NATIONAL INSTITUTE OF GENETICS

(JAPAN)

ANNUAL REPORT

No. 1.

(1949 ~ 1950)

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THE NATIONAL INSTITUTE OF GENETICS

(MISIMA, SIZUOKA-KEN, JAPAN)

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Contents

HISTORY

The National Institute of Genetics was officially organized on June 1st, 1949. Previous to this, the demand for a national institute devoted to the study of genetics in Japan had been expressed by Japanese geneticists on various occasions. It had been taken for granted from the beginning that such an institute should be an independent one, instead of being a part of a university or other institution. It had also been conceded that, in view of the extensive field now covered by this science, and the intricate relation between this science and many other sciences, the institute should be of a fairly large scale. The first formal announcement of such a demand was made by the resolution passed unanimously at the Thirteenth General Meeting of the Genetic Society of Japan held in August 1940 in Seoul. A little later, a special committee for the study of genetics was organized in the 'Foundation for the Promotion of Scientific Researches in Japan.' Most of the senior geneticists became members of this committee, and shared its activities. The formation of this committee paved the way for the establishment of a national center for the study of genetics in Japan. Besides, a small foundation for the promotion of theoretical and applied genetics, called the Genetics Research Institution, was organized in May 1947 by the donation of Mr. S. MATSUMURA, Member of the House of Councillors. Practically the same group of geneticists joined this foundation also and cooperated in their research activities. This foundation became the forerunner of the National Institute of Genetics.

In July 1948, the bill for the establishment of a national institute of genetics was presented by the Ministry of Education to the Diet, and passed. The formal start of the institute was made on July 1st, 1949, by the Government Law No. 146. On the same day, the office of the Institute was openned in the Ministry of Education with Mr. K. KENNOKI, Director of the Higher Education and Science Bureau as the Acting Director. Moreover, a council responsible for setting up the basic principles of the organization and function of the Institute was formed on the same day. At its first meeting held on July 30th, the council nominated Dr. KAN OGUMA, Emeritus Professor of Hokkaido

University, as the Director of the Institute, who was officially appointed on August 10th, 1949. Within a few months the rest of the staff was chosen, and by the middle of 1950, nearly all of the present members were appointed.

Thus the new Institute was started. For the establishment of the Institute under the current difficult circumstances, we are indebted to a number of interested scientists and officials. Especially, the valuable help accorded by Dr. H. C. KELLY of C.I.E., G.H.Q. and Dr. S. KAYA, formerly Director of the Higher Education and Science Bureau in the Ministry of Education, should not be passed without mentioning. Among the geneticists, Dr. H. KIHARA and Dr. K. MASUI were most active in realizing the project laid out by geneticists' group.

The whole Institute moved into the present building in Misima on October 29th, 1949. Shortly after this, the Institute received a request from the President of the Japan Monopoly Corporation to help their breeding experiments aimed at the improvement of the varieties of the tobacco plant cultivated in Japan. The proposal was accepted, and a branch of Tobacco Experiment Station of the Corporation was started in the Institute on May 25th, 1950. The botanical members of the Institute headed by KIHARA have volunteered their assistance in these experiments.

In November 1950, the Institute received another request from a group of poultry breeders to improve the white Leghorn strain in Japan for higher egg production. A new association called 'the Whole-Japan Association of Poultry Genetics' was organized for this purpose, and contributed the funds for this untertaking. The experiments are to be carried out in aviaries to be constructed on the campus of the Institute, under the supervision of Y. TANAKA.

In July 1950, Prof. R. GOLDSCHMIDT presented an offer to the Institute to submit his own library for the use of the Institute. On February 2nd, 1951, more than 50,000 reprints and about 600 books arrived in good condition. These reprints and books will become the nucleus of a library for the Institute, the need of which had previously been seriously felt.

LAWS AND REGULATIONS (Abstracts)

The Japanese Government Law No. 146

The National Institute of Genetics shall be an organ of studies on the principles of heredity, and for providing a theoretical basis to the solution of practical problems in heredity; also it shall guide and promote genetical researches in Japan.

The Ministry of Education Ordinance No. 30

The National Institute of Genetics shall have the following Departments:—the Department of Administration, the First Department of Research, the Second Department of Research, the Third Department of Research.

The Department of Administration shall consist of the Section of General Business and the Section of Finance.

The First Department of Research shall persue research works on: a. phenogenetics in man, b. phenogenetics in animals and c. phenogenetics in plants.

The Second Department of Research shall pursue research works on: a. problems concerning cytoplasmic inheritance and b. problems concerning chromosomal inheritance.

The Third Department of Research shall pursue research works on: a. physiological genetics and b. biochemical genetics.

Cabinet Order No. 247

The Board of Councillors shall advise the Director concerning the matters stated below:—a. planning of researches and other activities in the National Institute of Genetics for the coming year, b. budget for the coming year, c. appointment and dismissal of staff member and d. other important administrative business.

The Board of Councillors shall consist of members not more than sixteen in number.

The members shall be appointed by the Minister of Education from among competent persons in educational, academic and economic circles.

Regulations concerning Research Associates

Research Associates shall be appointed by the Director from among persons who have full training in genetics and intend to do research works in the Institute.

A Research Associate may use the equipment of the Institute for his research work; he may also use the organ of the Institute for the publication of the results obtained thereby.

Regulations concerning Research Students

Research Students shall be appointed by the Director from among applicants who have completed their course in genetics in some university or college, or who have qualifications of a corresponding grade, and who intend to pursue genetic research in the Institute under the direction of the staff.

Regulations concerning Practice Students

Practice Students shall be appointed by the Director from among applicants who have graduated from a Middle School of the Old School System, or from a High School of the New School System, and who intend to study genetics in the Institute under the direction of the staff.

LOCATION, BUILDINGS AND CAMPUS

It had been an important problem from the beginning of the campaign for the establishment of a national institute of genetics, to secure a suitable site and building for the institute. It had been agreed upon that, the site should be located within a reasonable distance from an academic center, and in a district of mild climate. There should be standing a building of proper size and construction, in view of the great difficulty in erecting a new one under the financially most difficult circumstances. Also an adequate amount of fertile land should be available in the neighborhood. After a great deal of searching within and around Tokyo, the present site was finally chosen. This site seemed to meet fairly satisfactorily all the requirements enumerated above. It is located in a suburb of the city of Misima, on a small foot hill

of Mt. Hakone. Buildings formerly used as a factory for manufacturing aeroplane accessories were standing virtually intact. A levelled area of nearly 19 acres was attached to these buildings. The city of Misima is located 118 kilometers west of Tokyo, and can be reached in two hours by express trains and in two and half hours by local trains. The climate is mild, and the neighboring district is noted for various kinds of vegetables of good quality, as well as for richness of dairy products.

One of the buildings, a large two-storey wooden building, 1,165.66 tubo (1 tubo=6 feet square) was taken for the use of the Institute. It was repaired, partitions were set up inside, and it was turned into a building containing 20 laboratories, 3 offices, a lecture room, a library, a dark room, store-rooms, etc. Two smaller buildings attached to the main building were remade into living apartments for the staff as well as a garage.

EXPERIMENTAL FIELDS

Of the whole land 19.23 acres in area, 11.46 acres were turned into a field suitable for growing plants for experimental purposes. At the start it was necessary to make the land arable. In January 1950 about the half the land was made suitable for cultivation, by breaking the ground with a tractor and by adding a large quantity of organic matters and neutralizing chemicals to the soil. The other half will be treated in the same way during 1951. The principal plants grown for experimental purpose in 1950 were as follows:—

Several varieties of *Triticum, Aegilops, Solanum melongena* var. *esculentum, Capsicum annuum, Nicotiana tabacum, Zinnia elegans, Cosmos bipinnatus, Aster* spp., *Saccharum officinarum* and the tetraploid and triploid water-melon *Citrullus vulgaris,* tetraploid radishes *Raphanus sativus, Ricinus communis* and *Morus bombycis.*

ABSTRACT OF DIARY FROM JUNE 1949 TO DECEMBER 1950

1949

June 1. The National Institute of Genetics was officially organized; Mr. TOSHIHIRO KENNOKI was appointed its Acting Director; and the Board of Councillors was formed.

July 30. First meeting of the Board of Councillors.

August 10. Dr. KAN OGUMA was appointed the Director of the Institute.

September 14. The land 23,526 tubo (19.23 acres) in area located at Yata in Misima was bought from the Fuji Industrial Company for the campus of the Institute.

October 1. Buildings 1,347 tubo in floor dimension were rented for the laboratories, offices, etc. of the Institute.

October 29. The Institute moved to the buildings in Misima.

1950

January 23. Second meeting of the Board of Councillors.

February 11. Public lecture in the Public Hall at Shizuoka.

12. Public lecture in Laborer's Hall at Misima.

March 29. Staff meeting.

April 29. Board meeting of the Genetics Research Institution.

Joint meeting of the National Committee of Genetic Researches of the Japan Science Council and the National Committee of Researches in Plant and Animal Breeding of the Japan Science Council.

May 25. Inauguration of the Misima Branch of the Hatano Tobacco Experiment Station of the Japan Monopoly Corporation.

May 26. Third meeting of the Board of Councillors.

September 3. Committee meeting of the Genetic Society of Japan.

September 4. Joint meeting of the National Committee of Genetic Researches of the Japan Science Council and the National Committee of Researches in Plant and Animal Breeding of the Japan Science Council.

September 5. General meeting of the Society of Chromosome Research.

September 24. Inauguration meeting of the Whole-Japan Association of Poultry Genetics.
November 18. Inauguration meeting of Misima Geneticists' Club.
December 15. Board meeting of the Genetics Research Institution.
December 16. Meeting of the Misima Geneticists' Club.

STAFF

Department and Laboratory Heads

Kan OGUMA, D. Agr., Director, and Head of the Second Department
Yoshimaro TANAKA, D. Agr., D. Sc., Head of the First Department
Taku KOMAI, D. Sc., Head of the Third Department

Part-time Staff

Hitoshi KIHARA, D. Sc.
Yosito SINOTO, D. Sc.

Laboratory Heads

Yô TAKENAKA, D. Sc.
Kan-Ichi SAKAI, D. Agr.
Seiji MATSUMURA, D. Agr.
Mitsuo TSUJITA, D. Agr.
Kazuo FURUSATO

Research Assistants

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Motô KIMURA
Kanji GOTOH
Tarô ITO
Bungo SAKAGUCHI
Tôru ENDO
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Morihei TSUKAMOTO, Head of Department
Sumiyoshi SUGIO, Head of General Business Section
Masao MIYAZAWA, Head of Finance Section
Naomi MATSUBARA
Hiroko NAKANO

Junzô KADOWAKI
Typist, Telephone operator, Chauffeur, Field-laborers, Janitors, etc.—9.

Misima Branch of Hatano Tobacco Experiment Station

Masao TANAKA, Head
Flora LILIENFELD, Ph. D.
Seiji IMAI
Assistants—3

COUNCIL

Yô K. OKADA, Professor of Tokyo University, Chairman
Seishi KAYA, Professor of Tokyo University, Vice-chairman
Fujio EGAMI, Professor of Nagoya University
Tanemoto FURUHATA, Professor of Tokyo University
Seizô KATSUNUMA, President of Nagoya University
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Masanori NAKAIZUMI, Professor of Tokyo University
Uichi NODA, Member of House of Councillors
Bungo WADA, Professor of Tokyo University
Yasuke YAMAGUTI, Professor of Ibaraki University

RESEARCHES CARRIED OUT IN 1950

A. HUMAN GENETICS

(Report by Taku KOMAI)

1. Microcephaly

Microcephaly is one of the most severe congenital defects in man. It causes high-grade idiocy. Various views have been propounded concerning its origin and heredity. This difference in opinion is at least partly due to the rarity of this abnormality. KOMAI, in cooperation with the psychiatrist Dr. K. KISHIMOTO of Nagoya University, is pursuing a genetic study of this abnormality. So far, they have collected nearly 50 cases with family histories. Psychiatric and anthropometric examinations have been made for most of them. Most of the cases have a genetic back-ground, and are apparently due to a completely recessive gene.

2. An Apparently New Disease with Splenomegaly and Anemia as Main Symptoms

A family of farmers living in a suburb of Kyoto have a lesion with splenomegaly and anemia as the main symptoms. KOMAI, with the collaboration of Dr. M. MASUDA and some students in the Prefectural Medical College of Kyoto, is studying the genetics of this disease. The disease resembles Banti's syndrome in many respects. It has the great peculiarity, however, that only women of the family are affected, and *all* the women connected to the pedigree on the mother's side have either splenomegaly or anemia or both.

3. Some Hereditary Characters of the Tongue

The presence or absence of the ability to roll up the lateral edges of the tongue in man is controlled by a pair of Mendelian genes. The manifestation of the character is completed at about the age 12. Among the 6-year old children, the incidence of the absence of the ability is about 50 per cent in both sexes. The incidence diminishes with age, until it becomes 29.5 per cent in males and 25.5 per cent in females at about 12, from which time onward the values remain practically constant. These values obtained from Japanese are somewhat different from the values so far recorded for Americans and Chinese, although the figures for these peoples are based on relatively meager material and need confirmation. Family studies on this ability have shown conclu-

sively its genetic back-ground.

Three families with a slight abnormality in the tongue, having the sublingual frenula abnormally extending to the front and hindering the free movement of the tongue, have been discovered. This peculiarity seemes to be due to a dominant gene.

B. CAT GENETICS

(Report by Taku KOMAI)

Opinions are varied concerning the inheritance of common coat colors in domestic cats, black, tabby and yellow. A census of cats carried out in some districts of Japan has revealed that black and tabby are due to autosomal genes, while yellow is produced by a sex-linked gene. As for the rare tortoise-shell male, KOMAI has expressed the opinion that this kind of male results from unequal crossing over between the *X*-choromosomes of a tortoiseshell mother cat. The son that receives the *X*-choromosome containing both the yellow gene and its allele will become a tortoiseshell. He will also become sterile owing to the presence of an abnormal *X*-chromosome containing too much of the femaleness factor for a normal male, but too little of the femaleness factor to become a normal female, and he becomes a kind of male intersex and sterile. According to this hypothesis, the mother of a tortoiseshell male should be tortoiseshell herself. All the four indisputable and one probable cases collected by KOMAI and the seven cases observed by Dr. C. KEELER conform to this postulate. The decisive evidence for the hypothesis will be obtained by cytological observations. Prof. S. MAKINO's examinations of the sections of testis of one of these cats did not show any mitotic figures, but his study on this line is still under way.

C. SILKWORM GENETICS

I. Studies on Unstable Genes in the Silkworm.

(Report by Yoshimaro TANAKA)

1. Inheritance of Multistar Marking

In the larva with normal marking, there are regularly found three pairs of spots; i. e. the "eye" spots on the second segment, the crescent spots on the fifth segment and the star spots on the eighth segment, the segment numbers being counted all through the thoracic and abdominal segments. When a larva is provided with paired or unpaired spots on one or more segments other than the above-mentioned, it is called multistar. The multistar marking is recessive to the normal and represented by the symbol *ms*.

The material of the present study consists of descendants of a single egg-batch of a Chinese bivoltine race Shao-shing, which the author obtained forty years ago from a breeder. The culture has been continued ever since, and several types have been isolated chiefly by selection through more than fifty generations. Of these types, the more important ones are as follows:

1) 0 type, which has no star spots, except the normal "eye" spots and the crescents.
2) 8–10 type, which has star spots on the 8th, 9th, and 10th segments.
3) 6–10 type, which has stars on the 6th, 7th, 8th, 9th, and 10th segments.
4) 4–10 type, which has stars on the 4th, 6th, 7th, 8th, 9th, and 10th segments.
5) 6–9 type, which has stars on 6th, 7th, 8th and 9th segments.

To explain the process of breeding of various star types, the 0 type may be taken as an example. At the start 33 individuals of this type appeared in a lot containing 160 larvae. These individuals were selected and inbred. The percentage of the invididuals showing the 0 type went up generation after generation, though not steadily, and 4 lots consisting exclusively of this type were obtained among 7 lots in the sixth generation. Since then, the author has been breeding only the 0 type in this strain. However, this type has never been made pure, throwing in every generation a few exceptional types.

Other star types behave similarly in many respects, although the variability is much different from one another, and also from the 0 type described above. The stability of the star spots is also different according to segment; e.g., the spots on the 8th segment are most stable, succeeded in stability by those on the 9th and 10th segments, while those on the 6th and 7th are most variable.

The author assumes the presence of several modifiers which reduce or increase the number of the spots. These modifiers do not act independently, but are correlated with one another to some extent. For instance, the stars on the 4th segment are comparatively stable when they are combined with those on 6–10th segments, but they cannot exist independently.

Crossing different star types conspicuously increases the range of variation in F_1 and F_2, but distinct segregation has never been observed.

From these facts, the author is inclined to conclude that the major gene, *ms*, does not change, but the modifiers are unstable, and their effect can be sifted by continued selection in both plus and minus directions. The genotype of the normal marking is $+^{p}+^{q}+^{ms}$ (p and q designate plain and quail marking respectively), plain $p+^{q}+^{ms}$, striped $p^{s}+^{q}+^{ms}$, quail $+^{p}\ q\ +^{ms}$, pale quail $p\ q\ +^{ms}$, multistars $+^{p}+^{q}\ ms$.

When *ms* co-exists with *p* and *q*, the pale quail multistar (*p q ms*) is formed.

2. *Inheritance of the Multilunar Marking*

The multilunar marking consists of a series of roundish brownish-yellow or dark-brown spots on the subdorsal lines of the larva. The gene for multilunar, *L*, is dominant to non-multilunar, and is equistatic to other markings, normal, striped, moricaud, quail and zebra. Only when it is combined with plain marking, *p*, does the pigment not develop on the skin, so that the presence of the *L* gene is hardly perceptible except to skilled eyes. The gene for multilunar is linked with the gene for "stick," and is located at the 0 point of chromosome IV.

In the *L* marking, the characteristic spots are observed on at least four segments, i. e. 2nd, 3rd, 5th and 8th, the segment numbers being counted from the thorax to the abdomen throughout. For the sake of description, the spots on the 2nd and 3rd segments are disregarded, and only those on other segments are mentioned.

The selection has been practised for more than thirty years covering about forty generations, and the following *L* types have been isolated:—

1) 5.8. type, in which *L* spots are limited to 5th and 8th segments.
2) 5.6.8. type, which has *L* spots on 5th, 6th, and 8th segments.
3) 4–8 type, which has *L* spots on 4th, 5th 6th, 7th and 8th segments.
4) 4–9 type, in which six pairs of *L* spots are developed.
5) 4–10 type, which is provided with seven pairs of *L* spots on all segments from 4th to 10th.

The author assumes several modifying genes which control their respective distributions of spots, in the presence of the major gene *L*. The 5.8 and 5.6.8. types, are always heterozygous for *L*-gene.

In spite of long continued selection, none of these spot-types has bred true; they produce some (10–30%) exceptional forms in each generation. Even in the most stable type 4–10, a few exceptional individuals appear almost invariably. When the 4–10 type is crossed with some other race, as many as 10–20% exceptional types appear even in the F_7 generation after rigorous selection for a pure 4–10 type.

According to the author's opinion, these breeding results can be explained by the unstability of modifying genes which can be changed in plus or minus direction by selection. There must be a limit, of course, beyond which the selection is ineffective. The major gene apparently remains unchanged from the beginning.

It seems to the author that the present case as well as the case of the multistars can hardly be explained by the assumption either of mutable genes or polymerism, or of the polygene hypothesis of MATHER.

3. *Inheritance of Knobs*

"Knobbed" is a remarkable characteristic of the Chinese race, "Dragon horn." These larvae are provided with four pairs of large skin protuberances on the second, third, fifth and eighth larval segments (thoracic and abdominal segments being included in the count). Usually the knobs of the fifth segment are the largest, succeeded in size by those of the eighth segment, those of the second segment being the smallest. Knobbed is dominant to normal, and is represented by the symbol *K*.

The facts that all the four segments on which knobs appear are each provided with a pair of spots (the eye-spots, crescent spots, or star spots), and that the positions of the spots and knobs coincide exactly, speak for a close relation between the swelling of the skin and the development of dermal pigment. This has been proved by crossing *K*-strain with *L* (multilunar) or *ms* (multistar) strain; knobs appear on all segments where *L* or *ms* spots are present. On the contrary, the striped marking factor inhibits almost entirely, when homozygous, the development of knobs, while *L*-spots and striped marking are both fully developed when they co-exist.

After a long-continued selection, the author obtained the following strains with regard to the distribution of knobs:

1) 5-8 type, which has two extra pairs of knobs on the sixth and seventh segments;
2) 5-9 type, which is provided with three extra pairs of knobs on the sixth, seventh, and ninth segments;
3) 5-10 type, which has knobs on all segments from the second to the tenth, except the fourth;
4) 5.0 type, in which knobs are absent from the eighth segment, and are present on the second, and fifth segments only;
5) 4-10 type, which has knobs on all segments from the second to the tenth;
6) 4.5.0 type, in which knobs are present on four segments from the second to the fifth, but absent from the eighth.

Extra knobs are as a rule, smaller than those regularly present on the fifth and eighth segments.

Selections have been practised with respect to the number of knobs, and they have proved to be highly effective in both directions, plus and minus. For example, those larvae provided with extra knobs on the fourth segment increased in number after selection extending over nine generations; then the selection was turned to the minus direction, and the individuals destitute of knobs on the fourth segment only were allowed to reproduce. The knobs on the fourth segment decreased rapidly, and after two or three generations, no larvae had knobs on that segment.

In another strain, only a few larvae had knobs on the tenth segment. Before the selection was practised, the percentage of such individuals had remained nearly the same. When once the selection was started for the extra knobs on the tenth segment, such larvae increased rapidly, and after several generations, they became more numerous than the larvae having no knob on the tenth segment.

Although the selection has been effective in both directions, no pure extra-knob type has been obtained, some aberrant forms appearing from time to time. These aberrant forms may be increased or decreased by selection.

I conclude, therefore, that the modifying genes which control the number of extra knobs are unstable, and vary in both the "plus" and "minus" directions while the major gene *K* remains unaffected.

II. Embryological and Genetical Studies of a Kind of Malformation in the Silkworm

(Report by Mitsuo TSUJITA)

1. Rôle of Nucleus and Cytoplasm in the Appearance of the Malformation

OMURA (1948) has reported on a strain of abdominal segment malformation in the silkworm larva. The present report deals with embryological and genetical studies of this strain. The malformation appears on the dorsal and ventral sides of several segments ranging both anteriorly and posteriorly from the 5th segment. The shape and degree of the malformation vary markedly from individual to individual. In extreme cases one or two segments are missing; often one or two segments on one side of the larval body are gone, and the body is curved like a hook. In the cases where the deformity is slight, the larva looks almost normal. Between these two extremities there are various degrees of abnormality. The number of caudal horns ranges from one to several, and these are irregularly located on the dorsal side. Besides, deformity may be found in various organs; for example, trachea and spiracles, dorsal vessel, muscles, ganglia, Malpighian tubules, silk glands, gonads and midgut. Among these gonad malformation is very conspicuous, the number of gonads on one or both sides may increase, to three or four; in some individuals, the gonad is missing on one side. Furthermore, the ovarian tubules and the testicular follicles may vary in number, from one to six. Sometimes the segmental structures appear normal, while the internal organs are abnormal. The most distinctive feature of this strain is that many deformed individuals emerge without getting any treatment with dilute hydrochloric acid. The penetrance of the gene for this abnormality is

about 50–70%. The cross between this strain and the normal strain yields no abnormal individuals in F_1, no matter which strain is used as mother, and a few mutants segregate in F_2 and F_3, with a much lower frequencey than expected on the monohybrid basis. Some apparently normal females were mated with abnormal males, and the eggs were exposed to high temperature (of 40°–41°C) within one hour after their being laid, i.e., about the time of the maturation division of the egg. By this treatment numerous exceptional individuals were obtained through merogony, the egg nucleus degenerating and two sperm nuclei conjugating together. In this case almost all individuals became abnormal, showing the characteristic features mentioned above. It has been concluded, from the results obtained by experiments ensuring various combinations of nucleus and ooplasm of the normal and abnormal strains, that the appearance of the malformations is largely governed by genes in the nucleus, irrespective of whether the cytoplasm comes from the abnormal strain or from the normal strain.

2. *Environmental Effects upon the Expression of the Malformation*

As stated by OMURA (1949), when the early-stage eggs of the strain showing the abdominal segment malformation are immersed in a dilute hydrochloric acid solution, abnomal individuals appear more frequently than otherwise, amounting to 80–100%. Thus, almost all individuals can be made abnormal by this treatment. It has been ascertained that no or few abnormal individuals are produced by change in the environment in early stages. Eggs of this strain were kept for 10~15 hours, directly after being laid, at the high temperature of 25°C, and then brought into a low temperature room (15°C) where they were kept for several days. This period corresponds to the stage extending from the migration of the egg nuclei toward the periphery to the diapause of the embryo.

Also, eggs which had been treated with the low temperature mentioned above were kept during 40–60 days at the refrigerating temperature of 5°C and then immersed in dilute hydrochloric acid. Strikingly, almost all of the larvae hatched from these eggs were normal. On the contrary, the eggs of the same strain produced 80–85% crippled larvae, when they were kept at temperatures of 25°–30°C for 36 to 48 hours after being laid, refrigerated for 40–60 days at 5°C, and then subjected to the usual hydrochloric-acid treatment.

Judging from these results, it may be said that, at 25°C, the stage from 15 hours to 36 hours after oviposition is the period during which the body segments are differentiated. Thus, the frequency of crippled larvae can be controlled to a fairly large extent by the adjustment of certain environmental conditions, notably temperature.

As stated above, the segment formation in the silkworm is under the

control of genic activity. The present experiments, however, have made it clear that the expression of this activity is strongly affected by the environmental conditions. However, when eggs of this strain, laid by moths which had emerged from apparently normal silkworms, had been subjected to low temperature treatment at an early embryonal stage through two or three generations, and placed in an ordinary temperature room, abnormal individuals emerged at a ratio of about 50–70%. This shows that the experimental results described above cannot be attributed to mutation. The differences observed are rather due to a varying penetrance of the same genes.

III. Studies on New Genes Belonging to the *E*-Series on Sixth Chromosome

(Report by Mitsuo TSUJITA)

The ancestor of this strain was discovered as a mutant among the hybrids between a Japanese race and a Chinese race. The mutant has duplicated star-shaped patterns. This character is dominant, and when the F_1 of this mutant and the normal is backcrossed to the normal, individuals with supernumerary stars and normal individuals segregate according to the 1 : 1 ratio. Among the larvae of the former type some have star-patterns on the 7th and 8th segments, or on the 8th and 9th segments; also there are individuals with star-patterns on the 7th, 8th and 9th segments. The embryos homozygous for this gene also have supernumerary abdominal legs on the 10th and 11th segments, and they die in the later embryonic stage or immediately after hatching. It is a striking fact that in this strain, larvae with duplicated crescent patterns on the dorsal side of the 5th and 6th segments occasionally appear, apparently as mutants. As this character is also dominant, normals and mutants segregate in the back-cross of F_1 according to the 1 : 1 ratio. Sometimes both larvae with crescent patterns on two segments and larvae with crescent-patterns on three segments emerged from the same batch of eggs. This strain is characterized by having no star-pattern. Embryos homozygous for this gene also die in a later stage; they are provided with thoracic legs and thoracic setae on all segments, and are incapable of blastokinesis.

From the strain of the multi-star pattern, some larvae entirely devoid of the star-pattern were obtained. These larvae were viable even though they were homozygous for the gene in question. Genetic analysis of this character is now under way.

The number of the spots, i. e. the stars and crescents, can be increased by selection through sib-mating.

Judging from these breeding results, the gene for the supernumerary stars and the gene for the supernumerary crescents are in multiple-allelic relation, both of them being located at the 0.0 point of the 6th chromosome, to which locus ten genes have already been assigned.

The gene for the multi-star pattern is undoubtedly different from E^{Cr} reported by TAKASAKI ('47), while the gene of non-star-spots apparen ly resembles E^{Cr}, but the latter can be easily distinguished from the former by its lethal action. The multi-crescent character is similar in appearance to E^{N} discovered by ICHIKAWA ('43), although different in some respects.

IV. Effect of B. H. C. on Meiosis

(Report by Mitsuo TSUJITA)

1. Abnormality in Spermatogenesis

NYIOM and KNUTSSON ('47) have reported that mitosis in the cells of the onion root is interrupted by the action of the γ-isomer of B.H.C. TSUJITA and SAKAGUCHI have observed that the mitosis of the spermatocytes in silkworm poisoned by this chemical is also markedly disturbed.

Larvae 3 days after the 4th moulting were dusted with B.H.C. powder, which contains 0.5% of the γ-isomer. The larvae soon afterwards showed signs of poisoning. Ten, twenty, thirty and fourty hours after the treatment, cytological observations of the poisoned larvae were carried out. The spermatocytes in the testes of healthy larvae were examined as controls.

In the spermatocytes of the poisoned larvae ten hours after the treatment, 26, 27, 29 and 30 chromosomes were counted on the equatorial plate of the 1st spermatocyte, although in some of them the normal 28 chromosomes were observed. Often aggregation of several choromosomes occurred. Moreover, lagging of one or several choromosomes was observed at the anaphase. These abnormalities increase with the advance of time and stage.

Among the materials from poisoned larvae thirty or fourty hours after the treatment with B.H.C., some showed about half of the chromosomes already at the poles, while the rest remained on the equatorial plate.

Thus, the spermatocytic division may be thrown into confusion by this treatment: also fusion of chromosomes occurs. This change seems to be due, partly, to the effect of B.H.C. on the protoplasm followed by some obstruction in the spindle-formation. Also, it is possible that the chromosomes themselves are affected.

2. Non-disjunction of Chromosomes

NYLOM and KNUTSSON ('47) suggest that the γ-isomer of B.H.C., like colchicine can induce polyploidy. The present experiment was carried

out to test this possibility. Although no polyploid has been obtained, trisomics due to non-disjunction of chromosomes were observed with fairly high frequency. The outline of the results is presented below.

Male and female larvae having the genic composition $p^S p^M$ were treated with 0.5% B.H.C. powder 3 days after the 4th moulting. Among the 200 treated larvae, 11 females and 5 males survived to emergence. These were mated with moths of a strain with the normal pattern ($+^p+^p$). The number and hatching rate of the F_1 eggs were almost the same as those of the control lots.

In the lots in which the male larvae had been treated, six larvae of an exceptional type appeared. These had both striped and moricaud patterns. Four of these (three females and one male) survived to emergence. These were mated with a normal strain. The eggs were not larger than those of the controls. The segregation of the larvae with respect to colour pattern is shown in the following table:

Table I.

Mating type	Striped pattern	Moricaud pattern	S–M pattern	Normal	Total
$p^S p^M \times +^p$					
No. 5031	44	46	46	51	187
„ 5032	44	50	51	59	204
„ 5033	31	55	47	70	203
$+^p \times p^S p^M$					
No. 5034	46	71	83	60	260

From the table shown above, we learn that the female was trisomic ($p^S p^M +^p$) as to the second chromosome. Consequently, among the larvae with the striped pattern, there are two types, i.e. p^S+^p and $p^S+^p+^p$, and similarly, the larvae with moricaud pattern are either p^M+^p or $p^M+^p+^p$. This was substantiated by cytological observations. Thus, it seems certain that B.H.C. has induced irregularity in the chromosome distribution, and a supernumerary chromosome has been added to the ordinary $2N$ chromosome set at the maturation division of the spermatocyte.

D. POPULATION GENETICS OF SOME INVERTEBRATES

(Report by Taku KOMAI)

I. The Lady-beetle, *Harmonia axyridis*

1. Geographic and temporal variation in the relative frequency of pattern types and in the frequency of elytral ridge

The various types of elytral pattern are due to a set of multiple-allelic genes. The relative incidence of these genes considerably varies

in different localities. Samples were obtained from 26 localities in Japan as well as in Korea and Manchuria. The geographic variation shows a gradual change so as to present a distinct cline in respect to this character. An abrupt gap, however, may be found at the Strait of of Tsugaru (the so-called Blakiston Line) and also at the Korea Strait. A similar geographic variation is found in the frequency of the individuals provided with a ridge near the distal end of the elytra. The presence or absence of this ridge is governed by a set of Mendelian genes, the gene for its presence being dominant. Furthermore, temporal variation (variation according to the difference in time) has been observed in materials collected in some localities. Materials collected on different occasions with 20 to 40 years' interval have been compared. The materials from Sapporo and Suwa at least, show a distinct change which took place during 20 years and 40 years respectively. This change may be seen in the incidence of both elytral pattern and the elytral ridge.

2. *Microgeographic variation*

There have been found, in the range of distribution of this beetle in Japan, at least two 'islands' which comprise characteristic populations very different from the neighboring populations. One is at Sanagé in Aiti Prefecture, visited last year by KOMAI and HOSINO. The beetle populations inhabiting pine-tress in this district are characterized by having a surprisingly high percentage of the otherwise extremely rare type, *axyridis*, while the populations inhabiting other plants, wheat, fruit-trees, etc., are practically identical in composition to the populations in the neighboring localities. It has been known that the aphids infecting the pine are different from those infecting other plants. We are, however, ignorant of how this difference in food aphids is connected with the difference in the beetle population. Another example of this beetle showing very different composition from those in the neighboring localities is that of Kamikawa in Hokkaido. Here, the composition as a whole is very different from the samples coming from other localities in Hokkaido. However, I have no knowledge of the food aphids of this example. Further inquiry is under way.

(T. KOMAI, and Y. HOSINO: Contributions to the evolutionary genetics of the lady-beetle *Harmonia axyridis*. II. Microgeographic variation. To appear in the July 1951 Number of 'Genetics')

II. The Land-snail, *Bradybaena similaris*

This common land-snail has four distict color and banding types, namely, yellow plain, yellow banded, purple plain and purple banded. These are known to be due to a set of triple-allelic genes. 83 popula-

tion samples of this snail from 62 different localities in Japan have been examined for the relative incidence of these genes. Generally speaking, samples from localities of the same district in Japan show similarity. There are occasional cases, however, in which samples from adjacent localities have very different composition. Also, distant colonies may have very similar composition. When compared with the study on the lady-beetle stated above, or the study on *Lymantria* by GOLDSCHMIDT, the absence of any cline in the land-snail in contrast with its presence in those insects appears striking. It is obvious that this difference is correlated with the difference in the capacity of migration between the two kind of animals.

III. The Butterflies, *Zephyrus taxila* and *Colias hyale*

The female of the Lycaenid butterfly *Zephyrus taxila* common in the mountainous districts in Japan has four distinct color types, namely, plain dark-brown, dark-brown with a light-brown marking on the fore-wing, dark-brown with a bluish marking on the fore-wing, and dark-brown with both the light-brown and bluish markings on the fore-wing. It has been postulated that these color types are produced by a set of triple-allelic genes. Four population samples of this butterfly from different localities of Nagano Prefecture comprise these four types, and the relative incidence comforms well with the postulate given above. No similar case has been recorded for butterflies.

Genetic studies on the Pierid butterfly *Colias hyale* are being pursued by S. AÉ, a student in the Kyoto University under KOMAI's direction. So far it has been confirmed that the white wing color character is due to a sex-controlled dominant gene *W*, and the homozygote *WW* seems to be viable at least in some cases. Population samples of this butterfly from different localities of Japan are being gathered. It is expected that the relative incidence of the genes for yellow and white color will show geographic variation.

E. PHYSIOLOGICAL GENETICS OF DROSOPHILA

(Report by Taku KOMAI)

OGAKI, with J. KITADA of Kyoto University, is working on the power of resistance to cold of various species and strains of *Drosophila*. Various strains of *D. melanogaster*, *D. virilis* and *D. americana* which had been kept at 25°C for a number of generations, were used. Practically all individuals of *D. melanogaster*, when kept at 0°C died within 30 hours. However, some individuals of *D. virilis* could withstand 0°C for 200 hours. Difference in power to withstand cold may be found among

various strains in both species. The strains showing mutant characters are not necessarily inferior in this respect to wild strains. F_1 usually has a higher power of resistance than either parent strain.

OGAKI is also working on the power of resistance to the effect of $CuSO_4$ in various strains of *D. melanogaster*. Different strains showed different powers of resistance to this chemical. The ranking of different strains as to this power does not coincide with the ranking as to the resistance to cold, indicating that the powers of resistance to cold and chemical are not merely manifestations of general vitality.

OGAKI, with T. YAGI of Kyoto University, is working on the induction of mutation by means of the photo-sensitive substance 'Illuminol'. Larvae of *D. melanogaster* were dipped in 0.01 aqueous solution of illuminol R II for one hour, and then illuminated with 100 w electric lamp through a Mazda VR 3 infra-red filter for 5 hours. A number of abnormal flies—mouthless, abnormal abdomen, Notch, half-thorax—appeared. Crucial genetic examination of these abnormal individuals is under way.

F. ENDOCRINOLOGY OF SOME INSECTS

(Report by Taku KOMAI)

KAJI has worked on the metamorphosis hormone of the moth *Phyrosamia cynthia ricini*. When a thoracic leg of the larva before the critical stage is transplanted to an older larva, the leg undergoes metamorphosis in consonance with the host. However, when a leg of the larva which has passed the critical stage is used, it undergoes metamorphosis by itself. For instance, a thoracic leg of a third-instar larva, transplanted to a fifth-instar larva, became a pupal leg, skipping the fourth- and fifth-instar stages. Also, a thoracic leg of a fifth-instar larva transplanted to a third-instar larva, underwent metamorphosis, after making two excess molts, in unison with the metamorphosis of the host. These experiments seem to indicate that, in the former case the larval leg of the transplant degenerated under the influence of the pupation hormone, whereas the development of the adult leg rudiment contained in that leg was accelerated; in the latter case the development of the adult leg rudiment was interrupted by the molting hormone.

In another experiment, in which a thoracic leg of a fourth-instar larva which had passed the critical stage was transplanted to a fifth-instar larva, the transplant molted when the host pupated, and the former became a pupal leg when the latter became an adult. This experiment apparently shows the identity of the pupating hormone and the imaginating hormone.

KAJI, with K. HAYASHIYA of the College of Textiles Fibers, Kyoto Technical University is working on the effect of metamorphoasis hormone on

different kinds of insect. These workers injected an extract from silkworm pupae or prepupae into larvae of the fly *Lucilia*. They also injected an extract of *Lucilia* prepupae or pupae into silkworm larvae. In both cases, the extract seemed to induce pupation in the operated larvae. The extract of *Lucilia* was apparently more effective on the silkworm, than the extract of the silkworm on the *Lucilia* larvae. The effective substance is soluble in water, acetone or alcohol, but insoluble in chloroform or petroleum ether, and is relatively resistant to high temperature or acid. Further work is being pursued.

KAJI, with Prof. M. ICHIKAWA of Kyoto University, has examined the function of the corpus allatum, by transplantation and ligature methods, using various stages of silkworms as material. The corpus allatum, when transplanted singly, did not induce molting; but when it was transplanted with the prothoracic gland, it induced molting. This result indicates that the prothoracic hormone can probably induce both pupation and imagination, and this activity is converted by the corpus-allatum hormone into molt-inducing.

KAJI, with Prof. M. ICHIKAWA and two students in Kyoto University, has examined the endocrine activity of the brain in Lepidoptera. Brains of fifth-instar silkworms were transplanted into fifth-instar larvae or prepupae of the butterfly *Luehdorfia japonica*, which has a very long (eleven months) pupal period. This operation evidently accelerated the metamorphosis of the pupal host, which developed very nearly to a butterfly in 3 to 4 months. The hormone from the transplanted silkworm brain apparently activated the prothoracic gland, and induced metamorphosis.

G. GENETICS OF SOME CEREALS

(Report by Seiji MATSUMURA)

1. Radiation Genetics Conducted on Cereals

Chromosome aberrations in einkorn wheat. Dormant seeds of *Triticum monococcum* L. var. *vulgare* KÖRN. were exposed to unfiltered X-ray irradiation, which was applied at 90KVP, 3 mA tube current and 15 cm distance for 12.5 to 62.5 minutes. The doses ranged from 2,700 to 13,500 *r* units. The frequency of chromosome aberrations (mostly reciprocal translocations) in the PMC's increased in a parabolic relation to the dose. The relatively small increase of the frequency at high doses has been assumed to be partly due to limitations by the "saturation effect". At the same dose (8,100 *r*) and target distance (15 cm) the aberration frequency decreased with an increase of wave lengths of X-rays obtained by varying the kilovoltage and the time of exposure (comp. MATSUMURA 1946: Prel.

Rep. in Jap. Jour. Gen. 21).

If the two-hit aberrations are due to two separate breaks, their new recombination should be limited in time and space. The effect of different wave length was studied by keeping both the dosage (8,100 *r*) and the time of exposure constant (296 min.), and changing the target distance. There has been found similar relation between frequency and wave length. These facts can be explained on the basis of the difference in ionization distribution within nuclei and chromosomes. In the case of hard X-rays, the majority of the total ionization produced by the electrons is more scattered than in the case of soft X-rays. The chromosome breaks induced by hard-ray radiation are generally scattered on different parts of chromosomes or on different chromosomes, so that the interchange between different parts occurs more readily than in the case of soft radiation, where the breaks are closely adjacent and the restitution of broken ends more commonly results (comp. MATSUMURA 1949: Prel. Rep. in Jap. Jour. Gen. 24).

In most of the cases of induced chromosome aberrations found in *T. monococcum* ④+5_{II}, often $6_{II}+2_{I}$ and seldom ④+$1_{IV}+3_{II}$ or ⑥+4_{II} have been observed, while in tetraploid plants, cases of loss of a whole chromosome or the deficiencies or duplications of chromosome pieces besides translocations have been confirmed. These findings may be understood by assuming the necessity of at least two complete genomes in the diplophase.

Chromosome aberrations of the same kind were also induced by fast neutrons and γ-rays. The preliminary accounts on dosage and aberration frequency relation found in these experiments have been published previously (comp. "Cytologia Vol. 16, 1951," MATSUMURA: Radiation genetics in wheat. I. Chromosome aberrations in einkorn wheat induced by irradiation).

Mutations in barley. Dormant seeds of *Hordeum distichum* were subjected to X-ray treatment (30–100 KVP, 8,100–16,200 *r*). Various kinds of mutants were found among the F_2 progeny of the irradiated seeds. These mutants showed chiefly chlorophyll abnormalities: albinistic, yellow, virescent, striped, shrivelled, fused, etc. There also appeared mutations in morphological and physiolosical characters of mature plants, such as: sterile ear, compact ear, dwarf, narrow leaf, early and late maturity. Most of these mutants behaved like simple Mendelian recessives. Of these the early maturity and compact ear (short culm) are apparently useful for breeding purposes (MATSUMURA, MOCHIZUKI and SUZUKA 1950: Rep. KIHARA Inst. Biol. Res. 4).

2. *Nullisomics Deficient in a Chromosome Pair of the D-genome Found in Pentaploid Wheat Hybrids*

Dwarf plants possessing 40 chromosomes occasionally appear among the offspring of the pentaploid wheat hybrid, *Triticum polonicum* (AABB) $\times$ *T. Spelta* (AABBDD). These are nullisomics with the sterile combination 20_{II}, deficient in a chromosome pair among the D-genome. If the 7 chromosomes of the D-genome are designated as a, b, c, d, e, f and g, 7 different nullisomics which might be called a-~g-dwarfs, according to the missing D-chromosome pair, are theoretically possible. MATSUMURA (1947) has actually been able to find all these 7 different dwarfs. Among the total of 25 different dwarf lines so far secured, 6 have been recognized as g-, 5 as f-, 6 as e-, 3 as d-, 2 as c-, 1 as b- and 2 as a-dwarfs. These lines differ in their fertility and morphological characters, according to which chromosome pair of the 7 is missing.

Among the offspring obtained by selfing these dwarfs, some unexpected *gigas*-plants with high fertility and more than normal height have been found. Such giants appear most frequently in the b-dwarf line; as a matter of fact, one-third of the offspring of this line was *gigas*. These *gigas*-plants are respectively called a-~g-*gigas*, according to the original 7 dwarfs (comp. MATSUMURA 1950: Cytogenetics and Breeding of Wheat, Tokyo).

The hybrids of these 7 different *gigas* strains with *T. polonicum* mostly show the chromosome conjugation $1_{III}+13_{II}+6_{I}$, unlike the combination $14_{II}+7_{I}$ found in F_1 *T. Spelta* $\times$ *T. polonicum*. In the hybrids with *T. Spelta*, the configurations $1_{III}+19_{II}+1_{I}$ and $20_{II}+2_{I}$ were most commonly met with, and in the case of b- and f-*gigas* also 21_{II} and $1_{IV}+19_{II}$ were frequently observed. In the different *gigas*-plants, therefore, the excess chromosome pair must have been derived from the A- or B-genome. It has further been assumed that b- and f-chromosomes have many segmental similarities with the excess pair derived from the A- or B-genome.

The hybrids between the different *gigas*-plants originating in the same dwarf line showed mostly the configuration 21_{II}, and sometimes $1_{IV}+19_{II}$ ($1_{III}+19_{II}+1_{I}$, $20_{II}+2_{I}$). Thus, the excess chromosome pair of the different *gigas*-plants from the same dwarf line is always identical. On the other hand, the hybrids between different *gigas*-plants derived from different dwarf lines (e.g. a-*gigas* $\times$ b-*gigas*), had the conjugation $20_{II}+2_{I}$ and $1_{III}+19_{II}+1_{I}$ (seldom 1_{IV}). Therefore, there is no doubt that the supernumerary chromosome in different *gigas*-lines is different. Such chromosomes could be called α, β, γ, δ, ε, ζ and η according to whether they have originated in a-, b-, c-, d-, e-, f- or g-*gigas* plants The chromosome a is semi-homologous to α, b to β, c to γ, d to δ, e to ε, f to ζ and g to η, α–η belonging to the A- or B-genome.

Dr. SEARS recently obtained all the 21 possible nullisomics in *Triticum vulgare* var. Chinese Spring. The writer is now studying the hybrids of these nullisomics with his a-~g-dwarfs. The results will be reported later.

3. *Genome-analysis in Agropyrum, a Genus Related to Triticum*

The genus *Agropyrum* comprises 3 sections; namely, *Euagropyrum*, *Elytrigia* and *Roegneria*. Intrasectional hybrids are easily obtained, but it is difficult to get intersectional hybrids (comp. MATSUMURA 1948: OGUMA Comm. Vol. Cyt. Gen. 1).

Among the hybridization experiments between *Triticum* and *Agropyrum*, that between *Triticum* and the *Elytrigia*-section is feasible, while the crossing of *Triticum* with *Roegneria*, an allied plant commonly distributed in Japan, has been unsuccessful. In the hybrid, *T. turgidum* (AABB)×*A. glaucum* ($2n=42$), there appear 5–10 gemini with the mode at 7. Also the hybrid *T. Spelta* (AABBDD)×*A. glaucum* has 2–11 gemini with the mode at 6. *A. glaucum*, therefore, apparently has a genome homologous with one of the *Triticum*-genomes, either A or B. It is difficult to decide whether this genome is A or B, because the hybridization of *A. glaucum* with einkorn wheat (AA) has been unsuccessful.

In the hybrid, *T. Timopheevi* (AAGG)×*A. glaucum*, 2–10 gemini (mode at 5) appear. As *T. Timopheevi* has the A-genome of *Triticum*, the mode of the gemini number is expected to be at 7. It is inferred from these facts that one of the genomes in *A. glaucum*, which is homologous with one of the *Triticum* genomes, is B (comp. MATSUMURA 1949: Jap. Jour. Gen. Suppl. 2).

According to these results the following genome formulae are assumed:

Euagropyrum	*A. cristatum*	HH
Elytrigia	*A. glaucum*	BBEEFF
	A. obtusiusculum	BBEEFF
	A. elongatum	BBEEEEFFFF
Roegneria	*A. ciliare*	IIKK
	A. semicostatum	IIKKLL
	A. Mayebaranum	II????

4. *Other Studies on Wheats*

a. *Triploid hybrids.* Hybridizations have been carried out in all possible triploid combinations between emmer wheat (AABB) or *T. Timopheevi* (AAGG) and einkorn wheat (AA). Crossing of einkorn wheat with *T. Timopheevi* has yielded distinctly lower setting and germination than the cross with emmers. The F_1-plants, however, grew more vigorously

than either parent, with the exception of the case of the crosses with *T. dicoccoides* or Khapli (*T. dicoccum*). The F_1 from *T. dicoccoides* or Khapli × *T. monococcum* died in the seedling stage, while the F_1 from *T. dicoccoides* or Khapli × *T. aegilopoides* were dwarfs, only 30 cm in height.

Chromosome conjugation in the hybrid *T. Timopheevi* × einkorn is relatively more frequent, and apparently more complicated than that in the hybrids between emmers and einkorn. This is rather surprising in view of the presence of a tetravalent occasioned by a translocation in the former. In *T. Timopheevi* × einkorn, the chromosome conjugation $1_{IV}+5_{II}+7_{I}$ was the commonest; even a penta- or hexavalent chromosome was sometimes observed, and the number of conjugated pairs varied from 5 to 7. In emmer × einkorn, on the other hand, the number of bivalents varied from 3 to 7, the mode being at 6. There have been found as many as three trivalents (once 4 trivalents), occasionally a tetravalent. Presumably 6 chromosomes from the A-genome of the emmer conjugate with those of A-genome in the einkorn, and at least one chromosome in both the A-genomes is semi-homologous. Furthermore, the A-genome of *T. Timopheevi* is apparently closer to the A-genome of the einkorn, than to the genome A of the emmer. The G-genome of *T. Timopheevi* also seems to be semi-homologous with the B-genome of emmer, and somewhat akin to the A-genome of the einkorn.

All the F_1-hybrids of these crosses were entirely or nearly sterile. All the 8 F_2-plants, obtained from open pollination, had nearly 28 or more chromosomes. Some of these had undoubtedly been derived from pollination by dinkel. But no mature offspring was produced by artificial back-pollination or pollination of dinkel. In F_3 and later generations the offspring with 28 chromosomes had gradually recovered their fertility, and they showed the appearance of the emmer type (MATSUMURA 1950: Rep. KIHARA Inst. Biol. Res. 4).

b. *The manifold effects of the lone-glume gene P.* An awnless tetraploid with long glumes (*PP*) was crossed to *T. dicoccoides* ($2n=28$), and another tetraploid with short glumes (*pp*) to *T. persicum* ($2n=28$). In the F_2 of these crosses long glume (*P*), awnless (*A*), hairy glume (*Hg*) and red coleoptile (*Rc*), in contrast respectively to short glume (*p*), awned (*a*), glabrous glume (*hg*) and green coleoptile (*rc*), were recongnized; the difference in each case is obviously due to a single gene. The difference between waxy and waxless is produced by a pair of the basic alleles *W-w* and their inhibitors *Iw-iw*. The genotype of the waxless *T. dicoccoides* is *wwIwIw*, and in the F_2 the ratio 13 waxless : 3 waxy is ordinarily observed. *W* and *Iw* show segregation independent of the genes *P*, *A* and *Hg*. *P-p* is linked to *Rc-rc* with a cross-over value of 20.3%. *P* gene for the long glume of *T. polonicum* with manifold effects inhibits in its homozygous state awn length, glume hair, coleoptile color

and awn color.

Two abnormalities have been observed in crosses between tetraploid wheats. The first, apparent failure to segregate, was reported by BIFFEN (1916) in a cross between a white-chaffed *T. polonicum* and a grey-chaffed *T. turgidum*. A similar phenomenon involving chaff color and hair was found by BACKHOUSE (1918) and ENGLEDOW (1920) in the cross *T. polonicum* × *T. durum*. The writer, on the basis of his own finding outlined above, is inclined to believe that these abnormalities are due to the inhibition of the *P*-gene. The second case of abnormality was found in glume length by ENGLEDOW (1920, 1923) in a cross *T. polonicum* × *T. durum*, who termed the phenomenon "shift." This abnormality could be explained also by postulating a major gene *P* and multiple modifiers. DARLINGTON (1928) and WATKINS (1940) consider that these two abnormalities reported for tetraploid wheats are examples of the outcome of autosyndesis in polyploid plants. My own experiments, however, have revealed that this is not the case (MATSUMURA 1950: Jap. Jour. Gen. 25).

5. *Cytogenetic Studies on Wheat-Rye Hybrids*

(Report by Tôru ENDÔ)

It has often been suggested that the wheat- and rye-genomes have been differentiated from a common ancestral genome. This hypothesis is based on the so-called semi-homology between the genomes of the two genera.

It was in 1889 that RIMPAU established the first *Triticale* strain in Germany. This finding was followed by a number of similar hybrid strains raised by many investigators who also carried out cyotological investigations on these strains.

ENDÔ pursued some cytological studies on RIMPAU'S *Triticale*, and reported his findings in 1949. These findings are essentially the same as those by the previous authors. The same kind of abnormalities in meiosis such as non-pairing and some other irregularities of chromosome behavior have been observed.

ENDÔ has suggested that a considerable number of segmental exchanges have taken place between genomes, as well as within the same genome during some sixty years since RIMPAU'S work and also that the rye-genome within the wheat plasm may have received some influence from the latter.

To examine whether this kind of alteration of genomes might be found, crosses were made in the spring of 1950 between rye and RIMPAU'S or other *Triticale* strains which were originally established in Russia as long ago as RIMPAU'S time. While many seeds were obtained from such crosses, most of them failed to germinate, and only a few seedling

developed. ENDÔ is now intending to make cytological examinations of these hybrid plants, and also to raise back-cross progeny.

6. *Determination of Right- and Left-handedness in the Spikelet of Triticum monococcum vulgare**

(Report by Motô KIMURA)

In Einkorn wheat, every ear has two sides, namely, one in which left-handed spikelets are predominant and the other in which right-handed spikelets are predominant. We can define the "handedness" of the spikelet by the situation of the first flower viewed from the dorsal side, designating it as left-handed if the first flower is on the left side and as right-handed if it is on the right-side. Each spikelet may conform or contradict, as regards its handedness, the prevailing tendency in the row to which the spikelet belongs, and the term "concordance" or "discordance" is used to designate the propensity of the spikelet.

Assuming that the determination of the handedness is controlled by the threshold reaction and that external influences as well as the specific potency are responsible for its determination, the relative values of the potency denoted by Y will be calculated by finding the "probit" of concordance proportion from the FISHER and YATES' statistical tables and subtracting 5 from it. 1) From the examination of 821 ears, we have constructed by this method curves showing the relative values of the potency in various parts of the ear. It has been found that the determination in any spikelet is not indifferent to that of the state of the neighboring spikelets. If $Y_{\bullet x}$, $Y_{\circ\bullet x}$, $Y_{\circ\circ\bullet x}$, etc. respectively be the values of Y in the xth spikelet (numbered from the lowest one), when the spikelet immediately below it ($(x-2)$th), the second one below ($(x-4)$th), the third one below ($(x-6)$th) and so on in the same row, become discordant, it has been found that:

$$(1)\quad Y_{\bullet x} < Y_{\circ\bullet x} < Y_{\circ\circ\bullet x} < \ldots \leq Y_x ,$$

where Y_x is the value of Y calculated independently for the xth spikelet. This shows that the more distant the discordant spikelet becomes, the smaller is its effect on the decrease of potency. On the other hand, if $_{\bullet}Y_x$ is the value of Y in the xth spikelet when the spikelet immediately below but belonging to a different row ($(x-1)$th spikelet) becomes discordant, then

$$(2)\quad {}_{\bullet}Y_x \leq Y_x \ (x \leq 14), \quad {}_{\bullet}Y_x > Y_x \ (x > 14) .$$

This fact might be explained by assuming that the tendency of bipolar polarization as regards the left- and right-handedness gradually decreases upwards on the ear until replaced by that of the unipolar one.

* Work by H. KIHARA, M. KIMURA and H. ONO.

Also it has been found that the influence produced by the simultaneous discordance in $(x-1)$th and $(x-2)$th spikelets is equal to the sum of the effects produced by the discordance of each spikelet independently:

$$(3)\quad {}_{\bullet}Y_{\bullet x}={}_{\bullet}Y_{x}+Y_{\bullet x}-Y_{x}$$

2) The relative values of the potency for the determination of left- and right-handedness have decreased as a result of X-ray irradiation in an early stage of the ear development. 3) In the cross between Einkorn wheat having a high potency and Emmer (*T. turgidum nigrobarbatum*) wheat having a low potency, it has been found that the relative value of the potency in F_1 is approximately equal to the mean value of the potencies in the two parents.

H. GENETICS OF FERTILITY AND SEXUALITY IN PLANTS

(Report by Yô TAKENAKA)

1. Sterility of Triploid Plants

Among the wild and cultivated triploid plants which have been collected and examined cytologically by the writer up to this time, there have been found four types to be distinguished on the basis of the degree and form of sterility. Of these types three give a few seeds either by natural pollination, by water culture of the cut flower-stem, or by crossing with its ancestral diploid, but the last type never gives seed by any treatment, as far as I have been able to determine.

a) *Hemerocallis* type

This type has been found in the triploid plants of the genus *Hemerocallis* in which the cross *inter se* and also the cross with diploid plants including their reciprocals are perfectly sterile.

The sterility may be due to some of the following causes: (1) irregularities in meiosis, (2) exceedingly short life of each flower, which is insufficient for allowing the style to wait for the delayed maturation of the embryosac as is usual in triploidy, (3) a part of the embryosac, mainly the egg nucleus, often becoming necrotic during its development, as is usually the case in polyploid plants. (4) It is also possible that their ancestral diploids have already perished, or even if they are present, the phylogenetic relations between the assumed diploid ancestor and the present triploids have become too remote in the course of evolutionary process.

Among the plants cytologically investigated by the writer, *Daphne odora* THUNB., *Crocus sativus* L. and *Zingiber Mioga* ROSC. (pentaploid) probably belong to this type.

b) *Lycoris* type

This type is found in triploids of the genus *Lycoris*, such as *L. squamigera* MAXIM. and *L. radiata* HERB. Although these plants apparently are completely sterile in the field, a quantity of seed can be gathered by the water culture of the cut flower-stem.

The sterility of these triploid plants under natural conditions is probably due to one or both of the following causes: (1) irregular meiosis, (2) a situation such that ferltilization may occur during the long life of each flower, but the proportion of fertilized embryosacs is too small to produce a ripe capsule, because of a struggle for nourishment between the fertilized embryosacs and the subterranean bulb, in which the few fertilized embryosacs fail to compete successfully with the bulb.

c) *Lilium* type

In *L. tigrinum* KER-GAWL, hardly any ripe seeds can be secured either by self-pollination or by intraspecific hybridization; only the hybridization with pollen of *L. Maximowiczii* REGEL. (diploid species) gives some germinating seeds, while the reciprocal cross produces none.

As the cause of this phenomenon may be assumed: (1) irregular meiotic division; (2) the life of each flower being so long as to permit embryosacs or ovules in the flower to be capable of maturing though in delayed condition; or (3) the presence of the ancestral diploid species. Accordingly, only a small proportion of such a cross gives some seeds.

d) *Crocus vernus* type

As is seen in the triploid garden varieties of *Crocus vernus*, some seeds may be obtained by natural pollination.

This rather high fertility for a triploid plant seems to be due to either, (1) the meiosis being less irregular than that usually found in other triploid plants, or (2) the genome of these plants consisting of several subgenomes, so that the plants are actually polyploids of a higher order than ordinary triploids.

The comparatively long life of each flower may also be a contributing factor.

2. *Sterility and Autotoxicosis of Colchicum autumnale*

Colchicum autumnale is generally found to be a sterile plant in the middle and southern parts of Japan. Its somatic cells contain 38 mitotic chromosomes, as shown by LEVAN. These chromosomes are not only of various sizes, but also show some features resembling fragmented or attached chromosomes.

At ordinary temperatures, the maturation division of PMC's shows not only swelling, stickiness, abnormal conjugation and abnormal distribution of chromosomes, but also delayed nuclear division, and in some cases, even the dissolution of the nucleus. Especially, the formation of

the cell plate is very incomplete or does not occur at all. Accordingly, monad and dyad microspores instead of tetrads, are found in a large majority of cases. In extreme cases, very small microspores without any chromosomes are occasionally found. These abnormalities are strongly suggestive of the change found in cells after the colchicine treatment for a rather long time or at a high concentration.

In material cooled at 5°C for 24 hours, however, the abnormal chromosome features and behaviors mentioned above become less frequent, the most remarkable sign of recovery from the abnormality being the formation of a cell plate in the phragmoplast of PMC, which is probably already in the tetrad stage. Thus, low temperature apparently weakens the effect of colchicine on the plant.

In material which had been kept for the first 2 days at about 10°C, and for the following 2 days at about 20°C, the maturation division was apparently nearly normal. However, many *C*-pairs appeared on the nuclear plate probably owing to the effect of colchicine toxication received before being subject to low temperature.

This phenomenon probably shows the threshold of the colchicine effect.

Almost all the pollen grains formed at either ordinary temperatures or the low temperature mentioned above belonged to the monad or dyad type, the fragmentary spores being probably devoid of any chromosomes, chromosome fragments or micronuclei.

Thus, it has been demonstrated that the meiosis becomes very irregular in *Colchicum* even under the climatic conditions at Misima, and that the irregularities differ significantly from those observed in hybrids or heteroploid plants and those produced by high- or low-temperature treatment. Rather, they seem to be analogous with the meiotic irregularities which appear under the influence of colchicine-treatment.

Under the influence of high temperature the swelling of cells occurs, which induces some change in the nature of the nuclear membrane, so as to allow colchicine molecules to penetrate through the cytoplasm into the nucleus and to combine with the polypeptid chains of the attractoplasm. Accordingly, the deleterious effect characteristic of colchicine toxication results, as well as abnormal features and chromosome behavior in nuclear and cell division.

Thus, *Colchicum autumnale* apparently becomes a sterile plant as a result of the relatively high atmospheric temperature which is prevalent in the middle and southern parts of Japan.

3. Karyotypes and Sterility in Hemerocallis

Under the title, "Karyological studies in *Hemerocallis* (1929, Cytologia)" I reported many years ago my findings of the cytology of many species of day lily. Further karyological and genetic studies on some other

materials are under way.

So far, karyotypic analyses have been carried out on 28 species, varieties, forms and garden varieties of this genus. The fundamental chromosome number in this genus is 11. These chromosomes can be classified into seven distinct types according to their shapes. All the karyotypes investigated contain either some or all of these types in various combinations.

The taxonomy of this genus is considered very difficult on account of the variability in their morphological characters, which obscures the specific distinction. The karyotype characters show the same kind of variability.

All triploid plants in this genus show complete sterility not only in self- and sister-pollination, but also in crosses between different species or varieties including many diploids.

This sterility of the triploid plants may be largely attributed to irregularities in meiosis which result in the formation of incomplete pollen grains and embryosacs. The embryosac, especially, is considerably delayed in maturation, and frequently contains necrotic tissue.

As for chromosome numbers, only diploid ($2n=22$) and triploid ($2n=33$) numbers have been ascertained. STOUT (1932) has assumed 6 to be the basic chromosome number. As stated above, I hold a different view, based on my own observations on karyotypes and chromosome behavior in PMC's of a large number of diploid and triploid plants.

4. *Studies on Sex-differentiation in Higher Plants*

From 1938 to 1943, experimental studies were conducted on sexual characters in higher plants, in the cases of colchicine-induced polyploidy, aneuploidy and other chromosome aberrations with various dioecious plants including *Rumex acetosa* L. as material. The preparations and records used in this study were left in the Biological Institute of Keijo (Seoul) University in Korea, where I had a position. As there is no hope of restoring them at least for the time being, I wish to give here a brief note of my observations based on some fragmental records at hand.

Among the crosses between tetraploid females induced by colchicine treatment and normal diploid males of *Cannabis sativa*, one strain contained among the offspring 7 females, 5 intersexes and 2 males. The chromosome constitutions were $3A+3X$ in the female, and $3A+2X+Y$ or some of its derivatives in the intersex, as well as in the male. Both YAMADA'S finding (1943) that the Y-chromosome was larger in size than the X-chromosome, and WARMKE and DAVIDSON'S assumption that the Y-chromosome influences the appearance of male characters, are considered to be largely correct.

In the crosses between tetraploid females induced by the same treatment and original diploid males of *Humulus japonicus*, one strain gave offspring consisting of 18 females and 7 intersexes. These females and intersexes showed respectively $3A+3X$ and $3A+2X+Y_1+Y_2$ in their chromosome constitutions. This observation agrees well with ONO's assumption (1941) that the sexuality of this plant is determined mainly by the ratio of the *X*-chromosome to the autosome. Similar studies were conducted on *Humulus Lupulus*, *H. Lupulus* var. *cordifolius*, *Asparagus officinalis* var. *altilis* and *Spinacia oleracea*.

The same kind of experiments were resumed in 1950, with the hope of discovering the relationship between chromosome- or choromosome-set aberrations and sexuality in various dioecious plants, by using the colchicine and radiation methods, and to reexamine my previous findings and the results obtained by other workers.

5. *Sterility of Phaseolus multiflorus under High Temperature*

(Report by Akira MIYAZAWA)

Phaseolus multiflorus commonly bears fruits in cool regions in Japan, but in milder regions the yield is much lower. This fact suggests incomplete development of reproductive organs in this plant as a result of high temperature. It has been found that the flower buds which pass the metaphase stage of the first maturation division from the end of August to the middle of September, bloom in about 14 days. Measurement was taken of the size of pollen grains during the period from September 2 to October 11. It has been found that the pollen grains range between 35 and 70 μ in diameter. The percentage of empty pollen grains amounted to about 20 percent of the whole number examined under the microscope on September 2. The size of such pollen grains varied from 40 to 70 μ. The percentage of empty grains gradually fell when the season advanced, to 3.9 percent on September 18, and 2.3 percent on October 1. The percentage fluctuated to some extent, but never became as high as in the first part of September. The range of fluctuation in size also declined significantly. These facts become understandable, if correlated with the change in the maximum temperature during the period. It may be surmised that those pollen grains which included the highest percentage of empty and variable (in size) ones, had been in the maturation stage when the temperature was as high as 31°C.

J. GENETICS AND CYTOLOGY OF SOME FLOWERING PLANTS

1. Genetics of Flowers in Zinnia elegans

(Report by Kanji GOTOH)

The capitate flowers of *Zinnia elegans* are highly variable in respect to the number of petalous florets on the head. Between the two extremes, i.e. the completely single flower and the completely double flower, there are many transitional types which are difficult to assign to clear-cut classes.

This experiment has been undertaken to make clear the genetic behavior of petalody in *Zinnia elegans*. In 1950, several crosses between various flower types as well as selfing experiments were made.

2. Genetic Studies on Solanum melongena and Capsicum annuum

(Report by Kan-Ichi SAKAI)

The principal object of the present investigation is twofold:—first, the study of the quantitative-character genes and second, the study of heterosis. A number of selfings and inter- and intravarietal crossings within each of the two species were made during the past year, and they are now in the process of being grown preparatory to further investigation.

*3. Karyological Studies of Lycoris radiata**

(Report by Hitoshi KIHARA)

Many individuals of the wild plant, *Lycoris radiata*, have been collected from various localities in Japan for morphological and ecological investigations. The chief purpose of this study is to find out the karyotypical differences among those individuals which, if present, would be originated through somatic mutations, since this species constitutes a single clone. The results so far obtained show that the chromosome complement of this species consists of thirty-three i-shaped chromosomes.

From the pollination by its own pollen as well as by the pollen of *L. sanguinea* ($2x$), many ripe seeds were obtained, which were then sown for the purpose of obtaining diploid individuals.

* Work by H. KIHARA and F. LILIENFELD.

4. *Cytogenetic Studies on the Genus Nicotiana*

(Report by Yô TAKENAKA)

Although tobacco plants have long been investigated by plant breeders in Japan, cytogenetic studies are very few. The writer has been carrying out cytogenetic studies on the genus *Nicotiana* since the summer of 1950.

The number and behavior of chromosomes in the meiosis of PMC's in 5 wild species have been studied. Of these *N. plumbaginifolia*, *N. repanda*, *N. glauca* and *N. sylvestris*, have respectively 10, 24, 12 and 12 gemini, and all of them show completely regular meiotic cycles. One exceptional species among the five, *N. glutinosa*, shows some irregularity, i. e. a sign of secondary association among its 12 paired chromosomes.

The chromosome number and behavior of 3 artificial tetraploids, induced by the colchicine method at the Hatano Tabacco Exp. Station in 1944 and transplanted into our garden last spring, were also studied. The tetraploid plant of the 'Odaruma' variety of *N. tabacum* was found to have completely reverted to the original diploid state at some time during the 7 years of cultivation. The tetraploid plant of the 'Nambu' variety of *N. tabacum* has returned to forms with various chromosome numbers ranging from approximately tetraploid to diploid. The amphidiploid plant from *N. plumbaginifolia* × *N. alata* showed 19 bivalents in the 1st meiotic division, just as expected, and some irregular distributions in the 2nd anaphases.

5. *Some Effects of Sodium Ribose Nucleate on Somatic Mitosis of some Plants*

(Report by Kanji GOTOH)

Detailed interpretations of the so-called reductional-type divisions induced by sodium ribose nucleate in tissues of plants have already been given by HUSKINS (1948) and WILSON and CHENG (1949) on *Allium cepa* and *Trillium* species.

According to these authors, in the reductional-type divisions each member of the homologous chromosome pairs goes towards opposite poles in most of the cases. The present experiment was undertaken to reexamine the findings by these workers, and to clarify the mechanisms of synapsis and reduction in mitosis.

Root tips of *Tradescantia paludosa* ($2n=12$) were treated with 1% sodium ribose nucleate solution for 12~24 hours, and were fixed in NAVASHIN'S fluid. Sections were cut 12~18 μ in thickness and stained with HEIDENHAIN'S iron-alum hematoxylin.

The results obtained are as follows :—

1. In a few cells two separate chromosome groups, each with six shortened chromosomes, the number corresponding to those of the haploid set in the plants, were found lying not far from each other, or a group of twelve chromosomes about to divide into two groups.
   In a few other cells two clusters of chromosomes were found. These seem to have resulted from the separation of these chromosome groups.
2. In a very few cases abnormalities in the arrangement of chromosomes were observed at the metaphase. Further experiments are in progress.

K. STUDIES ON LOWER ORGANISMS

1. A Method of Meseasuring the Rate of Growth of Nuerospora sitophila

(Report by Tarô ITO)

For the investigation of growth of this mold in response certain amino-acids or vitamins, it is important to find an exact method of measuring the amount and rate of growth.

At present the following methods are commonly used. First, the test-tube method (BONNER '43); this consists in observing the growth response of the mold to substances added to the medium. Second, the dry weight method (HOROWITZ '46), of weighing mycelia cultured for 55 to 72 hours and dried at 100°C. The mycelia are killed at this stage, and there is no subsequent growth. Third, the horizontal-tube method, which consists in measuring the rate of elongation of mycelia along a glass tube during a certain time. By this method, only the mycelia which grow in contact with the inner wall of the tube can be measured, so that precision can not be expected. All these methods have some defects, and I have devised the following technique, in order to meet the two conditions; first, to be able to weigh at some regular intervals, and second, to secure the subsequent development of the organism.

A glass tube 8 cm long of known weight, is stuffed with cotton at both the upper and lower ends and sterilized at 120°C. The mycelia are inoculated into the lower part of the tube, which is inserted in a test-tube containing liquid media. For measurement, the glass-tube containing the mycelia is drawn out of the test-tube, and is weighed after being dried in a desicator for 10 minutes.

By this method, I have investigated the growth of *N. sitophila* in response to the basic medium to which various quantities of two ammonium salt, ammonium tartaric acid and a. nitrate, have been added. Thus, it has been estimated that the maximum growth occurs at $C/N=$

12.2, and that the lower the concentration of these substances, the greater is the rate of growth in the early stage of culture. It has also been shown that, when a medium inoculated with the mycelia, left from 32 to 64 hours, and filtered to remove all traces of mycelia, is used for the new culture of mycelia, the growth is accelerated as compared with cases in which fresh medium is used.

2. *Studies of the Virus Infecting Silkworm*

(Report by Mitsuo TSUJITA)

a. The Virus Particles and their Growth

The virus particles used in the present study were obtained by the ultra-centrifugation for from 1.5 to 2 hours at 35,000 or 40,000 R.P.M. of the polyhedra-free blood of jaundice-diseased silkworms. Electron micrographs show that the diameter of these particles ranges from 10 to 30 mμ. To clarify the formation process of the so-called polyhedral body, living material and fixed preparations of the tissue of the diseased insect were observed. In the first stage a number of minute particles appear. These grow into definite-shaped particles, which aggregate into polyhedral bodies. In the course of this process, diplococcus-like, ellipsoidal or bead-shaped bodies are formed—these seem to be the forerunners of the polyhedral bodies.

The diplococcus-shaped or ellipsoidal bodies emerge from the polyhedral bodies, when these bodies are dissolved in a dilute (0.3–0.5%) solution of alkali (sodium carbonate).

A great number of particles emerge from the diplococcus-shaped granules which are enclosed in a proteid membrane when the granules are dissolved in a dilute alkali solution. It has been found by electron-microscopic examination that some of these particles are square-shaped rather than spheroidal, with diameters varying from 50 to 100 mμ; there are also particles of linear shape, with length varying from 300 to 350 mμ and with width from 50 to 100 mμ. In some cases these particles emerge directly from the polyhedral bodies when the latter are dissolved in a dilute alkali solution.

Inoculation experiments have shown that the particles have a strong virulent capacity, suggesting that they represent a developmental stage of the virus in the cell.

The facts mentioned above show that the so-called polyhedral bodies are apparently made up of 3 components: i) an outer envelope, ii) non-infectious protein and iii) intermediate bodies which contain a number of virus particles.

It seems that the non-infectious protein which constitutes the greater part of the polyhedral body is a product of the intermediate bodies.

b. Resemblance between the Function of Genes and the Activity of Insect Virus

We have been able to observe under the microscope polyhedral bodies of various shape in the cells of certain lepidopterous larvae suffering from jaundice disease. These polyhedral bodies are known to be formed by virus. In the silkworm hexagonal inclusions are formed. In the larva of the tussur, *Antheraea prenyi*, infected by virus, pentagonal, square-shaped or triangular bodies are formed in the tissue. In the Eri-silkworm, *Attacus ricini*, similarly infected, granular bodies are formed instead, while in the larva of the moth *Ivela auripes*, comparatively large triangular bodies appear. Inoculation experiments with these four kinds of viruses have shown that the shape of the polyhedral bodies is largely determined by the kind of virus, regardless of the host. It is accordingly clear that the different shape of the polyhedral body is due to the variety of the virus itself.

It seems to me that this fact shows the similarity of the activity of virus to the activity of the gene. For example, the shape and nature of the pigment granules in the cells of the Malpighian tubules are controlled by the nuclear gene. After examining various races of the silkworm, Dr. KIKKAWA and I have classified the four types of pigment granules in the Malpighian tubules as shown in the table.

Table II.

Four types of pigment granules in the Malpighian tubule cells in the silkworm

Type	Nature of pigment granule		Race
	Colour	Shape	
1st type	dense yellow	granular, diameter 1–5 μ	KH 19, KH 21
2nd type	yellow	needle- or rod-shaped	Normal strain, w_2, bw_2 and some eye- or egg-colour mutants
3rd type	yellow	granular, diameter 1–3 μ	010, 011, Japanese No. 106
4th type	almost colourless	minute granular within 1 μ	*d*-oily, *o*-oily

My cytological observations have revealed that these pigment granules are the derivatives of mitochondria. Moreover, these mitochondria seem to arise from minute granules in the cytoplasm. Probably, under the control of a nuclear gene, these minute granules are formed by the self-duplicating particles in the cytoplasm, and develop into coarser granules or filamentous substances to be called mitochondria. In this manner the formation of the polyhedral body by virus simulates the mode of formation of pigment granules in normal cells.

L. IMPROVEMENT OF SOME USEFUL PLANTS

1. Improvement of Sugar Beet by Means of Induced Triploidy

(Report by Seiji MATSUMURA)

Improvement of sugar beet by means of induced polyploidy, has been continued since 1941 in the KIHARA Institute for Biological Research under the guidance of Prof. H. KIHARA. Recently, this work has gained the cooperation of the National Institute of Genetics, the Laboratory of Plant Breeding of the Hokkaido University, the Hokkaido Agricultural Experiment Station and the Japan Beet-Sugar Manufacturing Company.

The maximum yielding capacity of autotetraploid sugar beets is hard to estimate accurately, because of the late maturity of $4x$ plant especially since unfavorable weather conditions during the late period of growth or an inadequate term of cultivation greatly influence their yielding capacity. It seems thus reasonable to estimate the yield of $4x$ plant sometimes lower than that of $2x$ (MATSUMURA, MOCHIZUKI and SUZUKA 1950: Rep. KIHARA Inst. Biol. Res. 4). On the other hand, $3x$ beets are more vigorous, grow better, and always show a higher yield than the other beets, according to the experiments conducted in the Hokkaido Agric. Exp. Station during the years 1945–47. In 1949 and 1950, comparative studies on $2x$, $3x$ and $4x$ sugar beets were carried out on a large scale in various districts in Hokkaido. The results show that, as expected, the $3x$ beets are superior to either $2x$ or $4x$. It is further expected that the intervarietal $3x$ hybrids, for instance, between the high yielding $4x$ variety and the disease resistant $2x$, will bring still better yields. However, the inferior germination rate of $3x$ seeds comes into question; this should be solved as soon as possible.

For a large scale production of $3x$ seeds, the self-incompatibility of this plant can be utilized. If $2x$ and $4x$ beets are planted in alternate rows, $3x$ seeds can be obtained through natural pollination either from the $2x$ or $4x$ plants. Microscopic examinations of root tips have revealed that about 30% of the progeny raised from seeds of the $2x$ mother plants are triploid. Also, the seeds from the $4x$ mother plants produce more than 70% $3x$ plants. The frequency of the $3x$ plants, however, is varied to some extent by some factors, such as the ratio between the $2x$ and $4x$ plants, the difference in blooming season, the difference in pollen-tube growth rate of the parents (MOCHIZUKI and MATSUMURA 1950: Rep. KIHARA Inst. Biol. Res. 4).

2. *Genetics and Breeding of Citrus Plants*

(Report by Kazuo FURUSATO)

a. Cytological observations

In order to elucidate the relationships between various *Citrus* species, chromosome numbers, chromosome behavior at meiosis, and karyotypes are being investigated. Most of the *Citrus* species are diploid with 9 gametic chromosomes. Some are tetraploid with 18 gametic chromosomes, or triploid with 27 somatic chromosomes.

b. Polyembryony and comparative studies of individual nucellar embryo plants

The phenomenon of polyembryony is very common in *Citrus*. My task has been to elucidate this phenmoenon in various hybrids. Methods have been devised to make possible the growth of all embryos. The work is still under way.

c. Albino seedlings

In *Citrus* a certain percentage of albino seedlings usually appears, sometimes amounting to 10 percent or more. Almost all of them are of nucellar origin. Cytological observations and experiments are under way in order to explain the development of these albino seedlings.

3. *Induced Polyploidy in Useful Plants*

By colchicine treatment tetraploids of some useful plants such as water-melon, radish, sesame and others were obtained. Morphological and physiological studies have been carried out to examine the possible utility of these tetraploids.

a. Tetraploid water-melon

A tetraploid water-melon plant produces triploid and tetraploid progeny when it is pollinated by the mixture of pollen-grains of tetraploid and diploid plants, in the ratio of about 90 percent triploids and 10 percent tetraploids. Probably this ratio results from certation between haploid and dipoid pollen-grains.

b. Grafting of polyploid water-melons

In preliminary experiments young buds of a diploid water-melon plant were grafted on diploid, triploid or tetraploid stocks. The grafts on triploid stocks grew more vigorously and gave higher yields than the grafts on tetraploid stocks. Grafting of buds of diploid, triploid or tetraploid water-melon on calavash stocks gave very high yields. These results show that the grafting of tetraploid buds on calavash may be utilized for producing triploid seeds for commercial purpose. Such grafts give much higher yields than ordinary tetraploids.

c. Triploid water-melons of different combinations of varieties

Attempts are being made to get triploids of various combinations of varieties of water-melon from tetraploids. In 1950 tetraploids of the variety Kahô were obtained, and from them triploid plants were bred.

d. Triploid fruit trees

Attempts are also being made to obtain triploids of various kinds of fruit-trees, in the hope of getting seedless fruits.

e. Polyploid forage, green-manure crops and vegetables

Tetraploids of some leguminous plants such as lupin and alfalfa, as well as of fodder radish, have been obtained. Also tetraploids have been raised for some vegetables like carrot, edible burdock, *Luffa*, calabash, etc.

M. THEORETICAL GENETICS

1. Semiallelic Genes

(Report by Taku KOMAI)

The relation between two chromosomal genes falls into one of the following categories:—They may be located either, a. on different chromosome sets, or b. at different loci on the same or homologous chromosomes, or c. at the corresponding loci of the homologous chromosomes. In the first case one finds in the subsequent generation independent assortment of the genes; in the second case, linkage between the genes; and in the third case, segregation of the genes. In some cases a state between the above b and c is seen. These are semiallelic genes. The characteristics of this kind of genes are: 1. They have similar but distinct phenotypes; 2. they are arranged in direct sequence, with no other intervening gene; 3. when they are located on homologous chromosomes, their manifestation is partially covered: 4. they never or very rarely recombine. Examples of semiallelic gene sets can be given from various animals. Especially, the genes for the human blood-types, A–B–O, M–N–S, Rh°–Rh′–Rh″, probably belong to this category. If so, the rare and much disputed recombination cases should be admitted to be possible.

(cf. KOMAI T. American Naturalist 84: 381-392, 1950)

2. On Variance due to Competition between Plants of Different Types in Plant Populations

(Report by Kan-Ichi SAKAI)

Plants of two varieties of rice, apparently different in plant color, tillering and grain yield were mix-planted in a difinite manner to examine the effect of neighbors of different types on the weight and number of panicles per plant and the mean weight of a panicle, in each of the two

varieties. The experiment was conducted by the randomized block design with six replications. Results of the analysis of variance showed the difference between varieties to be statistically significant so far as the weight and the number of panicles per plant were concerned. So was also the difference due to the interaction between variety and treatment regarding the total weight of panicles per plant and the mean weight of a panicle. That is, the weight of panicles per plant, and the mean weight of a panicle are significantly affected by the neighbors, resulting in phenotypes respectively exaggerated or arrested as compared with the expectation from the genotype.

The variance in hybrid populations of plants may be due to either genetic or environmental causes. It has generally been accepted that the latter in segregating populations is identical to that in the parental or F_1 population. But the experimental results demonstrated above suggest that the variance in segregating populations comprises not only the environmental element in the usual sense, but also the element due to the competition between plants of different types. The theoretical estimations of the latter element are to follow.

(1) Variance due to competition within population after backcrossing F_1 to parents

In case of monohybird segregation, the sum of all increments in both backcross populations, which one plant will receive through competition with n plants surrounding it, will be,

$$\sum_{h=1}^{n} c_h^2 + \sum_{i=1}^{n-1}\sum_{j=1+i}^{n} c_i c_j + \sum_{h=1}^{n} \alpha_h^2 + \sum_{i=1}^{n-1}\sum_{j=1+i}^{n} \alpha_i \alpha_j \quad \ldots\ldots(1)$$

where c or α stands for the increment given to the plant through competition with the homozygous (AA or aa) or the heterozygous (Aa) hth individual.

If the plants are singly-spaced in rows, the variance exhibited by each plant due to competition with the surrounding eight individuals will be,

$$\sigma_c^2(BP_1+BP_2)=(c^2+\alpha^2)K \quad \ldots\ldots(2)$$

where $K \equiv 3k_1^2+3k_2^2+10k_3^2+4k_1k_2+8k_1k_3+8k_2k_3$,

k_1 and k_2 are the constants given by the distance between hills and rows respectively, and k_3 those given by the distance between two neighboring plants at diagonal positions of the rectangle formed by four plants on two adjacent rows.

If r pairs of alleles (Aa, Bb, ..., Rr) are concerned,

$$\sigma_c^2(BP_1+BP_2)=(c_a^2+c_b^2+\ldots+c_r^2+\alpha_a^2+\alpha_b^2+\ldots+\alpha_r^2)K \quad \ldots(3)$$

Let $c_a^2+c_b^2+\ldots+c_r^2$ be C, and $\alpha_a^2+\alpha_b^2+\ldots+\alpha_r^2$ be A,

$$\sigma_c^2(B)=(C+A)K \quad \ldots\ldots(4)$$

(2) Variance due to competition within the population of successive hybrid generations of self-fertilization

In F_2, F_3, and F_{n+1} hybrid populations, it may be computed as,

$$\sigma_c^2(F_2)=\left(C+\frac{1}{2}A\right)K \quad \text{.....(5),}$$

$$\sigma_c^2(F_3)=\frac{3}{2}\left(C+\frac{1}{4}A\right)K \quad \text{.....(6),}$$

and

$$\sigma_c^2(F_{n+1})=\frac{2^n-1}{2^{2n-1}}(2^nC+A)K \quad \text{.....(7).}$$

(3) The mean of the variances due to competition in different F_3 families

These are computed as

$$\sigma_c^2(F_3 \text{ families})=\frac{1}{2}\left(C+\frac{1}{2}A\right)K \quad \text{.....(8).}$$

Variances caused by competition between plants of different genotypes in segregating populations as computed above should be taken into account in the analysis of variance of hybrid populations in biometrical genetics as well as in the study of population genetics of autogamous plants.

3. *Theoretical Studies on Individual Selection in Plant-breeding with Special Reference to Gene Recombination*

(Report by Kan-Ichi SAKAI)

It is now well accepted that the quantitative characters of plants and animals are often controlled by a large number of genes distributed on a definite number of chromosomes. Since a majority of economic characters of plants, such as, grain yield or time of heading in cereal plants are considered most likely to be due to genes of this kind, it will be of interest to plant breeders to give some theoretical considerations on the effect of recombination on the efficiency of individual selection in autogamous plants.

(1) Proportion of homozygotes in segregating hybrid populations

Assuming that two genes are located on every chromosome, and the average recombination value between the two is α, the proportion of all homozygotes in any segregating generations may be represented as

$$\left\{\frac{2^{n-1}+1}{2^{n-1}}+\left[\frac{\alpha^2+(1-\alpha)^2}{2}\right]^n\right\}^R \quad \text{.....(1),}$$

where R is the number of pairs of chromosomes and n the number of the segregating generations.

(2) Selective efficiency of dominant alleles in segregating hybrid populations

If we call the proportionate number of dominant homozygotes among selected phenotypic dominants the 'selective efficiency', then, i) the selective efficiency (E_r) of dominant homozygotes in the case of independent alleles may be expressed by the equation,

$$E_r = \left(\frac{2^n-1}{2^n+1}\right)^r \quad \cdots\cdots\cdots\cdots\cdots\cdots(2),$$

where r is the number of pairs of independent alleles. ii) The selective efficiency (E_R) of dominant homozygotes in the case where these two respective genes are linked on every chromosome in the repulsion phase may be computed by the equation,

$$E_R = \left\{1 - \frac{2}{1+2^{n-1}[1+\lambda_1{}^n - \lambda_2(1-\lambda_2{}^n)/(1-\lambda_2)]}\right\}^R \quad \cdots\cdots(3),$$

where

$$\lambda_1 \equiv \frac{1}{2}[(1-\alpha)^2+\alpha^2],$$

$$\lambda_2 \equiv \frac{1}{2}[(1-\alpha)^2-\alpha^2],$$

and R stands for the number of pairs of chromosomes.

(3) Interrelationship between the number of phenotypic dominants and the selective efficiency

In breeding work, it is possible for the breeder to know the frequency of occurrence of desired dominants in the hybrid populations. Hence it will be of much interest to him if he can estimate the selective efficiency (E) from the number of dominants (D) which he desires to select and breed. This estimation can be given from the solution of the following equations:—i) In the case of independent alleles, it may be expressed as

$$E = D^{K_1} \quad \cdots\cdots\cdots\cdots\cdots\cdots(4),$$

where

$$K_1 = \frac{\log_{10}\left(\frac{2^n-1}{2^n+1}\right)}{\log_{10}\left(\frac{1}{2}+\frac{1}{2^n+1}\right)}.$$

ii) If each two dominant alleles are linked on every chromosome in the repulsion phase, it may be expressed as

$$E = D^{K_2} \quad \cdots\cdots\cdots\cdots\cdots\cdots(5),$$

where

$$K_2 = \frac{\log_{10}\left(1-\frac{2}{1+2^{n-1}\Delta}\right)}{\log_{10}\left(\frac{1}{2^{n+1}}+\frac{\Delta}{4}\right)}$$

and

$$\Delta \equiv 1+\lambda_1{}^n - \frac{\lambda_2(1-\lambda_2{}^n)}{1-\lambda_2} \ .$$

(4) The size of hybrid populations for the individual selection and the effective number of individuals to be selected

The number of dominant individuals to be selected in order to include at least one homozygous dominant, the maximum frequency of failure to be 1/100, will be computed by,

$$n \geq \frac{\log_{10} 0.01}{\log_{10}(1-E)} \quad \cdots\cdots\cdots\cdots\cdots\cdots (6)$$

or

$$n \geq \frac{\log_{10} 0.01}{\log_{10}(1-D^K)} \quad \cdots\cdots\cdots\cdots\cdots\cdots (6'),$$

and the size (N) of the population should be

$$N \geq \frac{\log_{10} 0.01}{\log_{10}(1-DE)} \quad \cdots\cdots\cdots\cdots\cdots\cdots (7)$$

or

$$N \geq \frac{\log_{10} 0.01}{\log_{10}(1-D^{K+1})} \quad \cdots\cdots\cdots\cdots\cdots\cdots (7').$$

All the formulae given above will help us, in the practice of plant breeding, in deciding the best time for exerting the individual selection out of the successive hybrid generations, and the number of individuals to be selected, as well as the size of the hybrid population on which the individual selection will be made.

4. *Effect of Random Fluctuation of Selective Value on the Distribution of Gene Frequencies in Natural Populations*

(Report by Motô KIMURA)

Recently, in the field of population genetics, there is a sharp antagonism between WRIGHT on one side and FISHER and FORD on the other. WRIGHT maintains the evolutionary significance of the "WRIGHT effect", while FISHER and FORD reject it, and emphasize the extreme importance of the role played by natural selection. The present study is to examine this antagonism by means of precise mathematical analyses.

The long term distribution of gene frequencies in natural population under influence of the fluctuation in the force of natural selection (proposed by FISHER and FORD) can be calculated by

$$\varphi(x) = (C/V_{\delta x}) \exp\left\{2\int (M_{\delta x}/V_{\delta x})dx\right\},$$

which is a modified expression of WRIGHT'S formula (1938, '39, '42). Here $M_{\delta x}$ and $V_{\delta x}$ respectively denote the mean and the variance of δx (rate of change in gene frequency per generation) for a given gene frequency x.

If there is no dominance, the formula for the long term distribution becomes

$$\varphi(x)=Cx^{4Nv-1}(1-x)^{4Nu-1}(\lambda_1-x)^{4NA-1}(x-\lambda_2)^{4NB-1},$$

where

$$A=-\{\bar{s}/(2NV_s)+\lambda_1 u-\lambda_2 v\}/(\lambda_1-\lambda_2),$$
$$B=\{\bar{s}/(2NV_s)-\lambda_1 v+\lambda_2 u\}/(\lambda_1-\lambda_2),$$

and λ_1 and λ_2 are respectively the positive and the negative root of the quadratic equation:

$$x^2-x-1/(2NV_s)=0.$$

In this formula, N is the effective size, u and v are respectively the mutation rate of the gene A to and from its allele A', $\bar{s}$ and V_s are respectively the mean and the variance of the selection coefficient (s) of A, and C is a constant such that

$$\int_0^1 \varphi(x)dx=1.$$

On the other hand, for recessive genes, if the selection coefficient of the recessive individuals is t, the distribution can be given by

$$\varphi(x)=Cx^{4Nv-1}(1-x)^{4Nu-1}(\lambda_1-x)^{4NA-1}(x-\lambda_2)^{4NB-1}$$
$$\times[(x-\alpha)^2+\beta^2]^{4ND-1}\exp\left\{-8NE\tan^{-1}\frac{x-\alpha}{\beta}\right\}$$

where

$$A=\{\bar{t}/(2NV_t\lambda_1)+(u+v)\lambda_1-v\}/(3-4\lambda_1),$$
$$B=\{\bar{t}/(2NV_t\lambda_2)+(u+v)\lambda_2-v\}/(3-4\lambda_2),$$
$$D=(ab+a'b')/(b^2+b'^2),$$
$$E=(a'b-ab')/(b^2+b'^2),$$

and

$$a=-\lambda_1\lambda_2\alpha\bar{t}+(u+v)\alpha-v, \qquad a'=\lambda_1\lambda_2\beta\bar{t}+(u+v)\beta,$$
$$b=3-4\alpha, \qquad b'=-4\beta.$$

In this formula $\tan^{-1}X$ is defined by

$$\tan^{-1}X=\int_0^X(1+x^2)^{-1}dx,$$

and λ_1, λ_2 and $\alpha\pm\beta i$ are the four roots of the quartic equation:

$$x^4-x^3-1/(2NV_t)=0,$$

of which λ_1 is real and larger than 1, λ_2 is negative and $\alpha+\beta i$ and $\alpha-\beta i$ are both imaginary. From the study of the distribution curves it has become clear that although the effect produced by the random fluctuation in natural selection is relatively unimportant for small populations, it has a remarkable effect for large ones for the case in which the frequency of either allele is low (where dominance is lacking) or the frequency of the recessive gene lies inside a certain range of high frequencies (in the

case of complete dominance). Therefore the biological importance of the "WRIGHT effect" should be judged by the frequency distribution of the effective size (N) of populations in nature, as well as of the quantity NV_s, which is the product between the effective size and the variance of selection coefficient, for alleles contained in them.

cf. KIMURA, M. 1951. Effective Size of Populations and Random Fluctuations of Selective Values (in preparation).

5. *Physiological Theory of Polygenic Actions*

(Report by Motô KIMURA)

A polygenic system may be constructed by a group of genes, if each of them controls the different parts of the physiological reaction chain leading to the expression of a given character, and the effect produced by substituting one of them by its allele is so small that it can be easily counterbalanced by the environmental variation. To explain the mode of action of these genes, the writer has attempted a mathematical analysis of the chain reactions, using the model adopted by WRIGHT (1934), in which the catalytic transformation of the substance takes place by steps to attain the final product, the quantity of which corresponds with the character in question.

Let the chain be constructed by the linear linkage of $n-1$ reactions each of which is assumed to be monomolecular, and let $P_1, P_2, \ldots, P_{n-1}$ be respectively the amount of intermediary substances transformed in serial order, and P_n be that of the final product. If the concentration of the enzyme contributing to the change: $P_i \rightarrow P_{i+1}$ is e_i and that of $P_i \rightarrow D_i$ (other destructive change) is f_i, the relation:

$$P_n \propto \prod_{i=1}^{n-1} \{k_i e_i/(\alpha + k_i e_i + l_i f_i)\} \quad (k_i,\ l_i : \text{constants}) . \quad (1)$$

is obtained under the assumption that the amount of intermediary substances increases at a given rate $\alpha (= (dP_i/dt)/P_i)$, keeping a constant ratio among one another. If it is assumed that the concentration of each enzyme is proportional to the dose of genes (AA, Aa, aa) controlling it, many important results obtained by experiments of previous authors (e. g. arithmetic effect, geometric effect, dominance relation etc.) become understandable:

For example, if all plus genes accumulate in the larger parent and all minus genes in the smaller parent, the concentration of the enzyme in a given link of the chain may be represented as $e+2\Delta e$, e and $e+\Delta e$ for the larger parent, the smaller parent and the F_1 individual respectively, so that the measure (Q) of an F_1 individual approaches the geometric mean of those of the two parents.

$$Q_1 = \sqrt{(QQ')} + \varepsilon, \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where ϵ is a small and positive quantity.

The dominance relation between alleles may also be explained by using the relation (1).

In the studies of biometrical genetics, "transformation of scale" is often indispensable, and it is adopted through empirical tests. The study presented above gives the theoretical basis of such transformation.

6. *Recombination of Chromosome Segments through Continued Self-fertilization*

(Report by Motô KIMURA)

In this study the writer has mathematically investigated the process of the recombination of chromosome segments which takes place generation by generation through continued self-fertilization, and he has derived several formulae regarding the frequency distribution of the length of the heterozygous segment, the rate of increasing homozygosis, the number of effective factors and the distribution of segments finally attained in the population.

Let AA' be an initial pair of homologous chromosomes differing in many alleles as in the case of the species cross, and designate the length of homozygous segments derived from A and A' as $100L_A$ and $100L_{A'}$ units respectively, and that of heterozygous segments as $100L_h$ units, so that in any generation

$$L_A+L_{A'}+L_h=x_0\,,$$

where x_0 is the whole genetical length of the chromosome pair.

In a population undergoing self-fertilization n times, the frequency of the AA' pair is

$$(1-x_0)^{2^n}/2^n\,.$$

The frequency $(f_n(x)dx)$ with which L_h lies between x and $x+dx$ $(0<x<x_0)$ can be given by solving the following integral equation, the initial condition of which is $f_1(x)=2-x_0$:

$$f_n(x)=\frac{(1-x)^2}{2}f_{n-1}(x)+\int_x^{x_0}(2-\xi)f_{n-1}(\xi)d\xi+(2-x_0)(1-x_0)^{2(n-1)}/2^{n-1}\,.$$

The frequency of heterozygous pairs at the nth generation:

$$H_n=\int_0^{x_0}f_n(\xi)d\xi+(1-x_0)^{2^n}/2^n\,.$$

This is approximately equal to $(1+2nx_0)/2^n$, where x_0 is small; it will approximate $nx_0/2^{n-1}$, when n is large. In the following table the values of H_n are given for the initial 20 generations, assuming that the chromosome length is 100 units.

Table III.

n	H_n	n	H_n
1	1.0000*	11	0.00954
2	0.8333	12	0.00524
3	0.6083	13	0.00286
4	0.4075	14	0.00155
5	0.2578	15	0.00083
6	0.1567	16	0.00045
7	0.0926	17	0 00024
8	0.0535	18	0.00013
9	0.0307	19	0.000067
10	0.0172	20	0.000035

* This is the corollary of the assumption that the initial length of the heterozygous segment is 100 units and only a single crossing-over is allowed to occur in that region.

From these values, the curves showing the decrease of heterozygosis for plant hybrids with m pairs of such chromosomes can be easily constructed. If $m=7$, the frequency of heterozygous plants is lower than 3/10,000. After sufficiently many generations, when all the chromosome segments have reached the state of fixation, the population contains three kinds of pairs, namely AA, $A'A'$ and the recombined homozygote.

The frequencies of AA and $A'A'$ are both equal to $e^{-2x_0}/2$, and in the recombined homozygotes the frequency with which L_A/x_0 lies between t and $t+dt$ is

$$\varphi(t)dt=2x_0e^{-2x_0}\left\{I_0(4x_0\sqrt{t(1-t)}\,)+\frac{I_1(4x_0\sqrt{t(1-t)}\,)}{2\sqrt{t(1-t)}}\right\}dt\,,$$

where I_0 and I_1 are BESSEL functions.

cf. KIMURA, M. 1951. The Recombination of Chromosome Segments through Continued Self-fertilization (in preparation).

7. *Studies on the Process of Chromosome Substitution*

(Report by Motô KIMURA)

In order to find out the influence to be exerted by a foreign cytoplasm on the character expression of the gene, a chromosome substitution experiment is often practised between two different species or strains.

The methods involved in such an experiment are to repeat the backcrossing of F_1 and the descendant individuals to the pollen parent, with (the first method) or without (the second method) the duplication of F_1 chromosome. (cf. KIHARA 1948)

For such an experiment it is important to estimate how many generation are needed to attain a given degree of substitution under various conditions.

In the case of the second method, if there are m pairs of chromosomes, of which the ith pair have genetical length of $100x_0^{(i)}$ units, the proportions of individuals for which the substitution is completed will be

$$\prod_{i=1}^{m}\left(1-\frac{1+n_0x^{(i)}}{2^n}\right),$$

in a n times backcrossed population.

For example, the proportion of such individuals will be some 95% after nine times of backcrossing, if the hybrid has seven pairs of chromosomes each having a cross-over value of thirty per cent.

Similar formulae can de derived in the case of the first method.

If in the course of the experiment the fertility decreases bacause of the presence of plasmon sensitive genes, the formulae become much more complicated. The writer's analysis of Prof. KIHARA'S data of a substitution experiment with *Aegilops longissima* and *A. Aucheri* has revealed that the effect produced by such plasmon sensitive genes on fertility might be geometrically cumulative.

cf. KIMURA, M. 1950. The Theory of the Chromosome Substitution between two Different Species. Cytologia 15: 281–294.

8. *Theoretical Relations among Map-distance, Recombination Value and Coincidence Ratio*

(Report by Motô KIMURA)

The map-distance, the recombination value and the coincidence ratio are the three important conceptions in the studies of crossing-over, and many formulae have been proposed concerning the relations among them.

The present writer has attempted a general consideration concerning these relations and obtained some results which are reported here.

Let $\psi(x, y)$ be the recombination fraction between two points in one chromosome map, and let $C_K(x, y)$ be the coincidence ratio between two infinitesimal regions $(x, x+dx)$ and $(y, y+dy)$, then it will be proved that

$$C_K(a, b)=\left[-\frac{\partial^2\psi(x, y)}{2\partial x\partial y}\right]_{\substack{x=a\\y=b}}, \quad \cdots\cdots\cdots\cdots\cdots\cdots(1)$$

assuming that the frequencies of triple and multiple crossovers are negligibly small between two points a and b located on a chromosome.

Therefore, if the recombination fraction and the coincidence ratio are mere functions of the map-distance, we obtain the relation:

$$C_K(x)=-\frac{d^2\psi(x)}{2dx^2}, \quad \cdots\cdots\cdots\cdots\cdots\cdots(2)$$

where $\psi(x)$ is the recombination fraction between two points which are x distance apart, and $C_K(x)$ is the coincidence ratio for the two points.

Applying this to mapping functions which show the relation between the map-distance and the recombination fraction, we can obtain a function showing the relation between the recombination value and the coincidence ratio.

For example, from the mapping functions:

$$\psi(x)=\frac{1}{2}\sin(2x), \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

(LUDWIG 1935)

$$x=\frac{1}{12}\log_e\{1+4\psi(x)\}-\frac{1}{3}\log_e\{1-2\psi(x)\}, \quad \ldots\ldots(4)$$

(DE WINTON and HALDANE 1935)

$$\psi(x)=\frac{1}{2}\tanh(2x), \quad \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

(KOSAMBI 1944)

we can derive the following functions:

$$C_K(x)=\sin(2x), \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)'$$

$$C_K(x)=8\psi(x)\{1+\psi(x)\}\{1-2\psi(x)\}\{1+4\psi(x)\}/\{1+2\psi(x)\}^3, \quad \ldots(4)'$$

$$C_K(x)=2\tanh(2x)\,\mathrm{sech}^2(2x), \quad \ldots\ldots\ldots\ldots\ldots(5)'$$

or when x is very small

$$C_K(x)\fallingdotseq 2x, \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)''$$

$$C_K(x)\fallingdotseq 8x, \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)''$$

$$C_K(x)\fallingdotseq 4x. \quad \ldots\ldots\ldots\ldots\ldots\ldots(5)''$$

cf. KIMURA, M. 1951. Coincidence Ratio and Mapping Functions. (in preparation).

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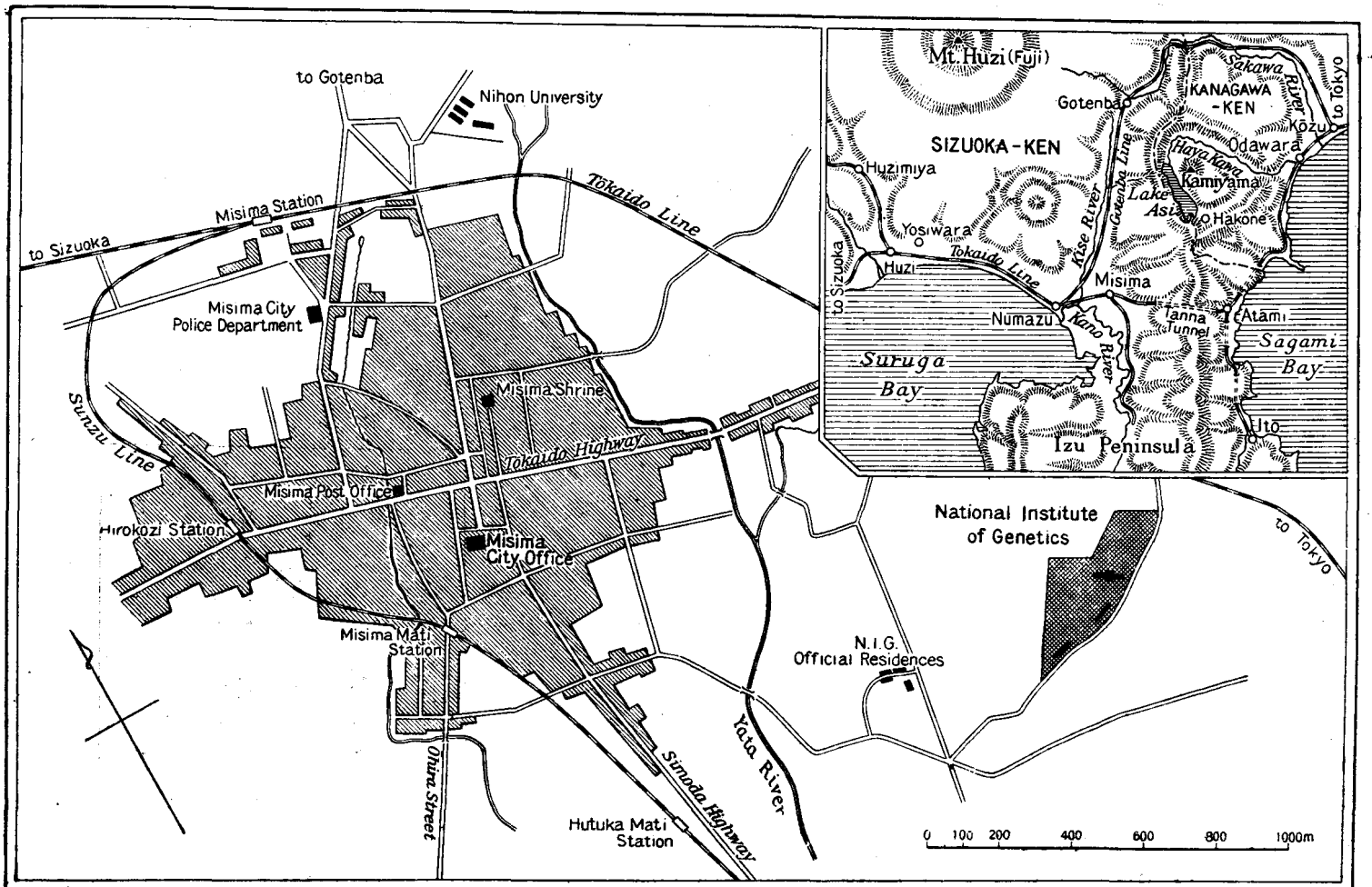
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