricultural Experiment Station,
var. — (French 57)		Kônosu, Japan (1949)
var. — (White)		〃
var. — (Russian 26)		〃
var. — (French 64)		〃
var. — (601)	Santa Catalina	Ladislao Ol'ah (1950)
var. *arras* Hochst. (Khapli)	Peiping, China	Wang (1934)

1) Common names or names used for our convenience of discrimination are given in brackets. No. 1, No. 2, No. 3 and so forth are the cultural Nos. of the stocks at Kyoto University, Japan.

— Continued —

var. —	(WK 7)		Parthasarathy (1952)
var. —	(WRSo)		〃
var. —	(WSC)	Pullman, Wash., U. S. A.	Yamashita (1952)
T. durum Desf.			
var. *Reichenbachii* Körn.			College of Agric., Hokkaido Univ., Japan (1927)
var. *coerulescens* (Bayle) Körn.			—
var. *hordeiforme* (Host) Körn.		Inner Mongolia Expedition	Hirayoshi (1938)
var. *melanopus* (Al.) Körn.			
	No. 1	Lhasa, Tibet (EP 598)	Stubbe (1952)
var. 〃	No. 2	〃	〃
var. *africanum* Körn.	No. 1	Islamia College Farm, Pakistan	Suzuka (1952)
〃	No. 2		〃
var. *apulicum* Körn.	(Bansi)		Parthasarathy (1952)
var. —	(Examis)		〃
var. —	(Jappa)		〃
var. —	(Motiya)		〃
var. —	(Gulab)		〃
var. —	(Pentad)	Pullman, Wash., U. S. A.	Yamashita (1952)
var. —	(Stewart)	〃	〃
T. orientale Perc.			
var. —			Watkins (1933)
T. persicum Vav.			
var. *stramineum* Zhuk.			Zuitin (1926)
var. *fuliginosum* Zhuk.			〃
var. 〃	(Black Persian)		Watkins (1933)
var. *rubiginosum* Zhuk.[1)]			Zuitin (1930)
T. turgidum L.			
var. *nigro-barbatum* Körn.			College of Agric., Hokkaido Univ., Japan (1927)
var. —	(Poulard)	Pullman, Wash., U. S. A.	Yamashita (1952)

1) This variety, *T. persicum* var. *rubiginosum*, has been proved to be hexaploid.

T. pyramidale Perc.		
var. *recognitum* Perc.		Miczynski (1930)
T. polonicum L.		
var. *vestitum* Körn.		College of Agric., Hokkaido Univ., Japan (1927)
var. *gracile* (EP 296)	Neting, Tibet (EP 596)	Stubbe (1952)
var. — (Polish)	Pullman, Wash., U. S. A.	Yamashita (1952)
T. Spelta L.		
var. *Duhamelianum* Körn.		College of Agric., Hokkaido Univ., Japan (1927)
var. *vulpinum* Körn.	Sahara	Winge (1926)
var. *Arduini* Körn.	〃	〃
var. — (WSC)	Pullman, Wash., U. S. A.	Yamashita (1952)
T. vulgare Vill. (*T. aestivum* L.)		
var. *erythrospermum* Körn.		College of Agric., Hokkaido Univ., Japan (1927)
var. *ferrugineum* Körn.	Russia	—
var. 〃 (Mongolia)	Inner Mongolia Expedition	Hirayoshi (1938)
var. — (Hohenheim)		Correns (1926)
var. *albidum* Al.	Inner Mongolia Expedition	Hirayoshi (1938)
var. *alborubrum* Körn.	〃	〃
var. *erythroleucon* Körn. No. 1	〃	〃
var. 〃 No. 2	〃	〃
var. 〃 No. 3	〃	〃
var. *graecum* Körn.	〃	〃
var. *lutescens* Al.	〃	〃
var. — (Chinese Spring)		
〃 No. 1	(P 218)	Sando (1948)
〃 No. 2		Sears (1949)
〃 No. 3	Tashkent, U.S.S.R.	Hirata (1950)
var. — (Pakistan No. 1)	Pakistan	Akuzu (1950)
(〃 No. 2)	〃	〃
(〃 No. 3)	〃	〃

— Continued —

var. — (Tashkent No. 1)	Tashkent, U.S.S.R.	Hirata (1950)
(〃 No. 2)	〃	〃
(〃 No. 3)	〃	〃
var. — (Timstein)	(C. I. 12347)	Heyne (1951)
var. *alborubrum* Körn. (Fortyfold)	Pullman, Wash., U.S.A.	Yamashita
var. 〃 (Federation)	〃	〃
var. *albidum* Al. (Ceres)	〃	〃
T. compactum Host		
var. *icterinum* Al. (Club wheat)		College of Agric., Hokkaido Univ., Japan (1927)
var. *Humboldti* Körn. (No. 44)		〃
var. *Fetisowii* Körn.	Inner Mongolia Expedition	Hirayoshi (1938)
var. — (WSC)	Pullman, Wash., U.S.A.	Yamashita (1952)
T. sphaerococcum Perc.		
var. *rotundatum* Perc.		Miczynski (1930)
var. *rubiginosum* Perc. No. 1		〃
〃 No. 2	Islamia College, Pakistan	Suzuka (1952)
T. Macha Dek. et Men.		
var. *sub-letschumicum* Dek. et Men.		Rudorf (1940)
var. *palaeo-imereticum* Dek. et Men.		〃
T. Sovieaticum Zhebrak	Colchicine induced amphidiploid of (*T. Timopheevi* × *T. durum* var. *hordeiforme*)	Sax (1948)
T. vulgare & *T. compactum*		
46 strains	Afghanistan	Suzuka (1952)
(Emmer) 2 strains	〃	〃
T. vulgare 50 strains	Nepal Himalaya Expedition	Nakao (1952)

2. Species of *Aegilops*

Species[1)]		Chromosome number(n)	Scurce (sender, year and origin)
Polyeides			
Ae. umbellulata Zhuk.	No. 1	7	Eig (1934), Suburbs of Bozanti, Turkey (240/1932)
	No. 2	7	〃 〃 (238/1932)
	No. 3	7	Kappert (1934)
Ae. ovata L.	No. 1	14	Ducellier (1930)
	No. 2	14	〃
	No. 3	14	Eig (1934), Suburbs of Bozanti, Turkey (241/1932)
	No. 4	14	Okazaki (1936), Bot. Garten, Berlin-Dahlem, Germany
	No. 5	14	de Cillis (1954)
Ae. triaristata Willd.			
var. *vulgaris* Eig	No. 1	21	Miczynski (1934)
var. —	No. 2	21	Motte (1932), Montepellier Univ.
var. —	No. 3	14	Eig (1934), Suburbs of Mersina, Turkey (231/1932)
var. —	No. 4	14	〃 〃 (232/1932)
var. —	No. 5	14	Kappert (1934)
var. —	No. 6	14	Eig (1934), Palestine
var. —	No. 7	14	Kappert (1934), Asia Minor
Ae. columnaris Zhuk.	No. 1	14	Eig (1934), Konia, Turkey, (35/1932)
	No. 2	14	Kappert (1934), Asia Minor
Ae. biuncialis Vis.	No. 1	14	〃 〃
	No. 2	14	〃 〃
Ae. variabilis Eig			
ssp. *eu-variabilis* Eig et Fein.			
var. *intermedia* Eig et Fein.	No. 1	14	Eig (1934), Suburbs of Tripoli, Syria (246/1932)
var. *typica* Eig	No. 2	14	Eig (1934), Suburbs of Tel-Aviv., Palestine (2160/1930)
ssp. — var. —	No. 3	14	Kappert (1934), Palestine
Ae. Kotschyi Boiss.	No. 1	14	Eig (1934), El-Arish, Palestine (2259/1930)
	No. 2	14	Selection from *Ae. Kotschyi* No. 1
	No. 3	14	〃
	No. 4	14	〃

1) No. 1, No. 2, No. 3 and so forth are the cultural Nos. of the stocks at Kyoto University, Japan.

— Continued —

Ae. triuncialis L.			
(*typica*—1)	No. 1	14	Love
ssp. *eu-triuncialis* Eig			
var. *typica* Eig			
(*typica*—2)	No. 2	14	Miczynski (1930)
ssp. *orientalis* Eig			
var. *persica* (Boiss.) Eig			
subvar. *hispida*	No. 3	14	Miczynski (1930)
subvar. *glauca* Micz.			
(*glauca*—1)	No. 4	14	Miczynski (1930)
(*glauca*—2)	No. 5	14	Vavilov (1930), Leningrad
Cylindropyrum			
Ae. caudata L.			
var. *polyathera* Boiss.	No. 1	7	Kappert (1934)
Ae. cylindrica Host			
var. *typica*	No. 1	14	Kagawa (1927)
var. —	No. 2	14	Chino (1947), Found in imported wheat from U. S. A.
var. —	No. 3	14	Yamashita (1952), Pullman, Wash., U.S.A.
var. — (Pubescent)	No. 4	14	〃
Comopyrum			
Ae. comosa Sibth. et Sm.			
ssp. *eu-comosa* Eig			
var. *thessalica* Eig	No. 1	7	Vavilov (1930), Greece (9805)
ssp. — var. —	No. 2	7	Kappert (1934), Asia Minor.
Ae. Heldreichii (Holzm.) Eig			
var. *subventricosa* Boiss.		7	Eig (1934), Maltepe, Turkey (12/1932)
Ae. uniaristata Vis.	No. 1	7	Eig (1934), Maltepe, Turkey (564/1930)
	No. 2	7	Kappert (1934), Palestine
Amblyopyrum			
Ae. mutica Boiss.	No. 1	7	Hyland (1954), Turkey (PI 203433)
	No. 2	7	〃 〃 (PI 203435)

Sitopsis				
Ae. speltoides Tausch				
var. *ligustica* Fiori	No. 1	7	Miczynski (1930)	
	No. 2	7	〃	Selection from a hybrid, *Ae. Aucheri* × *Ae. speltoides*
Ae. Aucheri Boiss.		7	〃	〃
Ae. longissima Schw. et Musch.				
	No. 1	7	Eig (1934), Herzlia, Palestine (7/1932)	
	No. 2	7	Kihara (1950), Successive backcross strain of (*Ae. longissima* No. 1 × *Ae. speltoides* No. 1) × *Ae. longissima* (859–1/1590)	
	No. 3	7	*Ae. longissima* No. 1 × (*Ae. longissima* No. 1 × *Ae. speltoides* No. 1) (851–1/1950)	
Ae. sharonensis Eig				
var. typica Eig		7	Sears (1948)	
Ae. bicornis Jaub. et Sp.				
var. *typica*		7	Miczynski (1934)	
Vertebrata				
Ae. squarrosa L.				
var. *typica* Zhuk.	No. 1	7	Vavilov (1930), Caucasus Prov. Derbent (9950)	
	No. 2	7	Kappert (1934), Palestine	
	No. 3	7	Hirata (1948), Tashkent	
	No. 4	7	Suzuka (1952), Afghanistan	
Ae. crassa Boiss.				
ssp. *macrathera* Boiss.	No. 1	21	Vavilov (1930), Central Asia Prov. Tashkent (246)	
Ae. crassa Boiss.	No. 2	14	Vavilov (1930), Irak	
Ae. turcomanica Rosh.		21	Sears (1952)	
Ae. ventricosa Tausch				
var. *comosa* Coss. et Dur.	No. 1	14	Love (1924), Cornell Univ., U.S.A.	
var. *fragilis* (Parl.) Fiori	No. 2	14	Ducellier (1932)	
var. —	No. 3	14	Kappert (1934), Palestine	
var. *vulgaris* Eig	No. 4	14	Eig (1934), North-Africa (519/1930)	
var. —	No. 5	14	Ol'ah (1950), Institute Fitotecnico, Santa Catalina	

3. Progress in researches of species hybrids in *Aegilops*

Studies on species hybrids in *Aegilops* were undertaken by BLEIER (1928) for the first time since the right chromosome numbers of the genus was established, and from that time many papers have been published on this subject. 21 species of *Aegilops*, including 9 diploid analyzers, have been studied on the basis of genome analysis by KIHARA and his collaborators. From among 210 possible combinations of species hybrids, 104 combinations have already been made and they have been cytologically studied by many cytogeneticists of the world as given in the following table.

Species hybrids		Possible combinations	Successful combinations (Reciprocal finished)
diploid hybrids		36	26 (12)
triploid 〃		81	37 (6)
tetraploid 〃	$4x \times 4x$	36	23 (9)
	$6x \times 2x$	27	3 (1)
pentaploid 〃		27	13 (2)
hexaploid 〃		3	2 (0)
Total		210	104 (30)

All the possible and successful combinations of species hybrids are tabulated on the facing attached page.

Table showing the possible and successful combinations of species hybrids in *Aegilops*

	Group	Genome	♂ / ♀	*caud.*	*umbel.*	*squar.*	*comosa*	*Heldr.*	*uniar.*	*mutica*	*spelt.*	*Auch.*	*bicor.*	*long.*	*sharon.*	*cylind.*	*ovata*	*triar.* 4x	*colum.*	*biunc.*	*variab.*	*Kots.*	*trium.*	*crassa* 4x	*ventri.*	*triar.* 6x	*crassa* 6x	*turco.*
Diploid species (analyzers)	C	C	*caudata*		K '37'49 So '37 Se '41	K '49 Se '41	K '49	↙	K '37'49 Se '41		K '37 Se '41	Se '41	K '37	K '49	↙	K '37 K·M '41	K '37	P '32	K '37	K '49	K '37	K '37	↙		K '37			
		C^u	*umbellulata*	↗		K '49	K '49 '37		Be '37 Se '41		↙	K '49	K '49	↙	↙	↙	↙				↙				↙			
	M	D	*squarrosa*	↗	↗		↙		Se '41 K '49				K '37			↙	↙							↙	K '49		↙	
		M	*comosa*	K '37	K '49 '37	K·L '35		↙	K '37 Se '41	K·L '35	↙	↙		K '49			↙		↙	↙								
			Heldreichii	T(un)			K '37		↙																			
		M^u	*uniaristata*	↗	P '32 K '37 '49	K '37	↗	P '32			↙		K '49 '37	↙	↙	↙	↙	↙	↙								↙	
		M^t	*mutica*				↗																					
	S	S	*speltoides*	K·L '35 K '37 Se '41	K' 37 Se '41		Se '41		Se '41			K·L '32	K '49	↙	Se '41	↙	K·L '32	↙										
			Aucheri	↗	↗		K '49				↗			↙	K·T (un)				↙	↙			↙					
		S^b	*bicornis*	↗	K '49	K '49			K '49.		↗				↙	↙			↙	↙				↙			K '49	
		S^l	*longissima*	K '49	K '49		K '49		K '49		K '49	K '49			K·T (un)	↙	↙			↙	K' 49							
			sharonensis	Se '41	Se '41.				Se '41		↗	K·T (un)	K·T (un)	K·T (un)														
Tetraploid species		CD	*cylindrica*	K '37	K '37	K '49			K '37		Ka. T '34 K '37		K '37	K' 37			A '30 P '30 K·L '32 Ka·Ti '34	↙		↙			Ka '31 P· '30 K·L '32		P '30 K·L '32 Ka, T '34	B '30		
		C^uM^o	*ovata*	K '37 B '28	K '37	K '49	K '49		K '49		K·L '32			K '49		K·L '32		K '37 P '32	K '49	↙	K '37		L·S '30 K '29 '32		K '29 P '30 M '31		↙	
		C^uM^t	*triaristata*	K '37					K '49		K '49					L·O '36	K '37		K '49	↙	K '37	K '49	L·O '36			K '37		
		C^uM^c	*columnaris*	K '49			K '49		K '49		K '49	K '49	K '49				↗	↗		K '37	K '37	K '49	↙				K '49	
		C^uM^b	*biuncialis*	K '49			K '49					K '49	K '49	K '37 '49		L·O '36	K '37	K '37	K '37		K '37	↙	↙			↙	K '49	
		C^uS^v	*variabilis*	↗	Be '37									↗			↗	↗	K '37	↗		K '37	L·O '36			↙		
			Kotschyi	↗														↗	↗	K '37	L·O '36 K '37		K '37					
		C^uC	*triuncialis*	K '49								K '49				K·L '32 P '32	K '29 K·L '32	↗	L·O '36 K '49	K '37	K '37	↗			K·L '32 M '13	↙	Mi '31	
		DM^{cr}	*crassa*			K '49							K '49												↙		↙	
		DM^v	*ventricosa*	↗	K '37	↗										K·L '32	K '29 K·L '32						↗	K '49		↙	↙	↙
Hexaploid species		C^uM^t+?	*triaristata*													K '37		K '37		K '49	K '49		K '37		K' 37		K '37 K '49	
		DM^{cr}+?	*crassa*			K '49			K '49				K '49				K·L '35		↗	↗			↗	K '49	K '35 K '49	↗		↙
		D(M?)+?	*turcomanica*																						K·T (uh)		K·T (un)	

Footnotes: 1. An arrow (↗ or ↙) indicates the success of the reciprocal cross. 2. This table was originally published by Kihara (1937) and further data have been added by Tanaka in 1954.
3. Abbreviations: A……Aase, B……Bleier, Be……Berg, K……Kihara, K·L……Kihara & Lilienfeld, K·M……Kihara & Matsumura, K·T(un)……Kihara & Tanaka(unpublished), Ka……Kagawa, Ka·Ti……Kagawa & Chizaki, L·O……Lindschau & Oehler, L·S……Longley & Sando, Mi……Miczynski, P……Percival, Se……Sears, So……Sorokina, T(un)……Tanaka(unpublished)

4. X-ray induced mutants and reciprocal translocation types, and their linkage relations in Einkorn wheats

Mutants

Characteristics (Symbols are given only for established genes.)	Remarks
T. monococcum:	
1. dwarf	
2. chlorophyll deficient, lethal	
3. light green, striped	
4. chlorophyll deficient	Weak at younger stage.
5. spiral culm (*sp* 3), dwarf	Characters other than dwarf are identical with *sp* 1.
6. light green, dwarf	
7. dwarf	
8. dwarf	
9. light green, dwarf	
10. anthocyanin-less, striped	
11. chlorophyll deficient	
12. tiger band (*tig* 2)	Identical with *tig* 1.
13. fused primary leaf (*fus*)	Located on g-chromosome.
14. spiral culm (*sp* 1)	Located on a-chromosome.
15. 〃 , striped	
16. early maturation (*e*)	Located on d-chromosome.
17. irregular ear form (*irr*)	Located on f-chromosome.
18. dwarf	
19. spiral culm (*sp* 2)	Located on a-chromosome.
20. lethal—2 (*l*-2)	Located on f-chromosome.
21. oldrose (*old*)	Located on d-chromosome.
22. lethal—1 (*l*-1)	Located on d-chromosome.
23. albino	
24. narrow leaf (*nar*), no pistils with extra stamens	Located on c-chromosome.
25. non-hardy (*nh*)	
26. light green (*lg* 1)	Located on b-chromosome.
27. anthocyanin-deficient	
28. irregular ear-form, dwarf	
29. light green, striped	
30. orange, lethal	

— Continued —

31. chlorophyll deficient	
32. ligule-less	
33. duck neck	
34. sterile anther	
T. aegilopoides:	
35. tiger band (*tig* 1)	Located on g-chromosome.
36. albino	

Most (probably all) of the listed ones are complex mutations, but only a few of their representative characteristics are given in the table. Their classification, fertility and viability are good if not stated otherwise. Characteristics regarding pigmentation are clear at younger seedling stages.

Reciprocal Translocations

Species	Symbols	RT-complements*
T. aegilopoides:		
	*a*T 1	a—b
	*a*T 2	b—c
	*a*T 3	e—f
	*a*T 4	e——g
	*a*T 5	c—d
	*a*T 6	d——f
	*a*T 7	d—e
T. monococcum:		
	*m*T 1	e—f
	*m*T 2	d—e
	*m*T 3	e—f
	*m*T 4	c——e
	*m*T 5	a——c
	*m*T 6	a——c
	*m*T 7	e——g
	*m*T 8	c———f
	*m*T 9	f—g

* 7 chromosomes of Einkorn genome (A) have been designated as a, b, c, d, e, f and g, and RT between a- and b-chromosome as a-b, and so forth.

Linkage relations

Chromosomes	Gene symbols or characteristics
a	*fus*, *sp* 1, *sp* 2, winter habit
b	*lg* 1
c	*nar*
d	*e*, *old*, *l*–1
e	*Hr* 2
f	*irr*, *l*–2
g	*Hn*, *Hl* 1, *Hr* 1, *tig* 1, *tig* 2

(Established by KIHARA and YAMASHITA)

5. Nullisomic dwarf strains and their gigas plants in the offspring of the pentaploid hybrid, *Triticum polonicum* × *T. Spelta*

Nullisomic Dwarfs

Nullisomic plants		Chromosomes	Gigas plants	Chromosomes
a-dwarf	Dwl-22	$2n=40$		
〃	Dwl-27	〃	a-gigas-a	($2n=42$)
			a-gigas-b	(〃)
b-dwarf	Dwl-4	〃	b-gigas-b	(〃)
			b-gigas-c	(〃)
			b-gigas-o	(〃)
c-dwarf	Dwl-11	〃	c-gigas-a	(〃)
			c-gigas-c	(〃)
〃	Dwl-32	〃		
d-dwarf		〃	d-gigas-3	(〃)
〃	Dwl-3	〃		
〃	Dwl-15	〃	d-gigas-a	(〃)
〃	Dwl-16	〃	d-gigas-b	(〃)
e-dwarf	(awnless)	〃		
〃	(awned)	〃		
〃	Dwl-8	〃	e-gigas-1	(〃)
〃	Dwl-9	〃	e-gigas-3	(〃)

e-dwarf	Dwl-13	$2n=40+$large frag.		
〃	Dwl-21	$2n=40+$large frag.		
〃	Dwl-24	$2n=40+$small frag.		
〃	Dwl-25	$2n=40$		
f-dwarf		〃	f-gigas-1	($2n=42$)
〃	Dwl-1	〃	f-gigas-b	(〃)
			f-gigas-c	(〃)
〃	Dwl-2	〃		
〃	Dwl-6 (waxy)	〃	f-gigas-a	(〃)
〃	〃 (waxless)	〃		
〃	Dwl-7	〃		
〃	Dwl-18	〃		
g-dwarf		〃	g-gigas-1	(〃)
〃	Dwl-5	〃, with a translocation	g-gigas-a	(〃)
〃	Dwl-10	$2n=40$		
〃	Dwl-19	〃, with a translocation		
〃	Dwl-28	〃		
〃	Dwl-29	〃		
〃	Dwl-30	〃		

6. Strains obtained by successive backcrosses of the hybrid, *Triticum vulgare* × *Aegilops caudata*, with the pollen of *T. vulgare*

Symbols and strain Nos.	Remarks
α^cVV (93)	Male sterile
$\alpha^c V^b V^b$ (174)	Fertility is good (ca. 70%)
$\beta V^b V^b$ (168)	Complete fertility

V^b= a modified genome of *T. vulgare erythrospermum*; V^b possesses one chromosome of *Ae. caudata*, which carries a gene for black ears.

α^c=*caudata* plasma; β=*vulgare* plasma;

α^cCC=*caudata* (*caudata* genomes in *caudata* plasma);

βVV=*vulgare* (*vulgare* genomes in *vulgare* plasma)

7. Date of flowering time of *Aegilops* in Kyoto

Species		Date
Polyeides		
Ae. umbellulata	No. 1	June 6
	No. 2	〃 1
	No. 3	〃 6
Ae. ovata	No. 1	May 11
	No. 2	〃 11
	No. 3	〃 25
	No. 4	〃 11
Ae. triaristata, 6 *x*	No. 1	May 26
6 *x*	No. 2	〃 〃
4 *x*	No. 3	May 30
4 *x*	No. 4	June 2
4 *x*	No. 5	May 31
4 *x*	No. 6	〃 30
4 *x*	No. 7	〃 〃
Ae. columnaris	No. 1	May 25
	No. 2	〃 29
Ae. biuncialis	No. 1	May 20
	No. 2	〃 25
Ae. variabilis	No. 1	May 15
	No. 2	〃 11
	No. 3	〃 15
Ae. Kotschyi	No. 1	May 9
	No. 2	〃 9
	No. 3	〃 11
	No. 4	〃 11
Ae. triuncialis	No. 1	May 26
	No. 2	〃 〃
	No. 3	〃 15
	No. 4	〃 11
	No. 5	〃 〃
Cylindropyrum		
Ae. caudata		June 4
Ae. cylindrica	No. 1	May 26
	No. 2	〃 18
	No. 3	〃 25
	No. 4	〃 〃
Comopyrum		
Ae. comosa	No. 1	June 2
	No. 2	〃 8
Ae. Heldreichii		June 9
Ae. uniaristata	No. 1	June 2
	No. 2	〃 5
Ae. speltoides	No. 1	June 25
	No. 2	〃 〃
Sitopsis		
Ae. Aucheri		June 25
Ae. bicornis		May 9
Ae. longissima	No. 1	May 30
	No. 2	〃 31
	No. 3	June 1
Ae. sharonensis		May 22
Vertebrata		
Ae. squarrosa	No. 1	May 22
	No. 2	〃 13
	No. 3	〃 〃
Ae. crassa, 6 *x*	No. 1	May 15
, 4 *x*	No. 2	May 11
Ae. ventricosa	No. 1	May 20
	No. 2	〃 11
	No. 3	〃 〃
	No. 4	〃 20
	No. 5	〃 18
Amphidiploid		
S^bS^bDD	No. 68	May 18
	No. 69	〃 15
CCC^uC^u	No. 26	May 20
	No. 27	〃 〃

(Planted on October 12, 1952 and observed by TANAKA in 1953).

8. Spring and winter growing habit of *Aegilops* and *Triticum*

Species	Winter type	Intermediate type[1)]	Spring type
Ae. umbellulata	+		
Ae. ovata		+	
Ae. triaristata, 6*x*	+		
Ae. columnaris		+	
Ae. biuncialis	+		
Ae. variabilis			+
Ae. Kotschyi		+	
Ae. triuncialis typica	+		
〃 *persica*			+
Ae. cylindrica	+		
Ae. caudata	+		
Ae. comosa	+		
Ae. uniaristata	+		
Ae. longissima	+		
Ae. sharonensis		+	
Ae. bicornis		+	
Ae. squarrosa	+		
Ae. crassa, 4*x*			+
〃 , 6*x*		+	
Ae. ventricosa	+		
Ae. turcomanica		+	
CCC^uC^u			+
S^bS^bDD	+		
T. aegilopoides boeoticum	+		
〃 *Larionowi*	+		
T. monococcum vulgare		+	
〃 (early-mutant)			+
T. Timopheevi No. 1			+
T. dicoccoides Kotschyanum		+	
〃 *spontaneo-nigrum*	+		
〃 *Straussianum*	+		
T. dicoccum liguliforme			+
〃 *arras* (Khapli)			+
T. durum Reichenbachii			+
T. persicum stramineum			+
T. polonicum vestitum			+
T. pyramidale recognitum			+

1). Rather sub-winter type.

— Continued —

T. turgidum nigro-barbatum		+
T. vulgare erythrospermum		+
T. Spelta Duhamelianum		+
T. sphaerococcum rotundatum		+
〃 *rubiginosum*		+
T. compactum icterinum		+
T. Macha sub-letschumicum	+	

(Observed by TANAKA)

9. Reaction of *Aegilops* and *Triticum* to *Puccinia triticina* Eriks

(Observed by HIRATSUKA in Tokyo)

Species or variety		Reaction [1] Seedling stage			Heading stage
	Race group [2]:	1	6	37	37
Ae. umbellulata	No. 2	S	R	S–MR	MR–R
Ae. ovata	No. 1	MR	R	R	R
〃	No. 2	R	R		
〃	No. 3	S	S		
Ae. triaristata, 6*x*	No. 1	S	S	S	S–MR
〃 , 4*x*	No. 4	R	MR		
〃 , 4*x*	No. 5	S	MR	MR–R	
〃 , 4*x*	No. 6	S	S	MR	
Ae. columnaris	No. 1	S	S	S	S
Ae. biuncialis	No. 1	R	R	R	R
Ae. variabilis	No. 1	S	S	S	S
Ae. Kotschyi	No. 1	S	S		
〃	No. 2	MR	S		
〃	No. 3	S	S		
〃	No. 4	S			
Ae. triuncialis	No. 1	MR	R	S–R	R
〃	No. 3	S	S–MR	S–MR	MR–R

1) R: resistant ; MR: moderately resistant ; S: susceptible

2) Race group 1 of *P. triticina* affects *Triticum* weakly.
〃 6 of *P. triticina* affects *Triticum* moderately.
〃 37 of *P. triticina* affects *Triticum* heavily.

— Continued —

		Race group: 1	6	37	37
〃	No. 4	S	MR	MR-R	R
〃	No. 5	S	MR	MR-R	R
Ae. cylindrica	No. 1	R	R	R	R
〃	No. 2	S	S	S	S
Ae. caudata		S	S	S	S
Ae. comosa	No. 1	S	S	R	R
Ae. uniaristata	No. 1	S	S	S	S
〃	No. 2	S	S	S	S
Ae. speltoides	No. 2	R	R	R	R
Ae. sharonensis		S	S		
Ae. longissima	No. 1	R	R		
〃	No. 2	R	R		
〃	No. 3	R	R		
Ae. bicornis, 2*x*		S	R	S	S
〃 ,4*x*		S	S	S	S
Ae. squarrosa	No. 1	S	S	S-R	MR
〃	No. 2	S	S	S-MR	R
〃	No. 2, 4*x*	S	S	S	S
Ae. crassa, 4*x*		S	S	S	S
〃 , 6*x*		S	S	S	S
Ae. ventricosa	No. 1	S	S	S-MR	MR-S
C C C^u C^u (synthesized)	No. 26	R	R	R	
T. monococcum var. *vulgare*		R	R	R	R
〃 (early) mutant		R	R	R	R
〃 var. *flavescens*		R	R	R	R
T. aegilopoides var. *boeoticum*		S	S	S	R
T. dicoccoides var. *spontaneo-nigrum*		S	S	S-R	S-MR
〃 var. *Straussianum*		R	S	S	R
〃 var. *Kotschyanum*		R	S	S-MR	R
T. dicoccum var. *liguliforme*		R	S	S-MR	MR
〃 var. *arras* (Khapli)		R	S	S	R
T. durum var. *coerulescens*		R	S	MR-R	R
〃 var. *Reichenbachii*		R	S	MR-R	R
T. turgidum var. *nigrobarbatum*		S	S	S	R
T. polonicum var. *vestitum*		R	R	R	R
T. persicum var. *stramineum*		S	S	S	MR

— Continued —

T. pyramidale var. *recognitum*		R	S	S	R
T. orientale		R	S	R	R
T. Timopheevi	No. 1	R	R	R	R
T. Spelta var. *Duhamelianum*		R	S–MR	R	R
〃 var. *vulpinum*		S	S	S	S
〃 var. *Arduini*		R	S	R	R
T. vulgare var. *erythrospermum*		R	S	S–MR	R
〃 var. *ferrugineum*		R	S	S	R
〃 〃 (Mongolia)		MR	R	R	R
〃 var. — (Hohenheim)		S	S	S–R	R
〃 var. *erythroleucon*	No. 1	S	S	S–MR	R
〃 〃	No. 2	S	S	S	R
〃 〃	No. 3	R	S	S	S
〃 var. *alborubrum*		MR–R	S	S–MR	R
〃 var. — (Timstein)		R	R		
T. compactum var. *icterinum*		S	S	S	R
T. sphaerococcum var. *rotundatum*		S	S	S	S
〃 var. *rubiginosum*		R	S	S	S–MR
T. Macha var. *sub-letschumicum*		R	S	S	S

10. Artificial autopolyploids of *Triticum* and amphidiploids from *Triticum* × *Aegilops*

T. aegilopoides var. *boeoticum*, 4*x*	Colchicine-treatment by Cua (1949)
T. durum var. *hordeiforme*, 8*x*	Colchicine-treatment by Cua (1949)
Aegilotricum No. 2	Amphidiploid derived from (*Ae. ovata* × *T. durum* var. *Arraseita*) by Tschermak (1926)
Aegilotricum, S^1S^1AA	Selection from (*Ae. longissima*, 4*x* × *T. aegilopoides* var. *boeoticum*, 4*x*) by Tanaka (1953)
Synthesized 6*x*-wheats:	
ABD 1	Amphidiploid derived from (*T. dicoccoides spontaneo-nigrum* × *Ae. squarrosa* No. 2) by Kihara (1944)
ABD 2	Amphidiploid derived from (*T. durum coerulescens* × *Ae. squarrosa* (No. 1 × No. 2)) by Kihara et al. (1948)
ABD 3	Amphidiploid derived from (*T. turgidum nigrobarbatum* × *Ae. squarrosa* No. 2) by Kihara et al. (1948)

— Continued —

ABD 4	Amphidiploid derived from (*T. persicum stramineum* × *Ae. squarrosa* No. 2) by Kihara et al. (1948)
ABD 5	Amphidiploid derived from (*T. persicum fuliginosum* × *Ae. squarrosa* No. 2) by Kihara et al. (1948), fertility poor
ABD 8	Amphidiploid derived from (*T. orientale* × *Ae. squarrosa* (No. 1 × No. 2)) by Kihara et al. (1949)

11. Artificial autopolyploids and amphidiploids in *Aegilops*

Species or variety		Chromosome number (*n*)	Source
Ae. longissima	No. 1, 4*x*	14	Colchicine treatment by Cua (1949)
Ae. ovata	No. 1, 8*x*	28	〃
Ae. uniaristata	No. 1, 4*x*	14	〃
Ae. squarrosa	No. 2, 4*x*	14	Colchicine treatment by Kondo (1940)
Ae. bicornis	No. 1, 4*x*	14	〃
Ae. sharonensis	No. 1, 4*x*	14	Colchicine treatment by Tanaka (1953)
Ae. umbellulata	No. 2, 4*x*	14	〃 , fertility poor
Synthesized			
S^bS^bDD	No. 68	14	Colchicine treatment of (*Ae. bicornis* × *Ae. squarrosa*) by Matsumoto (1942)
CCC^uC^u	No. 26	14	〃 (*Ae. caudata* × *Ae. umbellulata*) by Kondo (1940)
$S^lS^lC^uC^u$		14	Colchicine treatment of (*Ae. sharonensis* × *Ae. umbellulata* No. 2) by Tanaka (1953)
$M^uM^uC^uC^u$		14	Selection from (Ae. *uniaristata* No. 1, 4*x* × *Ae. umbellulata* No. 2, 4*x*) by Tanaka (1953)
$C^uC^uM^uM^u$		14	Selection from (*Ae. umbellulata*, 4*x* × *Ae. uniaristata*, 4*x*) by Tanaka (1953), fertility poor

12. Table showing the possible and successful combinations of amphidiploids among 11 diploid species in *Aegilops*

Group	Genome	♀ \ ♂	*caud.*	*umbel.*	*squar.*	*comosa*	*Heldr.*	*uniar.*	*spelt.*	*Auch.*	*bicor.*	*long.*	*sharon.*
C	C	*caudata*		Se '39 Ko '40	Se '41	Ma '42		Se '41	Se '41				↙
	C^u	*umbellulata*	↗					Se '41 T '53	↙				↙
M	D	*squarrosa*	↗					Ma·Ko '42			↙		
	M	*comosa*	↗					Se '41					
		Heldreichii											
	M^u	*uniaristata*	↗	T '53	Ma·Ko '42	↗			↙		↙		↙
S	S	*speltoides*	↗	K '37 Se '39				Se '41					Se '41
		Aucheri											
	S^b	*bicornis*			Ma '42 Se '48			Ma·Ko '42					
	S^l	*longissima*											↙
		sharonensis	Se '41	Se '41 T '53				Se '41	↗			T '53	

Footnotes: 1. The amphidiploid, *Ae. speltoides* × *Ae. umbellulata*, by Kihara (1937), was produced through the union of unreduced gametes, while the others were obtained by colchicine treatment.

2. Abbreviations: K......Kihara, Ko......Kondo, Ma......Matsumoto, Ma·Ko......Matsumoto & Kondo, Se......Sears, T......Tanaka

3. An arrow (↗ or ↙) indicates the success of the reciprocal cross.

(Arranged by Tanaka, 1954)

13. *Agropyron*

Species	Chromosome number	Source
A. ciliare Franch.	$2n=28$	Collected by Matsumura in Kyoto, 1937
A. cristatum Beauv.	$2n=28$	Collected by Makino and identified by Harrington, Colorado, U.S.A. 1952
A. elongatum	$2n=70$	Sent by Neatby, 1937
〃		Sent by Yamashita from Wash., U.S.A. 1952
A. glaucum Roem. et Schult.	$2n=42$	Sent by Armstrong, 1939
A. intermedium Beauv.		Sent by Hiratsuka (original seeds from E.G. Heyne, 1949)
〃	$2n=42$	Sent by Yamashita from Wash., U.S.A. 1952
A. griffithsii Scribn. (or *A. spicatum* Scribn. et Smith)	$2n=28$	Collected by Makino and identified by Harrington, Colorado, U.S.A. 1952
A. obtusiusculum	$2n=42$	Sent by Neatby, 1937
A. repens Beauv.	$2n=42$	Sent by Staatl. Botanischer Garten, Dresden, 1941
A. repens ?		Collected by Yamashita in Wash., U.S.A. 1952
A. riparium Scribn. et Smith	$2n=42$	Collected by Makino and identified by Harrington, Colorado, U.S.A. 1952
A. sp. (Sect. Roegneria)		
(Nakao 94)		Collected by Nakao in Nepal, 1953
〃 (Nakao 131)		〃
〃 (Nakao 254)		〃
〃 (Nakao 311)		〃
A. scribneri Vasey	$2n=28$	Collected by Makino and identified by Harrington, Colorado, U.S.A. 1952
A. semicostatum Nees.	$2n=42$	Collected by Matsumura in Kyoto, 1937
A. sibiricum	$2n=28$	Sent by Yamashita from Wash., U.S.A. 1952
A. smithii Rydb.		〃
A. smithii Rydb. var. *molle* Jones	$2n=42$	Collected by Makino and identified by Harrington, Colorado, U.S.A. 1952
A. subsecundum Hitchc.		Sent by Yamashita from Wash., U.S.A. 1952
A. trachycaulum Malte		〃
〃		Collected by Makino and identified by Harrington, Colorado, U.S.A. 1952
A. trichophorum Richt.	$2n=42$	Sent by Yamashita from Wash., U.S.A. 1952
A. triticeum Gaertn.	$2n=14$	Sent by Sears, 1950
A. yezoense Honda	$2n=28$	Collected by Matsumura in Hokkaido, 1951

V. Rules for nomenclature and symbolization of genes, and gene symbols in wheats

Rules proposed for nomenclature and symbolization, and gene symbols based on the rules, have been recommended by the National Committee of Genetics and the National Committee of Plant and Animal Breeding, Science Council of Japan in 1952. They are cited here with a few necessary corrections for better circulation and are submitted for open discussion and comments. Suggestions will be greatly appreciated.

National Committee of Genetics	National Committee of Plant and Animal Breeding
Hitoshi KIHARA: Chairman	Toshitaro MORINAGA: Chairman
Bungo WADA: Secretary	Makita KOGURE: Secretary
Hisao ARUGA	Fuyuwo KAGAWA
Tanemoto FURUHATA	Kiyoshi MASUI
Tutomu HAGA	Seiji MATSUMURA
Hideo KIKKAWA	Takane MATSUO
Taku KOMAI	Usaburo MIZUSHIMA
Sajiro MAKINO	Seijin NAGAO
Hajime MATSUURA	Shusaku NISHIDA
Daigoro MORIWAKI	Ichizo NISHIYAMA
Kan OGUMA	Yakichi NOGUCHI
Yo K. OKADA	Ichiei OSAWA
Tomowo ONO	Keiji SATO
Shungo OSATO	Yoshimaro TANAKA
Tamaki SHIMAMURA	Yataro TAZIMA
Naomasa SHIMOTOMAI	Yasuke YAMAGUCHI
Yosito SINOTÔ	Yoshito YAMASAKI
Yushi UCHIMURA	
Kosuke YAMASHITA	

1. Rules for Nomenclature and Symbolization of Genes

A. NOMENCLATURE OF GENES

I. Languages of higher internationality (e. g. English, Latin, etc.) are preferable for gene nomenclature.

II. If, for some reason, a German, Greek, Russian or Japanese word is used in gene nomenclature, it is written in Roman letters.

Examples: grün; déformée; erythros; visaka; oily; matamukashi

III. The name of a gene should be a noun, an adjective or a combination of both.

Examples: albino; white; white egg

B. SYMBOLIZATION OF GENES

IV. The symbol should be such as will call to mind the characteristic of the corresponding gene.

Examples: *al* (albino); *pe* (pink eye)

V. The number of letters used in each symbol is preferably two. Single letter should be reserved for comparatively prominent genes.

Examples: *Dw* (Dwarf); *ch* (chocolate); *lg* (liguleless); *D* (Dicheate); *I* (Inhibitor); *p* (plain)

VI. Polymeric genes are shown by adding Arabic numerals to the symbol designating primary characteristics. Different genes having similar manifestations are distinguished by adding one or more letters to a common symbol.

Examples: R_1, R_2, R_3; *oa, oc, od, os, ow*

VII. In a symbol formed from a noun and an adjective, the letter representing the adjective preceeds the noun, or the latter is dropped.

Examples: *Rs* (Red stem); *al* (planta albina); *pk* (pink cocoon)

VIII. When symbols are chosen for mutant characters, the wild type is taken as the normal or standard form. In cases where the wild type is uncertain, the standard may be selected from the cultured types.

If there is no cultured form, a more common wild type is selected as the standard.

IX. The standard type is designated by +. If necessary, the symbol of the mutant is suffixed to +.

Examples: +, $+^{Gr}$ (normal allelic gene to grey egg); $+^{la}$ (normal or erect gene against lazy)

A recessive mutant is designated by small letters; for a dominant mutant the first letter of the symbol is written in capital.

Examples: *ba* (barbelss awn); *Ze* (zebra marking)

X. Of multiple-allelic genes, the mutant gene discovered first is taken as basic. For other mutants, their discriminative letters are superscribed on the symbol of the basic gene. For the standard gene, the basic symbol is superscribed on +.

Examples: p, p^{M}, p^{S}, $+^{p}$; C^{B}, C^{Bp}, C^{Br} $+^{C}$

XI. Invisible lethal genes are represented by adding appropriate letters to *l*–.

Examples: *l–a*; *l*–1

XII. For different species or varieties which can be crossed easily and give rise to fertile hybrids, the same nomenclature and symbolization are used.

XIII. Chromosomes are designated by Roman numerals. For sex chromosomes, X, Y, Z or W can be used.

Examples: I, II, IV; Z

XIV. When there is a positive evidence of polyploidy, the same symbols are repeated as many times as there are alleles.

Examples: $+++$; $++a$; $aaaa$

Trisomic and tetrasomic chromosomes are represented similarly as in triploids and tetraploids respectively.

XV. The linkage of genes is shown by symbols written in the order of the loci with a horizontal line above the symbols.

Example: $\overline{AbCD}$

XVI. Gene formulae are usually written in a duplex system.

Example: $A+^{A}bbc+^{c}DD$

When the gametic gene formulae of the parents are known, they are shown by inserting a period between them.

Example: $Ab+^{c}D\cdot+^{A}bcD$

XVII. For two or more genes belonging to the same linkage group of known loci, symbols in the form of fraction are used with the female gametic formula as the numerator, and the male gametic formula as the denominator, without any line above the symbols.

Examples: $E+G+i/+f+H+$; $\frac{E\ G\ i}{f\ H}$; $\frac{E+G+i}{+f+H+}$

XVIII. A chromosomal aberration is represented by the abbreviation of the type of the aberration, with chromosome numbers in parenthesis, followed by symbols of the participating genes.

Examples: Translocation: T(I–II)$+^{od}$; T(III–W) *Ze* (W)
Deficiency: Df (II) p^{Sa}
Inversion: In (II) p^{Sa}
Duplication: Dp (II) $p\cdot p^{Sa}$
Attachment: $\mathrm{II}\frown\mathrm{II}$; $p\frown p^{Sa}$
Transposition: Tr (III)

XIX. So far as there is no serious inconvenience, the law of priority should be observed for the first published symbols.

XX. Italic type is used for genes, Roman small type for chromosomes and Roman capital type for genomes. (Additions under XX by Kihara).

2. Gene Symbols in Wheats

The need of a standardization of genetic nomenclature and symbols for wheats had long been felt by many plant breeders and geneticists. MATSUMURA (1938) made a survey of the published literatures on wheats in KIHARA's monograph "Studies on Wheats" (in Japanese) and suggested symbols for the morphological charcters involved. Later a uniform type of nomenclature and symbols of hexa- and tetraploid wheats, recommended by WORZELLA (1941), was accepted by the Committee on Nomenclature of Genetic Factors in Wheat and was submitted for consideration by the American Society of Agronomy as a guide for wheat workers (AUSEMUS et al. 1946).

Based upon the general rules for nomenclature of genes and gene symbols, the National Committee of Genetics and Breeding of the Japan Science Council, established in 1949, recommends the basic symbols for wheats, given in the tables on pages 29–34.

1) Inheritance studies on wheats have dealt largely with various hexaploid species, and also, with various tetraploid species as well as with hybrids between hexa- and tetraploids. The pentaploid hybrids are reasonably fertile and show fairly regular segregation for certain characteristics. Hybrids of diploid wheats with members of two other groups are sterile. The genetics of the diploids was studied by only a few workers and will be taken up separately, except for a few characteristics which closely resemble those found in tetra- or hexaploid wheats.

2) A hexaploid variety, *Triticum vulgare* Vill. var. *graecum* KÖRN., cultivated very widely throughout the world, was used as the standard type (designated by +), with a few exceptions.

For instance, though this variety has a hairy leaf, "glabrous" is used as the standard characteristic. As to awnedness and solidness of straw, the characteristics "true awns" and "hollow stem" of Einkorn wheat are shown as the standard types.

In general, genes are given designations suggestive of one of their chief phenotypic effects. Basic symbols, to be used for the genes, consist of the initial letters of the corresponding designations with addition of some other appropriate letters of the characteristics in question. As an example, the genes or hairy glume was called *Hg*: the first letter is derived from the characteristic itself (=hairy) and the second from the organ or place of appearance (=glume). Compared with the American system, the 2 letters are used in the reverse order. As another example, *Hl* is given as the basic symbol for hairy leaf. We know that there exist at least two genes, Hl_1 and Hl_2, as duplicate genes (digenic inheritance), as may be seen from the column "Manner of inheritance". Similarly in the case of "trigenic" inheritance for lax ear, the gene symbols L_1, L_2 and L_3 are used. Table 1 show the manner of inheritance of morphological characters in hexa-and tetraploid wheats.

3) Since the results of different workers concerning the physiological characters are at variance, especially in matters of resistance, it is sometimes very difficult to estimate the difference between the results or even to ascertain the dominant-recessive relations. Varied results of studies on disease resitance with different physiological races became very complicated recently and many genes had to be assumed. Therefore, some of the relatively older results would often be without value. In Table 2 the basic symbols for disease reistance are designated by capital letters which represent the first letter of the disease in question. Additional numerals can be of further help, namely Sr_1, Sr_2......are different genes for black stem rust resistance, Lr_1, Lr_2......for leaf rust resistance and so on.

4) The symbols for the genomes, A, B, D and G, were introduced by KIHARA (1924, 1940). A uniform designation of the 21 chromosomes from I to XXI was introduced by SEARS (1944). The 14 chromosomes of the A- and B-genomes have been numbered from I to XIV and 7 of the D-genome from XV to XXI.

5) In diploid wheats many mutants were induced by X-irradiation by SMITH (1936, 1939) and KIHARA and YAMASHITA (1947). The 7 linkage groups were finally established by SMITH and his co-workers (1948) and also by YAMASHITA (1953), but these results are not included in the following tables.

6) A list of the characteristics that have been reported very obviously as linked is given in Table 4, but the linkages of the genes for resistance between each other are not included. It could not yet be ascertained if the S-linkage group of hexa- and tetraploid wheats is identical with that of the diploids, including the genes Hl_1 and *Hn*.

Table 1. Morphological characters in hexa- and tetraploid wheats

Gene	Symbol	Genome (Chromosome)	Manner of inheritance	Authority
Compact	*C*	D(XX)	Monogenic, Pleiotropic	Biffen (1905), Nilsson-Ehle (1908), Unrau (1950)
Spelt	*S*	B(IX)	Monogenic (or closely linked genes), Multiallelic	Kajanus (1918), Watkins (1928), Sears (1944)
〃	S_D	D	Multigenic with *S*	Watkins (1928)
sphaerococcum	*sp*	D(XVI)	Monogenic, Pleiotropic	Ellerton (1939), Sears (1946)

— Continued —

Polonicum	*P*	A or B	Monogenic, Pleiotropic	Biffen (1905), Liepin (1929), Matsumura (1935)
Lax ear	*L*		Trigenic, Hypostatic to *C*	Nilsson-Ehle (1908), Kajanus (1923)
〃	L_D	D(XIX etc.)	Digenic	Yamashita (1937), Matsumura (1947)
Squarehead	*Sq*	D ?	Monogenic (or closely linked genes)	Boshnakian (1923), Arciszewski (1924)
Sterile base	*Sb*		Digenic	Jasnowski (1934)
Sterile tip	*St*		Monogenic	〃
bent ear	*be*		Monogenic	Yamashita (1937)
irregular ear	*ie*		Monogenic	Torrie (1936)
Hairy spikeletd base	*Hb*	A or B	Digenic	Mathis (1925)
Hairy rachis	*Hr*	A or B	Monogenic	Thompson & Hollingshead (1927)
Collar	*Co*	A or B		〃
Red glume	Rg_1	A or B (I)	Digenic	Biffen (1905), Nilsson-Ehle (1909), Unrau (1948)
	Rg_2	A or B		
Black glume	*Bg*	A or B	Monogenic, Epistatic to *Rg*	Lewicki (1925)
Grey glume	*Gg*		Monogenic	〃
Hairy glume	*Hg*	A or B	Digenic	Biffen (1905), Howard & Howard (1912)
Narrow glume	*Ng*		Monogenic with modifier	Philiptchenko (1928)
Phenol reaction of glume	*Pg*		Monogenic	Fraser & Gfeller (1936)
Awnless	*A*	A or B (VIII, IX, X)	Monogenic, Digenic, Trigenic	Biffen (1905), Matsumura & Mochizuki (1943), Sears (1944), Unrau (1950)
Tip awned	A_1	B (IX)	Monogenic, Multiallelic	Watkins & Ellerton (1940), Sears (1944)
Half awned	A_2	A or B (X)	Monogenic, Multiallelic	Watkins & Ellerton (1940)
Awned-3	A_3	A or B(VIII)	Monogenic	Unrau (1950)

— Continued —

tooth, apical	*ta*		Monogenic, Multigenic	Tai (1934), Vavilov & Jakushkina (1925)
Black awn	*Ba*	A or B	Monogenic	Howard & Howard (1912)
Red awn	*Ra*	A or B	Monogenic, Hypostatic to *Ba*	Kadam & Nazareth (1931)
Hooded awn	*Hd*	A or B(VIII)	Monogenic	Watkins & Ellerton (1940)
smooth awn	*sa*		Monogenic, with modifier	Sigfusson (1932)
Red kernel	*R*	D (XVI) etc.	Trigenic	Nilsson-Ehle (1909)
Inhibitor of *R*	I_R		Monogenic	Gaines (1917)
Kernel weight	*Wk*		Trigenic	Jasnowski (1934)
Blue kernel	*Bk*		Monogenic	Kattermann (1932)
Inhibitor of *Bk*	I_{Bk}		Monogenic	〃
Phenol reaction of kernel	*Pk*		Digenic	Fraser & Gfeller (1936)
round kernel	*rk*	D ?	Monogenic	Engledow & Hutchinson (1925)
Purple anther	*Pa*		Monogenic	Sharman (1944)
Red coleoptile	*Rc*	A or B	Digenic	Goulden, Neatby & Welsh (1928)
Enhancer of *Rc*	E_{Rc}	D	Monogenic	Yamashita (1937)
yellow seedling	*y*	A or B	Digenic	Sapehin (1932), Kihara (1937)
albino	*al*		Digenic	Neatby (1933), Kihara (1937)
procumbent seedling	*ps*		Trigenic	Yamada & Fujiyoshi (1947)
Lethal seedling	*Le*		Complementary	Kostyuchenko (1936)
Red stem	*Rs*		Digenic	Jenkin (1925), Matsumura & Mochizuki (1943)
Dwarf	*D*		Monogenic, Digenic, Trigenic	Goulden & Waldron (1924), Nakamura (1930)
Inhibitor of *D*	I_D		Monogenic	Goulden & Waldron (1924), Nakamura (1930)
Pith	*Pi*	B	Monogenic, Multiallelic with modifier	Engledow (1920), Yamashita (1937)

— Continued —

Hollow stem	*Ho*	D (XX)	Monogenic, Epistatic to *Pi*	Matsumura (1936), Yamashita (1937)
Hairy node	*Hn*	B (IX)	Monogenic	Vavilov & Jakushkina (1925), Matsumura & Mochizuki (1943)
Procumbent tillering	*Pt*	D (XVII)	Monogenic	Yamashita (1937), Matsumura (1947)
Waxy foliage	*W*	A or B	Monogenic	Watkins (1927)
〃	W_D	D	Monogenic	〃
Inhibitor of *W*	I_W		Monogenic	Matsumura (1950)
Hairy leaf	Hl_1, Hl_2	B (IX)	Digenic	Matsumura & Mochizuki (1943)
liguleless	*lg*		Digenic	Barulina (1933), Kulkarni (1934)
branched head	*bh*		Monogenic	Sharman (1944)

Table 2. Physiological characters in hexa- and tetraploid wheats

Gene	Symbol	Genome (Chromosome)	Manner of inheritance	Authority
Stem rust resistance (*Puccinia graminis tritici*)	*Sr*	A or B (X) etc.	Monogenic, Digenic (or complementary), Multigenic	Harrington & Aamodt (1923), Clark & Ausemus (1928), Hayes & Aamodt (1923), Sears & Rodenhiser (1948)
Inhibitor of stem rust susceptibility	*Sri*			Clark *et al.* (1932, 1935)
Yellow rust resistance (*P. glumarum*)	*Yr*		Monogenic, Digenic, Multigenic (Multiallelic)	Biffen (1905) Watkins (1927), Straib (1933)
Leaf rust resistance (*P. triticina*)	*Lr*	A or B (IV) etc.	Monogenic, Digenic	Mains & Leighty (1926), Johnson (1926), Kajanus (1927), Unrau (1948)
Bunt resistance	*Br*	D (XVI) etc.	Monogenic, Digenic, Multigenic	Gaines (1920), Briggs (1926), Unrau (1950)
Tilletia levis	*Br-l*			
T. tritici	*Br-t*			

— Continued —

Mildew resistance (*Erysiphe graminis*)	*Mr*		Monogenic	Mains (1934)
Smut resistance (*Ustilago tritici*)	*Sm*		Monogenic (Multiallelic), Digenic, Complementary	Tingey & Tolman (1934)
Mosaic resistance				
{Green mosaic	*Mg*		Monogenic	Miyake (1938)
{Yellow mosaic	*My*		Monogenic, Digenic	
Ergot resistance (*Claviceps purpurea*)	*Er*		Complementary	Biffen (1912)
Hessian fly resistance	*Hf*		Monogenic, Digenic	Cartwright & Wiebe (1936)
Cold resistance	*Cr* (*cr*)		Monogenic, Multigenic	Worzella (1935)
Early maturity	*Em*(*em*)		Monogenic, Digenic, Trigenic	Thompson (1918), Aamodt (1927)
Spring type (vs. winter type)	*Sg*	B (IX) etc.	Monogenic, Digenic, Trigenic	Kajanus (1927), Churchward (1938), Unrau (1950)
Inhibitor of winter type	*Sgi*		Monogenic	Cooper (1923)
Flinty (vs. mealy)	*Fl*		Monogenic, Digenic, Multigenic	Freeman (1917), Harrington (1922)
Protein content	*Pc*		Multigenic	Clark (1926)
Gluten strength	*G*		Trigenic	Worzella (1934)
Granulation	*Gr*		Multigenic	〃 (1942)
Carotenoid pigment	*Ca*		Multigenic	〃

Table 3. Characteristics in diploid wheats

Gene	Symbol	Genome (Chromosome)	Manner of inheritance	Authority
Hairy spikelet base	*Hb*	A	Digenic	Kihara (1944)
Fragile rachis	*F*	A	Monogenic	Smith (1936)
Hairy rachis	*Hr*	A	Monogenic	Kihara (1944)
Black glume	*Bg*	A	Monogenic	Smith (1936)
Hairy glume	*Hg*	A	Monogenic	〃
Lethal seedling	*Le*	A	Digenic	Sears (1944)
Hairy node	*Hn*	A	Monogenic	Kihara (1944)
Hairy leaf	*Hl*	A	Digenic	〃
Hairy leaf-sheath	*Hs*	A	Monogenic	〃

Table 4. Linkage relations

Group	Linked characters	Genome (Chromosome)	Crossing-over value (%)	Authority
S-group	Awnless (A_1) and Spelt (S)	B(IX)	25–35	Kajanus (1923), Watkins (1928), Matsumura & Mochizuki (1943)
S-group	Awnless (A_1) and Hairy node (Hn)		5–28.5	Gaines & Carstens (1926), Matsumura (1936)
S-group	Spelt (S) and Hairy node (Hn)		36.2	Matsumura & Mochizuki (1943)
S-group	Hairy leaf (Hl_1) and Awnless (A_1)		14.2	〃
S-group	Hairy leaf (Hl_1) and Spelt (S)		26.6	〃
S-group	Hairy leaf (Hl_1) and Hairy node (Hn)		2.0	〃
	Compact (C) and Red kernel (R)	D(XX)	ca. 30	Shen (1933), Unrau (1950)
	Protein content (Pc) and Red kernel (R)		25.7–30.9	Worzella (1942),
	Black glume (Bg) and Hairy glume (Hg_1)	A or B	0–12.5	Kajanus (1918), Mathis (1925)
	Red glume (Rg) and Hairy glume (Hg_2)		0–7	Henkemeyer (1915), Kajanus (1918)
	Gluten strength (G) and Red glume (Rg)		30.5–38.5	Worzella (1942)
	Polonicum (P) and Red coleoptile (Rc)	A or B	20.3	Matsumura (1950)
	Phenol reaction of glume (Pg) and kernel (Pk)		0	Fraser & Gfeller (1936), Miczynski (1938)
Einkorn	Hairy leaf (Hl_1) and Hairy node (Hn)	A	3.9	Kihara (1944)
Einkorn	Hairy leaf (Hl_1) and Hairy rachis (Hr)	A	6.0	〃
Einkorn	Hairy node (Hn) and Hairy rachis (Hr)	A	11.3	〃
Einkorn	Hairy node (Hn) and Hairy leaf-sheath (Hs)	A	0	〃

VI. Supplement

"Origin of Wheat,"

an educational film on the discovery of the ancestors of common wheat and its synthesis

The film was organized by KIHARA and his collaborators and was made by the technical staff of the Nichi-Ei Scientific Films as Scientific Film Series No. 3 of the Ministry of Education, Japan.

The film was shown at a special meeting at the Hotel Grande Bretagne, Bellagio, Italy, on August 29, 1953. A few revisions appeared to be necessary and the alterations were carried out in January, 1954. A copy of the film is available at request to the Nichi-Ei Science Film Production Ginza, Tokyo, Japan, for $60. This does not include postage, taxes, and other expenses.

A scenario of the film is presented in the following supplement.

(1)T

Scientific Film
Series 3
Origin of Wheat
Ministry of Education
Japan

(2)T

By

Dr. Hitoshi Kihara
Professor of Genetics
Kyoto University
and his Collaborators

(2')T The subject of this film is the search for the ancestors of bread wheat, *Triticum vulgare*, which took 35 years of continuous studies carried out by Professor Kihara and his collaborators.

(3)T *From where comes the wheat, the blessed grass which gives us our bread? Nobody knows.* ......J. Henri Fabre

(4) The epochmaking period in the study of wheats began in 1918.

(5) In this year the right chromosome numbers in the genus *Triticum* were determined.

(6) According to Sakamura, all wheat species can be divided into three groups with different chromosome numbers. Sax reported similar results.

(7) Formerly it was assumed that all wheat species have the same chromosome number, namely 8 haploid and 11 diploid chromosomes.

(8) The findings of Sakamura were confirmed by many later studies. Here you see the chromosomes of the three groups,

(9) as observed by Kihara in the pollen mother cells. 7, 14

(10) and 21 chromosomes can be easily counted.

(11) In the somatic cells of those groups were found accordingly 14,

(12) 28 and

(13) 42 chromosomes.

(14) Among wheats both wild and cultivated types are known. To the most advanced type belongs our bread wheat with a tough, firm ear and easily threshing grains.

(15) In more primitive types the ear can be also firm but the grains are not so easily threshed, while the wild types have an easily disarticulating ear and husked grains.

Unbreakable ears and naked grains......characters, which have been acquired under cultivations since ancient times, are adaptations to man's needs.

(16) In 1913, Schulz has divided the wheat species into three groups on the basis of morphological characters. His Einkorn or *monococcum* group comprises the wild growing *Triticum aegilopoides* and the cultivated *Triticum monococcum*.

(17) In the Emmer group we find the wild growing *Triticum dicoccoides* and several cultivated types, for instance, *Triticum dicoccum*, *durum*, *turgidum* and *polonicum*.

(18) In the Dinkel or *vulgare* group we find the cultivated husked *Triticum Spelta* and naked types, *Triticum compactum* and *vulgare*.

(19) Let us arrange those wheats in a table. In this table the Dinkel group is the only one without a wild type. This classification into three groups is in full agreement with Sakamura's arrangement, based upon the chromosome numbers, 7, 14 and 21.

(20) To-day the most widely cultivated wheat is the bread wheat whose botanical name is *Triticum vulgare*. Next to it, the macaroni wheat of the Emmer group, *Triticum durum*, is grown extensively,

(21) while Einkorn is scarcely cultivated.

(21′) But in ancient times Einkorn represented the wheat crop in Egypt and elsewhere. Also Emmer was in use of old times. It is supposed that the origin of bread wheat is the most recent.

(22) In the Einkorn and Emmer groups wild types are found which are considered to be the ancestors of the cultivated forms, while the wild type of bread wheat was not yet discovered. What kind of wild growing wheat was the bread wheat's precursor? Did it already die out or was it not yet found? To solve this question, we must consider the karyological situation.

(23) The chromosome numbers of the three wheat groups show a polyploid relationship with 7 as basic number. Accordingly, Einkorn wheats are diploid, Emmer wheats tetraploid and Dinkel or *vulgare* wheats hexaploid.

If the polyploid species were derived from the doubling of 7 chromosome-sets, they would be autopolyploids. However, Emmer could not be obtained by experimental doubling of Einkorn chromosomes. Emmer, therefore, cannot be autotetraploid. Similarly, Dinkel can not be autohexaploid.

If a tetraploid has 2 different kinds of chromosome-sets, for instance, A and B, it is, after Kihara's terminology, an allotetraploid. Such plant forms must be derived from hybridization between 2 different species. In order to decide whether a similar relationship exists between Emmer and Dinkel,

(24) Kihara began, in 1918 in Sapporo, to study pentaploid hybrids between two groups. (25)

(26) In 1927 this study was transferred to Kyoto University.

(27) In 1942, Kihara Institute for Biological Research was established, where an important part of the research was carried out.

(28) (29) (Field-working)

(30) (31) Crossing technique: castration or emasculation of mother plant.

(32) (33) Two days later, pollination with pollen from the anthers of the father. (34)

(35) In a little while after dusting the stigma with pollen,

(36) the pollen tubes elongate and grow into the stigma tissue until they reach the ovary. (37)

(38) In an intragroup hybrid, for instance a tetraploid hybrid between two Emmer species,

(39) the homologous chromosomes from both parents conjugate and 14 bivalents appear at metaphase, like in the parents. Therefore, species which belong to one group, can be considered to represent the same collective species.

(40) Now, let us describe a pentaploid hybrid between *Triticum polonicum* and *Spelta*.

(41) When Emmer is pollinated with Dinkel pollen, many shrivelled seeds are obtained. But germination is poor.

(42) On the other hand, when Dinkel is the mother,

(43) a small number of plump seeds are set. Germination is good.

(44) In the somatic cells of the pentaploid hybrid, 35 chromosomes are found, 14 belonging to Emmer and 21 to Dinkel.

(45) (Microscopic observations)

(46) In the meiosis of the hybrid 14 bivalent and 7 univalent chromosomes are observed. The bivalents belong to the Emmer chromosome-sets A and B, which both parents have in common. The univalents belong to another set of chromosomes, different from A and B. We can see in detail the behavior of these chromosomes.

(47) The pollen mother cell turns slowly from side view to polar view. Again the side view.

(48) The homologous chromosomes from both parents conjugate in the prophase. In the first metaphase 14 bivalents form the equatorial plate, then they divide and the daughter halves move toward the poles. Soon after that the 7 univalents arrive at the equatorial plate and split longitudinally.

In the second division the 14 daughter chromosomes of the bivalents split longitudinally, but the 7 halves of the univalents are distributed at random to both poles, without further splitting. Therefore, gametes with 14 to 21 chromosomes are formed.

(49) On the female side the embryosacs with intermediate chromosome number are fertilized, while on the male side 14 and 21 chromosome pollen grains perform fertilization with much higher frequency than those with intermediate chromosome numbers.

(50) If both male and female gametes unite in free combination, F_2-plants

must have chromosome numbers ranging from 28 to 42.

(50′) The theoretical frequency of F_2-plants with various chromosome numbers is in good accord with the observed.

(51) T How will the chromosome numbers change in successive generations?

(52) In the offspring of 28- and 42-chromosome plants these parental chromosome numbers remain constant. Among the 29- to 41-chromosome plants the 35-chromosome ones behave like the F_1-hybrid. The others can be divided into 2 groups, one with 29 to 34, the other with 36 to 41 chromosomes. The former decreases its chromosome number generation by generation until 28. It is called "decreasing group". The latter increases the number of chromosomes in successive generations until 42 and is called "increasing group".

(53) In both groups fertility and morphological characters approach those of the respective parent hand in hand with the decrease or increase of chromosome numbers.

(53′) Constant plants with intermediate chromosome numbers are completely or nearly sterile and their viability is strongly reduced.

It became evident that to keep reproductive and physiological functions on a normal level, the 7 chromosome-sets have to be complete. Such sets are called "genomes".

(54) From this study it was for the first time made clear that the behavior of hybrids between species with different chromosome numbers follows certain definite rules.

(55) In a pentaploid wheat hybrid 2 homologous pairs of genomes, AA and BB, form 14 bivalents. 7 univalents are derived from the Dinkel parent. If these are lacking, the chromosome number reverts to 28, the number of the Emmer parent. On the other hand, if all 7 univalents have been doubled, a 42-chromosome plant is the result, having the chromosome number of the Dinkel parent.

(56) The third chromosome-set, typical of Dinkel, was designated, by Kihara as the D-genome.

(57) Therefore, the Dinkel group has the genome formula AABBDD.

(58) From the pentaploid hybrids it has become evident that one of the ancestors must have been tetraploid AABB wheat. But which related species contributed the D-genome? A tetraploid grass, *Aegilops cylindrica*, related to wheat contains this genome, besides another genome, C, known from *Aegilops caudata*. Therefore, *Aegilops cylindrica* itself could not have contributed directly to the make-up of bread wheat. Kihara concluded that only a diploid grass of the genome constitution DD could be the long sought after other ancestor.

(59) Now, what morphological characteristics should have a DD-plant, supposed to be the ancestor of bread wheat as well as *Aegilops cylindrica*? Let us follow Kihara's train of thoughts.

(60) In disarticulation of ear, *Aegilops caudata* is of umbrella type with ears breaking off only at the base,

(61) while *Aegilops cylindrica* is of barrel type with ears breaking to pieces with the upper portion of the rachis adherent to the spikelet.

(62) If we assume that barrel is dominant over umbrella,

(63) the DD-ancestor of *Aegilops cylindrica* should be of barrel type.

(64) On the other hand, Emmer has the wedge type of disarticulation, which means that the lower portion of each internode adheres to the spikelet, while Dinkel is of barrel type. If we assume that barrel is dominant over wedge,

(65) the DD-ancestor of bread wheat should also be of barrel type.

(66) With regard to the character of empty glumes, Emmer has a narrow glume with a conspicuous apical tooth, while the glume in Dinkel especially in *Triticum Spelta* is broad with truncate apex. Therefore, the hypothetical DD-plant must have a glume like Dinkel.

(67) This brings us to disarticulation of ear......, shape of empty glume......, chromosome number......of the DD-plant.

(68) Let us try to identify it.

(69) The only diploid species which answers the morphological requirements of the hypothetical DD-ancestor is *Aegilops squarrosa*.

(70) Namely, disarticulation of ear......barrel type.

(71) Shape of empty glume......truncate.

(72) Chromosome number......14.

But, has *Aegilops squarrosa* the D-genome? To prove this was more difficult than it would seem, since all attempts to cross *Aegilops squarrosa* with *cylindrica* and bread wheat failed. Finally this proof has been beyond doubt established.

(73) Thus, an ancestor of bread wheat was found. Now, we will see how bread wheat could have been synthesized from *Aegilops squarrosa* and a tetraploid wheat.

(74) A hybrid between wild Emmer, *Triticum dicoccoides*, and *Aegilops squarrosa* has 21 somatic chromosomes and is sterile.

(75) As a result of meiosis in such a hybrid usually sterile gametes are formed. But sometimes gametes with the somatic chromosome number of 21 are formed. From the union of two such gametes 42-chromosome hexaploid plants were synthesized.

(76) Morphology of the synthesized wheat on the left side is very similar to that to *Triticum Spelta*. A hybrid between the artificial product and *Triticum Spelta* showed normal chromosome pairing at first metaphase. This proved definitely that the synthesized plants belong to the collective species *vulgare*.

(77) By similar means, several hexaploid wheats were synthesized. Of all of them, one, synthesized from cultivated *Triticum persicum* and *Aegilops*

squarrosa, resembles most our bread wheat.

(78) Synthesized hexaploid on the left side and bread wheat.

(79) From this last result, it is highly probable that the tetraploid ancestor of bread wheat has been not a wild type, but a cultivated one.

(80) Now, where did the bread wheat originate ? This question is still a matter in dispute.

(81) *Aegilops squarrosa* is distributed from Transcaucasia to Afghanistan and the wild Emmer, *Triticum dicoccoides*, from Armenia to Palestine.

(82) The hybridization could have taken place there where the areas of both overlap. But in those parts no wild growing hexaploid wheat was ever found. Since the hexaploid wheat is vigorous, it is hard to assume that the wild type died out. It appears more probable that the bread wheat is not derived from a wild growing hexaploid.

(83) How far back do we have to place the origin of the bread wheat ?

(84) The area of cultivated Emmer wheats extends eastwards to Tibet but does not reach China. Dinkel wheats are supposed to spread fast and widely owing to the vital powers of their hexaploid constitution. We may assume that our bread wheat is at least 4,000 years old.

(85) In the light of all the discoveries made in the laboratories, exploration of the natural habitats of the whole group related to wheat has become a task of utmost importance. Botanical expeditions to Palestine, Asia Minor, Transcaucasia, Iran, Iraq and Afghanistan should be organized. Let us stress with Vavilov, the great explorer of the origin of cultivated plants, the importance of international cooperation. Only with joined efforts will such undertakings bring good results.

TECHNICAL STAFF

NICHI-EI SCIENTIFIC FILMS

Produced by T. ISHIMOTO

Directed by N. OTA

Photographed by K. SUZUKI

Animation by Y. KATAOKA

Narrated by T. SHIMANOUCHI

Sound Recording by K. TANKA

VII. Miscellaneous

1) International Genetics Symposium, 1956

At the 12th General Assembly of the International Union of Biological Sciences held at Nice, France, in 1953, it was agreed that a symposium on the subject of genetics should be held in Japan in 1956. This decision was confirmed later at the 9th International Congress of Genetics, Bellagio, Italy.

The Science Council of Japan, as the representative national organization of Japanese scientists, has been charged with the arrangement of this event. The Organizing Committee, established in the Council, is now engaged in the preparations for the meeting.

Provisional agenda and tentative programme are as follows:

Provisional Agenda:

Section I. Physical and Chemical Approaches to Problems in Chromosomes.

Section II. Problems in Applied Genetics:

- a. Induced Mutation
- b. Heterosis and Resistance
- c. Polygenic Inheritance
- d. Microorganisms and Viruses
- e. Blood Groups

Section III. Standardization of Nomenclature and Symbols of Genes

Tentative Programme:

Sept. 6 (Thur.): Plenary Session; Reception at noon; Section I and II (b) .... Night in Tokyo

Sept. 7 (Fri.): Section I and II (a); Exhibits related to Silkworm, Poultry and Classic Documents; Reception...........Night in Tokyo

Sept. 8 (Sat.): Section I and II (e and c); Invitation to classical Japanese theatre for those visiting Nikko on Sunday...........Night in Tokyo

Sept. 9 (Sun.): Excursions (1) in and around town, (2) visit Nikko resort; Invitation to classical theatre for those staying in town...........Night in Tokyo

Sept. 10 (Mon.): Section I and II (d); Reception at noon; Leave Tokyo and visit to Kihara Inst. for Biol. Res. (new premises in Yokohama) and National Inst. of Agric. Sciences (Hiratsuka)...........Night in Hakone

Sept. 11 (Tue.): Leave Hakone for Kyoto, visit en route to National Inst. of Genetics (Mishima)...........Night in Kyoto

Sept. 12 (Wed.): Section III (General rules). Exhibits related to Wheat and Radish; Reception at noon; Section III - Special meetings for Silkworm, Wheat, Rice, etc...........Night in Kyoto

After adjournment of the Symposium, several excursions will be arranged for visiting various institutions of interest to geneticists, and also tours will be planned for the sightseers.

Circulars of further information will be available at the Secretariat, International Genetics Symposium, Science Council of Japan, Ueno Park, Tokyo, Japan. (Telegraphic Address: SCIENCOUNCIL TOKYO).

2) **Wheat Symposium**

At the special meeting on the 29 th of August in 1953, at the Hotel Grande Bretagne, Bellagio, Italy, it was agreed to plan a symposium on the subjects of wheat genetics to be held in Japan in 1956, if possible (s. page 1). Due to the financial circumstances of present Japan, however, it would be almost impossible to organize this project in 1956 when the International Genetics Symposium will be held. Therefore, I would like to suggest to put off the plan until the next International Congress of Genetics to be held in Canada in 1958. Your opinions in connection with this matter would be very much appreciated. (H. Kihara).

3) **"Studies on Wheat,"** a monograph edited by Dr. H. Kihara (written in Japanese) has appeared (May 25, 1954) from YOKENDO, a publisher in Tokyo. H. KIHARA, I. HIRAYOSHI, S. HOSONO, S. MATSUMURA, I. NISHIYAMA, I. UCHIKAWA and K. YAMASHITA have written chapters related to their specialities. (pp. 753 ,¥ 1,000).

4) **Kihara Institute for Biological Research**, which is now located in Kyoto, will have moved to Yokohama by 1956 when the International Geneties Symposium is held.

WHEAT INFORMATION SERVICE
No. 1

昭和29年10月25日　印刷
昭和29年10月28日　発行

編集者	山　下　孝　介
発行所	京都市左京区北白川 京都大学農学部遺伝学研究室
印刷所	東京都新宿区西五軒町32 旭印刷株式会社