FURTHER EXPERIMENTAL STUDIES ON THE INHERITANCE OF SUSCEPTIBILITY TO A TRANSPLANTABLE TUMOR, CARCINOMA (J. W. A.) OF THE JAPANESE WALTZING MOUSE.*

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In a previous investigation one of us has shown that a carcinoma of the Japanese waltzing mouse grows on implantation in a high proportion of this race and in no instance in the common mouse. The first filial generation of hybrids produced by cross-breeding these two varieties were almost as susceptible as the Japanese waltzing mice, but their offspring, both in the second and third filial generation were all non-susceptible. These findings could not at that time be accounted for on the basis of Mendel's law, especially if susceptibility was considered as a unit factor, or on the basis of any other hypothesis of inheritance. The growth of the tumor in a single F_2 mouse subsequent to the publication of these results suggested that an occasional susceptible animal might occur in later generations, providing sufficient numbers were obtained.

The object of the present investigation was to determine, if possible, the mode of inheritance by which such results as these are obtained, and for this purpose larger numbers of hybrids derived from other stocks of common mice have been tested. Before considering subsequent results it will be useful to review briefly the work already accomplished in this field of research.

Cuénot, whose series of papers on color inheritance in mice constitute a classic in genetics, has in collaboration with Mercier attempted to ascertain whether or not any one color variety of mouse is markedly more favorable than others to the growth of implants of a given tumor. In that all the color varieties with which they worked were found to

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be essentially equal in their reaction towards the tumor, their results may be briefly described as negative.

Leaving the question of color and turning to that of race, marked differences in susceptibility are found. Haaland, Loeb, Loeb and Fleischer, Tyzzer and Higuchi have shown that race is an important factor in the transplantation of tumors. The larger part of the results obtained by these investigators have shown varying percentages of positive and negative animals after inoculation, according to the race used. Thus, Tyzzer reports a series of inoculations in which four races of mice were used. These races were (1) tame mice from a Providence dealer, (2) tame mice from Buffalo-Cambridge stock, (3) inbred laboratory stock, and (4) Japanese waltzing mice. The Jensen tumor used in inoculation grew in 11.7 per cent of the Providence mice, in 41.6 per cent of the Buffalo-Cambridge stock, in 80 per cent of laboratory stock, and in none of the Japanese waltzing mice. With the Ehrlich tumor the same four races show 26.3, 64.3, 91.7, and 37.5 per cent respectively of positive animals.

The susceptibility of F_1 hybrids obtained by crossing the laboratory stock with Japanese waltzing mice was also tested. In these tests the results were as follows:

JENSEN TUMOR.

Laboratory stock mice, tumors in	80%
F_1 hybrids, tumors in	10%
Japanese waltzing mice, tumors in	0%

EHRLICH TUMOR.

Laboratory stock mice, tumors in	100%
F_1 hybrids, tumors in	50%
Japanese waltzing mice, tumors in	75%

Although the numbers employed were small, it would appear that the F_1 generation hybrids are, with respect to their reaction to implants of both these tumors, in closer agreement with the Japanese waltzing than with the common parent.

The same author has, on investigating the reaction of

Japanese mice, tame mice and their hybrids to implants of carcinoma (J. w. A.) of the Japanese mouse, obtained results which may be tabulated as follows, the plus sign indicating successful, the negative sign unsuccessful implantation:

CARCINOMA J. W. A.

Japanese waltzing mice	142 +	3 —
Common mice	0 +	48 —
F_1 hybrids	69 +	1 —
F_2 hybrids	0 +	54 —
F_3 hybrids	0 +	16 —

The conclusion, based on these results, that susceptibility to the waltzing mouse tumor was inherited, but neither as a Mendelian unit character nor in accordance with any other hypothesis of inheritance, appeared justifiable on the ground of the complete disappearance of susceptibility in the second (F_2) and third (F_3) filial generations.

The subsequent occurrence of a positive or susceptible hybrid animal of the second filial generation is of importance as indicating the occasional reappearance of susceptibility in subsequent generations (Tyzzer, 1915). A larger series of experiments has thus been planned in order to investigate further the type of inheritance underlying the unusual results obtained in this earlier work.

The material employed in these experiments will now be considered in detail, and later on the results obtained will be discussed and certain conclusions drawn as to the nature of the mode of inheritance here manifested.

MATERIAL.

A single tumor, a carcinoma derived from the Japanese waltzing mouse and designated as tumor J. w. A., has been employed in all the experiments presented in this paper. The histological characteristics and biological behavior of this tumor on transplantation have been discussed in previous articles (see bibliography).

The mice employed consist of Japanese waltzing mice, two distinct stocks of common mice, and hybrids obtained by

cross-breeding the first named variety with the two latter stocks.

1. Japanese waltzing mice are designated in the charts as J. w. The race from which the animals used in the experiments were derived is one that has been inbred for at least six years without any addition of new individuals from outside the stock. The result must therefore have been to produce a race of great uniformity with respect to whatever inheritable factors it may possess. This tendency has also been intensified by the selection of individuals with the smallest amount of black, and, since the amount of black formed depends largely upon hereditary factors, such selection will serve to decrease the number of animals used as parents, thus leading to closer relationships and a greater degree of inbreeding than would result without it. The homogeneity is further shown by the uniformity of their reaction to their tumors. Both carcinoma J. w. A. and sarcomas J. w. B. and J. w. G. have from the first grown on implantation in practically one hundred per cent of this stock. These results are in contrast with those obtained from the implantation of tumors in less inbred stocks. For example, a carcinoma of the stomach, which originated in a laboratory stock of wild mice, grew when implanted in four of eleven, but on the second transfer failed to grow in twelve mice of the same stock. The uncertainty of the results in the experimental inoculation of the tumors of tame mice is a matter of common knowledge. Although the results obtained depend in part on the character of the individual tumor, this is to be regarded as a fairly constant factor, at least at any given transfer, so that, presuming a satisfactory inoculation technic, constant uniformity in the growth of tumor implants furnishes strong evidence of racial homogeneity.

2. Brown agouti stock. — This stock originated from a pen of brown agouti animals which was set aside from the general experiments in color inheritance and inbred since 1909 at the Bussey Institution. This pen of mice contained in all probability several unrelated animals, as no particular

effort was made to pick out closely related individuals. The animals are not always brown agouti in color, but they have been continuously inbred so that they may at least be considered as closely related. Mice from this stock were used in a series of five experiments, A 1 to A 5 inclusive, and will be designated as Br. Ag.

3. Dilute brown stock. — This is the most homogeneous stock of common mice that has been bred at the laboratory of the Bussey Institution. All the present animals are direct descendants of a single pair of closely related, homozygous, dilute brown (silver fawn) mice obtained in the spring of 1909. From the start the stock has been kept free from any out-cross and has therefore an unbroken stretch of more than twenty generations of inbreeding. The mice comprising this race are very strong, healthy, fertile animals, and show not the slightest trace of any harmful results from the continuous inbreeding which has been carried on. Mice of this race are the tame mice used in the experiments B 1 to B 3 inclusive. They are designated as d. Br. in this paper.

It will be seen, therefore, that the stocks used are genetically favorable for obtaining uniform and reliable experimental results. It seems important to emphasize this phase of the work, for if mixed or relatively impure races are used, variable and inconclusive results are almost certain to be obtained. We feel that the material used is of sufficient constancy and definiteness to lend strength to any experimental results obtained in the study of its hereditary behavior.

Each animal born has been given a distinguishing mark and recorded so that accurate pedigrees are available for all the stock used. In order to emphasize the individual as the important unit, a longer time and more care have been necessary than would have been the case if the race had been the unit chosen for study. The general method of recording is that employed at the Bussey Institution in the experiments in color inheritance already reported by one of the writers (Little, 1913). While the data is here presented for the most part by generations, particular emphasis has

been put on keeping as accurate a record as possible for each individual (see appendix for individual records of tumor growth).

Beginning with fourteen days after inoculation, weekly observations have been made and the approximate size of the tumor has been sketched on the card of each individual animal in all the experiments. It is on these records that the conclusions concerning the comparative growth of the tumor in the various generations are based.

KEY TO GENERATIONS.

Br. Ag	Brown agouti, pure stock.
d. Br.....	Dilute brown, pure stock.
J. w.....	Japanese waltzing, pure stock.
F_1.....	First hybrid generation.
F_2	Second hybrid generation produced by breeding together F_1 animals.
F_3	Third hybrid generation, produced by breeding together F_2 animals.
$(F_1 \times$ J. w.$)^1$.....	First generation back-cross, produced by breeding F_1 animals with pure Japanese waltzing mice.
$(F_1 \times$ J. w.$)^2$.....	Second generation back-cross of F_1 animals with pure Japanese, produced by breeding together the first back-cross animals $(F_1 \times$ J. w.$)^1$.
$(F_1 \times$ Br Ag.$)^1$ or $(F_1 \times$ d. Br.$)^1$	First generation back-cross, produced by breeding F_1 animals with pure tame races, Br. Ag., or d. Br., as the case may be.
$(F_1 \times$ Br. Ag.$)^2$ or $(F_1 \times$ d. Br.$)^2$.....	Second generation back-cross of F_1 animals with the pure tame races, produced by breeding together animals of the first generation back-cross.

The method of charting is that which has been extensively employed in communications from the Imperial Cancer Research Fund and elsewhere.

The inherited characters which are under consideration in the present investigation are susceptibility and non-susceptibility to carcinoma J. w. A. of the Japanese waltzing mouse. Susceptibility consists of the ability of the inoculated animal to provide a favorable soil for the tumor's growth. This is dependent on the absence of any antagonistic reaction of

the tissues and on a growth of stroma and blood vessels sufficient for the tumor's support and growth. The latter would necessarily be found in the individual in which the tumor originated and would also be expected in closely related individuals. Non-susceptibility is not, however, identical with immunity to implanted tumor, but consists of an ability to develop immunity. The tumor for a period of six or seven days develops as well in the non-susceptible as in the susceptible mice, but this is followed in the former by the appearance of an immunity which is evidently brought about by the formation of a substance or substances that in the presence of living implanted tumor produces injury and inflammation around the latter, so that it eventually becomes isolated from the healthy host tissue necessary for its support. Non-susceptibility would naturally be expected to the implantation of tumor cells of alien races or varieties. It has been repeatedly shown that young animals are in general more favorable for the development of implanted tumors and react more uniformly. Age, therefore, must be taken into account, and is thus given for each animal in the following experiments. Murphy has found that the embryo even of a foreign species will provide the necessary conditions for the growth of tumors until the age at which the spleen and lymphoid organs appear. He also finds that by destroying a large part of the lymphoid tissue by radiation susceptibility to tumor implants is thereby increased. In the present experiments, although some relatively young animals were tested, all were at an age when both spleen and lymph nodes were well developed. In the consideration of susceptibility the comparative rate of growth may be taken into account. The significance of differences in this respect is not clear, since they may depend on modifying rather than on essential conditions. However, the late resorption of tumors, which have developed well and attained considerable size, indicates an effective though delayed immunity reaction, and as such is to be regarded as evidence of non-susceptibility. In fact, a much more pronounced reaction is necessary to destroy a well-developed tumor than a small implant.

EXPERIMENTS.

In certain of the following eight experiments a single tumor was sufficient to inoculate the entire number of mice, in others it was necessary to use two or more tumors to provide sufficient living tumor tissue. In order to obtain adequate control in the latter case, the animals were so grouped that a representative number of each class were inoculated with each tumor. The trochar method of implantation was employed and the inoculation was done as rapidly and with as uniform technic as possible. The dosage was also made as uniform as practicable by this method and the tissue was selected with the view of implanting living tumor in every instance. The groups which previous experience had shown to be probably non-susceptible were inoculated first while the susceptible groups were done last, and the animals were numbered in the order of their inoculation.

The number, class, and age of each mouse, as well as the result of the implantation, will be found in the appended charts, in which the tumors are represented at approximately one-seventh their actual diameter.

EXPERIMENT A 1 (J. w. A.).

Sept. 3, 1914. — Two J. w. A. tumors which had been growing for thirty-one days in Japanese waltzing mice No. 4058 and No. 4066 were used to inoculate the following seven groups of mice subcutaneously on the right side:

Eleven F_2 hybrids.
Twelve F_3 hybrids.
Eleven back-cross (F_1 x Br. Ag.)[1] hybrids.
Eleven brown agouti (Br. Ag.) stock mice.
Twelve back-cross (F_1 x J. w.)[1] hybrids.
Eleven F_1 hybrids.
Eleven Japanese waltzing (J. w.) mice.

On account of the rapid growth of the tumors in the back-cross (F_1 x J. w.)[1] and the F_1 hybrids, these were killed five weeks after inoculation. The Japanese waltzing mice survived, some for a longer, some for a shorter time. The negative animals of the other groups are charted for seven weeks, although they have since been under observation.

EXPERIMENT A 2 (J. w. A.).

Sept. 17, 1914. — A single J. w. A. tumor which had grown for forty-five days in J. w. mouse No. 4067 and weighed 1,700 grams was used to inoculate one hundred and thirty-one mice classed as follows:

Fifty F_2 hybrids.
Thirty-seven back-cross $(F_1 \times \text{Br. Ag.})^1$ hybrids.
Six brown agouti (Br. Ag.) stock mice.
Twelve back-cross $(F_1 \times \text{J. w.})^1$ hybrids.
Six F_1 hybrids.
Twelve Japanese waltzing (J. w.) mice.
Eight second generation $(F_1 \times \text{Br. Ag.})^2$ back-cross hybrids.

Each mouse received approximately 13 milligrams of tumor tissue. An F_2 hybrid (No. 4211) produced a slowly growing tumor which failing to retrogress killed the animal nearly fourteen weeks after inoculation.

EXPERIMENT A 3 (J. w. A.).

Oct. 13, 1914. — Bits of the tumor which had grown forty days in J. w. mouse No. 4163 were used to inoculate one hundred and eighteen mice; average dose 10 milligrams.

Twenty-seven F_2 hybrids.
Five F_3 hybrids.
Sixteen back-cross $(F_1 \times \text{Br. Ag.})^1$ hybrids.
Forty-one brown agouti (Br. Ag.) stock mice.
Six back-cross $(F_1 \times \text{J. w.})^1$ hybrids.
Eleven F_1 hybrids.
Three Japanese waltzing (J. w.) mice.
Five second generation $(F_1 \times \text{Br. Ag.})^2$ back-cross hybrids.
Four $(F_1 \times F_2)^1$ hybrids.

A second exception to the usual results was obtained in this experiment. In an F_2 hybrid (No. 4392) a tumor developed which grew slowly for eight weeks, when the animal disappeared, possibly from being eaten by other mice in the same cage. Of four progeny of an F_1 mated with an F_2 hybrid, one developed a progressively growing tumor.

EXPERIMENT A 4 (J. w. A.).

Oct. 27, 1914. — A tumor weighing 4.010 grams which had grown fifty-four days in J. w. mouse No. 4121 was used to inoculate twenty-seven mice; average dose 30 milligrams.

Eleven F_2 hybrids.
Three F_3 hybrids.
Four F_1 hybrids.
Six Japanese waltzing (J. w.) mice.
Three $(F_1 \times F_2)^1$ hybrids.

Two of the last group survived and one of these developed a tumor.

EXPERIMENT A 5 (J. w. A.).

Jan. 15, 1915. — A tumor after growing thirty-six days in J. w. mouse No. 4393 was used to inoculate the following one hundred and sixteen mice:

Thirty-three F_2 hybrids.
Seven F_3 hybrids.
Seven back-cross $(F_1 \times \text{Br. Ag.})^1$ hybrids.
Twenty-six back-cross $(F_1 \times \text{J. w.})^1$ hybrids.
Ten F_1 hybrids.
Six Japanese waltzing (J. w.) mice.
Nineteen second generation $(F_1 \times \text{Br. Ag.})^2$ back-cross hybrids.
Three $(F_1 \times F_2)^1$ hybrids.
Five second generation $(F_1 \times \text{J. w.})^2$ back-cross hybrids.

Only one in the five animals of the last group developed a tumor, although derived from susceptible parents.

EXPERIMENT B 1 (J. w. A.).

Sept. 25, 1914. — A single J. w. A. tumor weighing 1.100 grams, after growing fifty-three days in a J. w. mouse, No. 4056, was used to inoculate eighty-four mice of the following classes:

Twenty-six F_2 hybrids.
Five F_3 hybrids.
Twenty-one dilute brown stock mice.
Twenty-two F_1 hybrids.
Ten Japanese waltzing mice.

This experiment yielded no unusual result.

EXPERIMENT B 2 (J. w. A.).

Oct. 27, 1914. — A tumor which had grown to .834 gram in J. w. mouse No. 4121 in fifty-four days was inoculated subcutaneously in the following forty-eight mice; average dose 11 milligrams.

Twenty-three F_2 hybrids.
Nine back-cross $(F_1 \times \text{d. Br.})^1$ hybrids.
Ten dilute brown stock mice.
Six Japanese waltzing mice.

In one F_2 hybrid (No. 4551) a small nodule appeared, which did not increase in size between the second and the sixth week after implantation, but subsequently grew to large size. The mouse was killed seventy-two days after inoculation and the tumor employed in the following experiment.

EXPERIMENT B 3 (J. w. A.).

Jan. 7, 1915. — The following eighty-nine mice were inoculated subcutaneously on the right side with J. w. A. tumor which had been growing twenty-six days

in J. w. mouse No. 4594 and similarly on the left side with tumor J. w. A. which had been growing seventy-two days in an F_2 hybrid (No. 4551).

Thirty-five F_2 hybrids.
Eleven F_3 hybrids.
Eleven dilute brown stock mice.
Nineteen back-cross (F_1 x J. w.)[1] hybrids.
Five second generation (F_1 x d. Br.)[2] back-cross hybrids.
Eight Japanese waltzing mice.

The object of inoculating a J. w. A. tumor which had been successfully transplanted to an F_2 hybrid was to determine whether adaptation to a somewhat unfavorable host would influence its subsequent behavior. There was, however, no evidence of adaptation on the part of the tumor, for it showed no more growth in the non-susceptible classes of mice than did the tumor from the J. w. mouse.

If now the results of these experiments are analyzed (see appended charts), it will be seen that the two tame races do not show any marked differences in their reaction to the tumor either as pure stocks or in their hybrids with the Japanese race.

COMBINED RESULTS OF EIGHT EXPERIMENTS WITH CARCINOMA J. W. A.

Class of Mouse.	Number Inoculated.	Susceptibility.	
		+	−
J. w.	58	58	0
Com.	99	0	99
F_1	62	61	1
F_2	183	3	180
F_3	38	0	38
(F_1 x J. w.)[1]	63	63	0
(F_1 x J. w.)[2]	5	1	4
(F_1 x Com.)[1]	78	0	78
(F_1 x Com.)[2]	34	0	34
(F_1 x F_2)[1]	9	2	7
Total	629*		

* Sixty-three additional animals died too soon after inoculation to be included.

It will, therefore, be convenient to tabulate together the data obtained in the A and B series of experiments. If this is done, it will be seen that the difference between the common races and the Japanese race is absolute. The ninety-nine mice of the common stock who lived for a sufficient period after inoculation to provide a critical test as to their reaction to the tumor transplant, all failed to grow the tumor. On the other hand, the forty-eight Japanese mice were all of them positive, having well defined tumors which showed a steady growth (see appendix).

Of the F_1 hybrids obtained from cross-breeding common and Japanese mice, sixty-one out of sixty-two were susceptible. It is not known whether the one negative F_1 animal was a true exception or not, since no reinoculation was attempted. It is quite possible that its negative behavior may have been due to some unavoidable circumstance of technic in inoculation.

The F_2 generation hybrids show in contrast to the 98.3 per cent susceptibility of the F_1 generation a remarkable decrease in the number of susceptible animals. Only three out of one hundred and eighty-three recorded grew the tumor. This is approximately 1.6 per cent positive. The number used is considerable. Both races of common mice have susceptible F_2 animals among their hybrid offspring.

The ancestry of the two susceptible F_2 mice in the A series of experiments (Br. Ag. stock) is of interest. The first one, mouse No. 4211 (male 656 stock number), was out of a bi-maternal litter; two sisters, 104 and 106, having littered together. The father of both litters was 57. The second susceptible F_2 mouse, No. 4392 (female 777 stock number), came from a later mating of female 106 by male 57. She was then certainly a half sister and possibly a full sister of mouse No. 4211, the first susceptible animal obtained in these experiments. As to what significance, if any, is to be attached to this fact of close relationship, we are at present in doubt. It is peculiar that two in thirteen mice derived from these F_1 hybrids were positive, whereas one hundred and one of other parentage were negative. If

any marked tendency of this sort is met with, it will be necessary to consider something more than chance in the distribution of susceptibility in the F_2 generation as a whole. The fact that a susceptible F_2 mouse has occurred in the entirely unrelated B series makes it certain, however, that it is a phenomenon of general applicability and that we are not dealing with a peculiarity restricted to a single family of the brown agouti race.

The number of F_3 animals is unfortunately not very large, only thirty-eight being thus far tested. All these have proved negative. Positive animals will probably be obtained in this generation when larger numbers are raised.

The reaction to the implantation of carcinoma J. w. A. in the back-cross generations is of considerable interest. The young produced by crossing the F_1 hybrids with pure Japanese mice are very difficult to raise. The young animals are delicate and are markedly susceptible to disease. Of course, the fact that this cross should produce a generation fifty per cent of which are waltzers undoubtedly accounts in part for the high mortality, as waltzing mice are notoriously difficult to rear. However, even the non-waltzers in this particular generation appear to be less vigorous, and it is evident that the Japanese race is one which is not well fitted to withstand conditions under which common mice thrive. It appears probable that these back-cross animals, really three-fourths blood Japanese, inherit to a considerable degree the constitution of the Japanese race. They furthermore simulate more closely the Japanese mice in their reaction to the tumor transplant, one hundred per cent of them being positive in a total of sixty-three animals.

Only five young have been raised from these back-cross $(F_1 \times J.\ w.)^1$ mice. These have, however, shown a markedly different degree of vigor and a different behavior towards the tumor implant. They are normal-appearing, healthy mice, easily raised after weaning, and on inoculation four out of five have been found non-susceptible to the implant.

The parallel back-crosses between F_1 generation hybrids and common mice have produced uniformly vigorous, healthy

mice. Seventy-eight of the first generation of this back-cross were inoculated with negative result in all. Thirty-four of the second generation produced by breeding the first generation back-cross animals *inter se* were all non-susceptible.

The one remaining cross, that of F_1 generation mice, bred to their F_2 offspring, has only given a very small number of young. It tends to show, however, that there is an increased liability to tumor growth in these animals as compared with those of the F_2 and F_3 generations. In the nine animals inoculated there were two which grew tumors.

The biological character of the tumor through its continued growth in an F_2 hybrid has not been appreciably modified, for it subsequently reacted on implantation in every respect similar to parallel implants of tumor taken from the Japanese waltzing mouse (see Experiment B 3). Adaptation of the tumor, therefore, is evidently of slight importance in the interpretation of the data at hand, and variation in the host rather than in the tumor appears to determine the results.

The total number of mice (six hundred and twenty-nine) on which our conclusions are based represent those of the six hundred and ninety-two inoculated which survived long enough to give a critical test as to their reaction to the tumor implant. The growth charts given in the appendix will show the occurrence of the sixty-three animals which died so soon after inoculation that they could not be considered as a critical part of the experiment.

DISCUSSION.

It is the common experience of investigators of the inheritance of size characters in plants and animals that in a cross involving races of distinct sizes the first hybrid generation shows a condition intermediate between the parents. Examples of this type of result have been recorded by Castle with respect to the ear length of rabbits; by MacDowell in studying the inheritance of body size in rabbits; by East in various size characters of tobacco and of maize; and by many other investigators working with very diverse types of plants

and animals. Whenever in such crosses the F_1 hybrids are bred together they give rise to an F_2 generation in which most, if not all, of the individuals fall between the parent forms in respect to size and are therefore generally considered intermediate. The F_2 animals show usually a distinctly greater degree of variability in respect to size than do the F_1 hybrids, and in some cases individuals may be produced even more extreme in size than the parent types. Such inheritance has been given by Castle and others the general name of *blending* inheritance, as contrasted with *Mendelian* inheritance.

Whether or not a system of multiple Mendelian factors will prove to be the basis of this apparently blending type of inheritance will not here be considered. It will be sufficient to say that blending inheritance as supported by such evidence is practically the only type which occupies the minds of investigators in conjunction with or in place of Mendelian inheritance.* It is therefore of importance for us to test the applicability of an hypothesis of blending inheritance to the results of the experiments here recorded. If blending inheritance can be eliminated as a possibility, the field will be left just so much the clearer for the consideration of a Mendelian explanation.

Blending inheritance hypothesis. — The first point of importance bearing on this question is that the two parent races used in our experiments differ absolutely from one another with respect to their reaction to implantation of the waltzing mouse tumor. The transplanted tumor grows in approximately one hundred per cent of the inoculated animals of one race, while it grows in none of the other races. Here then is the best possible chance for intermediates to occur when these widely divergent races are crossed. The

* Slye states that as a result of mating an animal having a dominant character with another having a recessive character, offspring are produced some of which are pure dominants, lacking the recessive character, others of which are hybrids having both the dominant and the recessive characters, as may be demonstrated by the appearance of the latter in their offspring. This cannot in any way be correlated with either blending or Mendelian inheritance.

first generation hybrids, however, grow the tumor about as successfully as the positive parent race, *i e.*, in 98.4 per cent. If this is to be regarded as an intermediate result, then on the basis of blending inheritance it would be expected that a distinct majority of the second hybrid generation animals should grow the tumor successfully. This result is not obtained, for only one animal in approximately each sixty (or 1.6 per cent) of the second hybrid generation grows the tumor (see table). In a few others the tumor grows for a time but eventually disappears. This cannot be considered as a blending result, for even if all those animals which presented a greater development of the tumor than the non-susceptible parent stock are taken into account, the results cannot be considered as intermediate. The number of animals showing this condition is small, and we do not find a single instance of it in the F_1 generation, where we should expect the most perfect field for "blending" to occur. Alternative inheritance with respect to tumor susceptibility is clearly operative. In the back-cross generations also clear evidence of a non-blending type of inheritance is seen. Thus, the animals produced by a cross between F_1 and the positive parent are one hundred per cent positive, and those produced from F_1 crossed with the negative parent are all negative. No sign of blending is observed.

The results are markedly distinct in that the hybrid generations present alternative rather than intermediate conditions with respect to the reaction to the implanted tumor. We are unable, therefore, to interpret the results obtained in our experiments on the basis of the hypothesis of blending inheritance.

It then becomes necessary to consider whether the facts of inheritance in this case are in accord with those of the inheritance of color characters and of other Mendelian characters in mice. Are we dealing with some form of Mendelian inheritance which although obscure, because of the complex and hidden nature of the factors involved, is nevertheless based upon the random segregation of germinal units? The adequacy of the Mendelian laws in explaining

the observed facts of color inheritance in mice is well known. It has been the common experience of almost a score of investigators in Europe and in this country that analysis of the phenomena of color inheritance in general has advanced most rapidly through adopting mendelizing unit factors or determinants as the basis for genetic differences between the various color varieties.

Mendelizing factors which are of opposite nature so that they cannot both be contained in a single unfertilized germ cell are termed "allelomorphic." Since individuals or "zygotes" are formed from the fusion of two gametes or germ cells, it follows that in respect to any two allelomorphic factors an individual may be of the following constitution: If A and a are the allelomorphic factors, the individual may be AA, aa or Aa, according to whether it was formed from the union of gametes *like* (AA or aa) or *unlike* (Aa) with respect to the factor in question. The first two combinations (AA or aa) are called "homozygous," being formed from the union of *like* gametes. The last combination (Aa) is "heterozygous," being formed from the fusion of *unlike* gametes.

In such a heterozygote as Aa, if the A character expresses itself to the exclusion of the a character, it is called "dominant," while the a character is called "recessive," and is evident only in individuals which are aa in constitution. Thus, completely colored animals may be either homozygous or heterozygous with respect to the character pigmentation, since the factor for color is dominant; while albinos must always be homozygous, since the factor for albinism is recessive. If the heterozygote is a blend between A and a, dominance is said to be imperfect.

At the present time there are at least seven allelomorphic groups of color factors and one pair of allelomorphic physiological factors known in mice. It is not necessary to go into detailed consideration of the evidence on which the existence of these allelomorphic groups rests. It is sufficient to say that they have each been recognized by more than one investigator (see bibliography). It is not at present

certain whether the members of any one group are the result of the presence of specifically different germinal factors or whether they represent merely distinct grades of activity or different forms of a single factor. For the present purposes it makes little difference which of these conditions actually exists. All that is necessary to consider here is the fact that many independent hereditary units are active in forming the various color varieties of mice.

The terms used in describing the color varieties of mice and the factors involved in their formation are for the most part those used in a previous publication by one of the writers (see Little, 1913).

The groups of allelomorphs in mice are as follows:

(1)	C — full pigmentation (Y of some authors).	c — complete albinism (y).
(2)	D — density of pigmentation.	d — dilute pigmentation.
(3)	S — solid coat (U of some authors).	s — spotted coat (u).
(4)	F — solid forehead.	f — blaze (white forehead).
(5)	P — full black and brown eye pigmentation.	p — pink eye reduction.
(6)	A — agouti coat (G of some authors).	a — non-agouti coat (g).
(7)	B — black pigmentation.	b — non-black pigmentation.
(8)	W — non-waltzing.	w — waltzing.

These groups of allelomorphs have all been proved to be independent of one another in inheritance. This is not very surprising, for Morgan has found in the fruit fly, *Drosophila ampelophila*, that complete independence is to be expected in inheritance unless factors are borne in the same chromosome.

Since the researches of certain investigators in the oögenesis of mice have fixed the number of chromosomes in mice at twenty, we should expect that an equal number of allelomorphs might well be found which were entirely independent in inheritance. Morgan and his pupils have identified and investigated the inheritance of more than fifty-five groups of allelomorphs in Drosophila. With this fact in mind, an hypothesis utilizing ten or twenty pairs of mendelizing factors loses much of the fantastic and speculative appearance which it would have presented before their work was recorded.

Single Mendelian factor hypothesis. — The next point to be considered is whether or not a simple Mendelian hypothesis will account for the results of the present series of experiments. It is apparent from the outset that if a single factor underlies susceptibility to the transplantable tumors in mice, this is dominant over non-susceptibility. On this supposition approximately seventy-five per cent of the F_2 generation should be susceptible, whereas only 1.6 per cent of this generation have proved so. The almost complete absence of susceptible animals in this generation suggests that we may possibly be dealing with a reversal of dominance. If this were true we should expect a return of susceptibility, which on reversal would become recessive in at least twenty-five per cent of the F_2 and F_3 generations. The results which we have obtained, therefore, make it necessary to abandon the idea that there is in the stocks with which we have worked a single factor difference to account for susceptibility and non-susceptibility to the transplanted tumor.

Slye has published a report of experiments on the inheritance of the spontaneous tumors of mice. She finds, as have several earlier investigators of this problem (see Tyzzer, 1907; Murray, 1911), that various families show distinctly different hereditary tendencies in their ability to form spontaneous tumors. In the paper referred to Slye states that she is treating cancer as a *unit character*, that she has used methods in testing the inheritance of this character similar to those used in judging the inheritance of such a character as albinism. From her treatment of the subject throughout the paper it is evident that she considers *factor* and *character* as interchangeable or synonymous terms. That such is only rarely the case has been shown by a number of the more recent researches of both plant and animal geneticists.

When one considers that the reactions of mice to a single transplantable tumor are extremely diverse and certainly do not depend upon a single mendelizing factor, it seems hardly conceivable that the origin of the many types of spontaneous tumors in mice will prove to be dependent on a single

factor, or that they can all of them be grouped together as a single unit character.

As to Dr. Slye's statement that the problems of the inheritance of cancer cannot be solved by investigations with transplantable tumors, it is hoped that as the study of growth regulation is an important phase of tumor investigation, so the study of the inheritance of factors preventing or allowing abnormal growth may later on assist in the solution of the problem of cancer inheritance.

Since the single mendelizing unit, as well as the blending inheritance hypothesis, fails to explain the present results, the inheritance of susceptibility to transplanted tumor on the basis of multiple factors showing Mendelian inheritance may next be considered. Unless this applies, we shall be forced to admit that the facts are inexplicable on any present theory of inheritance.

The multiple factor hypothesis. — This may apply in several different ways as follows:

Cases have been reported by several investigators in which a given character may be produced by the action of any one of several independent mendelizing factors. One of the best known examples of such a condition is that reported by Nilsson-Ehle in wheat, where red color is produced by the action of any or all of three independent factors, which may be designated A, B and C, respectively. When all of the three are lacking, and only when this is the case, a white wheat is produced. The wheats possessing either A, B or C are red, and we have, therefore, in the F_2 generation from a cross between red (ABC) and white (abc) wheat a ratio of sixty-three red to one white individual, as follows:

27....	ABC	
9....	ABc	
9....	AbC	
9....	aBC	
3....	Abc	
3....	aBc	
3....	abC	
		Sixty-three red.
1....	abc	
		One white.

In this case all the individuals having the dominant character, red, are more or less similar, so that they have been classified under one descriptive term irrespective of whether the color is based on the presence of one, two, or three of the necessary factors. In raising only a small number of F_2 plants it is quite probable that the one white individual expected in approximately every sixty-four of this generation might not be obtained. There thus is no *a priori* ground for not expecting to find characters depending for their manifestation on one of four, five or *n* factors, and having an alternative form produced only when all four, five or *n* factors were inactive. The fact of interest in connection with the present work is that many factors, or better perhaps, "absences of factors," are in some instances necessary in order to produce a given character. In the example given above the application of this principle would extend only to recessive characters.

Attention may now be called to an allied yet distinct condition. The possibility of a dominant character dependent for its manifestation upon the simultaneous presence, in either a homozygous or heterozygous condition, of several factors may now be considered. Such a character will appear to be dominant instead of recessive, yet the principle of multiple factors underlying its formation is entirely Mendelian. A well-known example of a dominant character dependent upon the simultaneous presence of two independent mendelizing factors is that of color as opposed to albinism in sweet peas (Bateson, Punnett). Here the two factors, which we may call A and B, must both be present in either a single or double "dose," that is, either in a heterozygous or homozygous condition, in order for any color to be formed. The experimental result is that when (colored) AABB plants are crossed with aabb (white) individuals all the F_1 generation is colored AaBb, the single "dose" of A and B together being sufficient to produce

color. If F_2 is raised, it will consist of the following types:

1.... AABB	
2.... AaBB	
2.... AABb	
4.... AaBb	
	Nine colored.
1.... AAbb	
2.... Aabb	
1.... aaBB	
2.... aaBb	
1.... aabb	
	Seven white.

Only two somatic types, colored and white, will be formed. These will, however, bear to one another a 9:7 ratio instead of a 3:1 ratio, as is the case in F_2 from a cross involving only one factor as the basis of the character under observation.

This general line of reasoning may be carried further and a character formulated which depends upon the simultaneous presence of three factors A, B, and C. Here F_2 will consist of twenty-seven individuals with at least one "dose" of A, B, and C (therefore having the character in question) to thirty-seven individuals lacking one or more of the three factors A, B, and C (therefore lacking the character in question). We thus see that when one pair of factors is involved, the F_2 ratio is three individuals with the character to one without the character. When two pairs of factors are involved, the ratio in F_2 becomes nine with, to seven without, the character, or 1.28 to 1. When three pairs of factors are involved, the balance shifts still further, so that there are more individuals (37 : 27) without the character in F_2 than with it, the ratio being 1 to 1.37. As the number of pairs of factors involved increases, the ratio grows more and more unequal. Thus, with ten pairs of factors the ratio is 1 to 17.7, and with twenty pairs of factors a ratio of 1 to 314.3 (see Little, 1914).

The objection may be raised that no case is known in actual experimentation, with the exception of that of

sweet peas, which fits this especial phase of Mendelian inheritance. We believe, however, that the method of inheritance of certain color characters may be considered comparable to that of the tumor susceptibility which we have studied, and that in both cases the type of inheritance involved is identical. Eight pairs of allelomorphic characters have already been utilized in certain of our experiments with mice. While a single cross involving all eight pairs has never been made, it is nevertheless fairly certain that they are independent in inheritance and would give the following results:

If a wild mouse, intense, dark-eyed, black, agouti, and solid coated, is crossed with a waltzing albino potentially dilute, pink-eyed, brown, non-agouti, with two types of spotting, the offspring of the F_1 generation should all resemble the wild parent in color and habit.

The F_2 generation should yield two hundred and fifty-six color varieties (see Appendix B). Of these, sixty-four will be albinos and therefore identical in appearance though genetically distinct. Of the one hundred and ninety-two remaining varieties only one would exactly reproduce the F_1 hybrid type characteristic of the wild grandparent. The other one hundred and ninety-one would show variations of many sorts, but would all be distinguishable by breeding tests from one another. Thus, only one variety in the two hundred and fifty-six which it is possible to produce will exactly resemble the wild grandparent in its color and habit. As will be seen from the data given in Appendix B, however, the number of individuals in this one class is three times as great as that in any other one variety, and will bear to all other F_2 forms together approximately a 1 to 10 relationship. If instead of eight factors we were dealing with ten, the ratio would be 1 to 17.7.

Most of the color varieties which have been studied are distinguishable from one another somatically. If, however, the characters in question had to do with susceptibility to implanted tumor or some other physiological peculiarity, less evident somatically than pigment formation, we should

expect that a majority of the F_2 varieties would be indistinguishable from one another. This would lead to the lumping together of the forms of F_2 which do not possess at least a single dose of all the factors necessary for tumor growth under the general head of "non-susceptible." That this is the sole difference between the inheritance of visible characters and the inheritance of susceptibility to transplantable tumors is strongly indicated by the exact agreement of the two when all color varieties not resembling the wild mouse are lumped together. The results of the present experiments are thus most readily explained on the basis of the multiple Mendelian factor hypothesis. Aside from this we have no other known type of inheritance which applies to the data obtained.

No signs of linkage of the factors for tumor growth with the known color factors have been observed in our experiments. Since, however, the material had not been chosen with any idea of testing this particular problem it is not surprising that signs of linkage have not been observed. The possibility that some degree of linkage between factors affecting tumor growth and color factors may exist must therefore constantly be borne in mind. The object of the present investigation is, however, to show that many factors are involved in determining the reaction of a given animal to the tumor J. w. A. and that these factors are independent of each other.

In the following chart the plus sign indicates the presence of all the factors necessary for the character in question, *i.e.*, in one series the "wild" coat character, in the other "susceptibility" to the inoculated tumor. On the other hand, the minus sign indicates the absence of some of the factors necessary for the character in question. The five generations in which large numbers were obtained in the tumor inheritance work are included in the chart. The results obtained in other generations are omitted because the numbers thus far tested appeared too small to afford critical evidence for the

similarity of the two cases. In so far as they go, however, they are in accordance with the other results.

Color Characters.	Generation.	Tumor Growth Characters.
(a) Wild house mouse (agouti) ..... +	Parent.	Japanese waltzing mouse (susceptible)..... +
(b) Albino..... —		Common mice (immune). —
All of wild house mouse color ..... +	F_1	All susceptible ..... +
Only an occasional individual ..... +	F_2	Only an occasional individual ..... +
Great majority ..... —		Great majority..... —
All of wild mouse color.... +	Back cross F_1 with + parent.	All susceptible ..... +
Theoretically, if there were more than ten factors, one in several thousand would be like wild parent; all the rest would be unlike in some respect.	Back cross F_1 with — parent.	None have proven susceptible; all are..... — Theory applicable to color factors applies here.

By comparison the similarity in the inheritance of the two types of character is remarkable.

Before testing the application of our hypothesis to the work already recorded by other investigators, it may be well to point out two lines of further investigation which we hope to pursue in order to test definitely the applicability of the theory of multiple factors to the case of transplantable tumors.

First, detailed matings and tests of various lines of F_3 animals will be followed up carefully. Such tests should reveal the presence of various strains differing from one another in the factors for tumor growth which they possess. These differences will be manifested by corresponding differences in the ratios of susceptible to non-susceptible animals

in the offspring of the various lines. It should be possible to isolate strains of F_2 or F_3 hybrids, giving a much more easily observed ratio than the present one of one to sixty in the F_2 generation. As the lower ratios will also mean that the animals involved have only a few factors differing from the Japanese, the effort to obtain strains having low ratios will have a double object.

Second, the offspring obtained by breeding together the young from the cross between Japanese and F_1 hybrids should give a larger number of susceptible animals than the straight F_2 or F_3 generation. This increase should be in a definite ratio, according to the number of factors involved, and will, therefore, be open to experimental tests. If confirmatory results are obtained from these two sources and distinct advances are made towards the isolation of a strain of hybrids differing by five or less factors from the Japanese, it may fairly be claimed that the correctness of the hypothesis will have been established.

Until further experiments are made we should think of the growth of the transplanted tumor as depending not upon any determined number of factors, but rather upon a certain factor complex which is found in essentially all the animals of the Japanese waltzing race. Conversely we may think of the common (brown agouti or dilute brown) race as possessing a different factor complex from that of the Japanese race.

The complex of the tame race is capable of producing immunity to the tumor in the presence of part of the Japanese factor complex. If, however, all the members of the Japanese factor complex are represented, as in F_1, tumor growth is produced. The common race has a factor complex which by itself produces an environment unfavorable to tumor growth, while the opposite is true of the Japanese race. The hybrids of the first generation contain a sample of both complexes, and here the elements favorable to tumor growth furnished by that derived from the Japanese parent are sufficient to overcome any tendency to immunity which

that derived from the common parent might tend to produce.

When, however, the gametes are formed by the F_1 animals to produce the F_2 generation, the factors in the Japanese complex being mendelizing units are distributed in these gametes by the law of chance, and accordingly only one gamete in a great many will contain all the members of the Japanese factor complex. The fact that a great majority of the F_2 animals are non-susceptible to the inoculated tumor indicates that when only part of the members of the Japanese complex are present, continued tumor growth is impossible. The fact also that in certain F_2 animals a temporary growth of the tumor takes place, to be followed in turn by complete retrogression of the implant, may be explained on the basis that such animals represent a factor complex which contains most but not quite all the elements or factors found in the pure Japanese race. This temporary growth shows further that if the hypothesis of multiple factors is correct, certain of the factors probably reach their expression as active forces on tumor growth at different periods during the development of the individual. This is at least true of all mendelizing characters which become visibly manifested.

Although dominance of "susceptibility" in the F_1 generation suggests the presence in the Japanese race of a considerable number of epistatic* factors, such is in all probability not the case. The appearance of "susceptibility" as a dominant does not necessitate the addition of substances lacking in the tame race. In fact, quite the opposite is probably true. Thus, if we suppose the "Japanese" complex to be made up of $A^J\ B^J\ C^J\ D^J \ldots\ldots\ X^J$, and the "tame" complex of a number of factors $A^T\ B^T\ C^T\ D^T \ldots\ldots\ X^T$, then the one condition necessary for susceptibility to appear is the presence of at least a single representation of all the factors characteristic of the Japanese complex, as in the F_1 hybrid $A^J\ A^T\ B^J\ B^T\ C^J\ C^T\ D^J\ D^T \ldots\ldots\ X^J\ X^T$. Various recombinations of these factors in the F_2 generation fail to

* Genetic not medical terminology.

produce susceptibility unless at least a single dose of all the factors in the Japanese complex is present. Thus, if a certain F_2 animal was of the formula $A^J A^T B^J B^T C^T C^T D^J D^T \ldots\ldots X^J X^T$, it might be non-susceptible since it did not possess even a single dose of the C^J factor, even though all the other factors in the Japanese complex were represented.

Application of the Multiple Factor Hypothesis to the Work of Other Investigators.

Cuénot and Mercier have published a report on the results of certain experiments which they have carried on to determine the nature of the inheritance of susceptibility and immunity to an inoculable tumor of common, *i.e.*, non-waltzing mice.

They conclude that susceptibility and non-susceptibility are not Mendelian characters, and that neither hypotheses of one, two or *n* factors will explain the facts in an exact manner. It should, however, be remembered that when this was written by them the modern methods of utilizing multiple factors were to all intents and purposes unknown.

So far as their results are given, they can be satisfactorily explained on the hypothesis which we have advanced. They themselves feel that the character inherited is a certain racial percentage of "takes." This type of explanation, while it is similar to that adopted by Jennings, in explaining the inheritance of size differences in Paramecium, and while it accounts for Cuénot's and Mercier's results, fails to fit the facts observed in Tyzzer's earlier work or in the experiments here recorded. The idea of "genotypes" or races differing from one another in their complex of hereditary factors is the most applicable part of their explanation. It is, of course, this idea of "genotypes" that underlies the modern theories of multiple factors and of "pure lines."

The hypothesis, however, that there are races of mice which differ from one another constantly in the percentages of the "positive" and "negative" animals which they contain is not supported, in the form in which Cuénot and Mercier have advanced it, by the writers' experiments.

The essential difference between their hypothesis and that which we advance is the following: On their supposition a genotype when isolated will consist of animals all of which possess the ability to produce a certain fixed percentage of positive or susceptible animals among their progeny. The animals contained in this genotype will continue indefinitely to produce animals as descendants all of which possess the same ability as they did. It is as though we had between the conditions of one hundred per cent positive and zero per cent positive a number of permanent intermediate percentages which represented the centers of variation of a number of genotypes.

We may now imagine that one of these genotypes has a characteristic percentage of eighty per cent positive and another of twenty per cent positive animals. These two genotypes having been carefully isolated, the breeding of either positive or negative animals would not result in permanently modifying the percentage of takes characteristic for the genotype. No animal transmitting either a higher or a lower percentage of "positives" than that characterizing their particular genotype could be obtained without the appearance of a mutation. This naturally is a possibility in any material, but is a phenomenon of so infrequent occurrence that it may be left out of consideration in the present case.

On our hypothesis, wherever a positive animal appears it means that this animal contains at least a single representation of the factor complex of the (Japanese) one hundred per cent positive race. This means that this animal is at least as near to the make-up of the one hundred per cent positive parent as are the F_1 hybrids between common and Japanese mice, even though it may occur in a generation giving only 1.6 per cent positive or even less.

Moreover, on Cuénot's and Mercier's hypothesis that, when we have two races apparently the extremes of a plus and minus variability in the degree of susceptibility, we should expect an intermediate and blending inheritance when these two forms are crossed, but such a result was not

obtained. It is scarcely conceivable that the factors underlying susceptibility and non-susceptibility to inoculated tumors in the races of common mice used by the other investigators are fundamentally different from those found in the common mice which we used. It is much more probable that they are similar factors but present in our races in a degree of homozygosis approaching a genotypical condition; while in their material the factors were almost certainly more unevenly distributed, approximating the condition characteristic of mixed populations in general. If, therefore, the factors in the various cases are fundamentally the same, any general hypothesis explaining the facts of inheritance of part of the experimental results should be applicable to the results as a whole. This we believe to be true of the hypothesis which we have advanced.

In addition to the work already referred to, Loeb and Fleischer have carried on a series of investigations on the factors underlying the hereditary susceptibility of mice to a transplantable carcinoma.

The material which they used was in several ways distinctly different from that afforded by the tame and Japanese races and their hybrids. It was, however, of such a nature as to furnish an interesting line of support to the evidence which we have been able to obtain.

Loeb and Fleischer used one race of American mice and two European races, obtained by distinct importations, as their parent stocks. They found by tests reaching over several generations that the percentage of American mice to grow the inoculated tumor was eighty-four, while those of the European races I and II were twenty-three and three per cent respectively.

They next proceeded to cross the American race with each of the two European races. They found that F_1 from American x European I gave sixty-eight per cent susceptible, while F_1 from American x European II gave one hundred per cent susceptible. F_2 from the American x European I gave thirty per cent susceptible and F_2 from American x European II gave twenty-six per cent susceptible.

It will at once be noticed that there are certain marked differences between the results above mentioned and those obtained by Tyzzer, 1909, and by the writers. In the first place, in the experiments of Loeb and Fleischer the F_1 generation showed a percentage of susceptibility intermediate between the parent races. The F_1 mice obtained from American mice crossed with European race II, which were one hundred per cent susceptible, were in too small a number (14) to establish the susceptibility of this generation. The decrease of the percentage of susceptible animals in F_2 is in accordance with the previous work of Tyzzer and with the present experiments.

These points of difference and of similarity are readily understandable on a Mendelian hypothesis of multiple factors. We have supposed that in the case of the experiments reported in this paper a number of factors are found in the germ cells of one race which are either not present or replaced by allelomorphic factors in the other race. We have further supposed that successful growth of the transplanted tumor depends upon the simultaneous presence in the zygote, at least in a single representation, of a considerable number of factors of the susceptible race.

This hypothesis will apply as well to the experiments of Loeb and Fleischer. The fact that the American race gave in the neighborhood of twenty per cent of its members non-susceptible to the transplantable tumor shows at once that it is not a race homozygous for the susceptibility producing factor complex. The percentages of susceptibility in the two European races show that they both probably have even fewer of the necessary factors in a homozygous state, and that they probably differ from one another as well. Race I, for example, has probably distinctly fewer of these factors in a homozygous condition than has race II.

The cross with the American race produces exactly what might be expected. In the cross of American by European I the F_1 generation is intermediate in its percentage of susceptibility and F_2 shows that the combinations of factors necessary for tumor growth are less common than in the

F_1 generation. This is to be expected on the multiple factor hypothesis. The same applies to the F_1 and F_2 from the American by European II cross.

The character of the F_3 from these crosses may be predicted as follows on the hypothesis of multiple factors: If a large number of F_2 animals, mated inter se at random, are used to produce the F_3 generation, the percentage of susceptibility in the F_3 generation should be the same as in F_2. This condition of random mating, producing large numbers, is most nearly realized in the F_3 generation of the cross between American and European I. The one hundred and twenty-two animals comprising this generation show a percentage of susceptibility of twenty-four as compared with thirty per cent in the F_2 generation of the same cross. In the F_3 generation of the American by European II cross the percentage of susceptibility in sixty-six animals is only two as compared with twenty-six per cent in the F_2 of this cross. This difference is probably at least partly due to the relatively small numbers of young raised in that particular cross.

The behavior of the back cross generations tested by these authors is also amply in accord with this hypothesis of multiple factors, and it appears that this set of results, which almost completely parallel the results of the usual "size inheritance" crosses, offers extremely valuable evidence in showing the close relationship of an apparently blending inheritance and an obviously alternative inheritance of the characters on which susceptibility to inoculable tumors are based.

The results of the present series as well as of previous experiments may be explained by the hypothesis that susceptibility to a transplantable tumor is based on a factor complex, or on the coexistence of a number of inherited factors in the individual. These factors, even when in only a single representation (or half dose), as they must occur in the first filial generation of hybrids, are sufficient to produce susceptibility. The animals of subsequent generations, which

lack one or more of these factors, are non-susceptible, and the ratio of the susceptible to the non-susceptible in the second filial generation should indicate the number of factors on which these characters are based. With the present material, Tumor J. w. A., however, the susceptible F_2 individuals are so rare that it would require much more abundant data than we have here presented to arrive at any conclusion concerning even the approximate number of factors necessary. It is probable that the number is rather large, for if susceptibility were based on from twelve to fourteen factors, as many positive animals would occur as we have obtained. Further experiments are at present being carried out with another tumor, which with the same stocks of mice promises to be more favorable in this respect. Since one of the characters studied (non-susceptibility) amounts to an ability to develop immunity to a given foreign cell, it will be of interest if the same principles are found to apply in the inheritance of susceptibility to infectious diseases.

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APPENDIX.

The behavior of eight pairs of Mendelian factors.

In the construction of a similar table to apply to factors determining tumor growth we should not be justified in using symbols indicating their dominant or recessive nature, but could represent actual conditions by symbols merely indicating unlikeness, as A^J and A^T, rather than A and a.

Wild mouse ACBDPWFS crossed with albino waltzer acbdpwfs.

F_1 generation (AaCcBbDdPpWwFfSs) all appear like wild mouse.

EXPECTED RATIO OF VARIOUS COLOR TYPES IN F_2 GENERATION.

6561....	A	C	B	D	P	W	F	S
2187....	A	c	B	D	P	W	F	S
"	a	C	B	D	P	W	F	S
"	A	C	b	D	P	W	F	S
"	A	C	B	d	P	W	F	S
"	A	C	B	D	P	w	F	S
"	A	C	B	D	p	W	F	S
"	A	C	B	D	P	W	f	S
"	A	C	B	D	P	W	F	s
729....	a	C	b	D	P	W	F	S
"	a	c	B	D	P	W	F	S
"	a	C	B	d	P	W	F	S
"	a	C	B	D	p	W	F	S
"	a	C	B	D	P	w	F	S
"	a	C	B	D	P	W	f	S
"	a	C	B	D	P	W	F	s
"	A	c	b	D	P	W	F	S
"	A	c	B	d	P	W	F	S
"	A	c	B	D	p	W	F	S
"	A	c	B	D	P	w	F	S
"	A	c	B	D	P	W	f	S
"	A	c	B	D	P	W	F	s
"	A	C	b	d	P	W	F	S
"	A	C	b	D	p	W	F	S
"	A	C	b	D	P	w	F	S
"	A	C	b	D	P	W	f	S
"	A	C	b	D	P	W	F	s
"	A	C	B	d	p	W	F	S
"	A	C	B	d	P	w	F	S

729....	A	C	B	d	P	W	f	S
"	A	C	B	d	P	W	F	s
"	A	C	B	D	p	w	F	S
"	A	C	B	D	p	W	f	S
"	A	C	B	D	p	W	F	s
"	A	C	B	D	P	w	f	S
"	A	C	B	D	P	w	F	s
"	A	C	B	D	P	W	f	s

243....	a	c	b	D	P	W	F	S
"	a	c	B	d	P	W	F	S
"	a	c	B	D	p	W	F	S
"	a	c	B	D	P	w	F	S
"	a	c	B	D	P	W	f	S
"	a	c	B	D	P	W	F	s
"	a	C	b	d	P	W	F	S
"	a	C	b	D	p	W	F	S
"	a	C	b	D	P	w	F	S
"	a	C	b	D	P	W	f	S
"	a	C	b	D	P	W	F	s
"	a	C	B	d	p	W	F	S
"	a	C	B	d	P	w	F	S
"	a	C	B	d	P	W	f	S
"	a	C	B	d	P	W	F	s
"	a	C	B	D	p	w	F	S
"	a	C	B	D	p	W	f	S
"	a	C	B	D	p	W	F	s
"	a	C	B	D	P	w	f	S
"	a	C	B	D	P	w	F	s
"	a	C	B	D	P	W	f	s
"	A	c	b	d	P	W	F	S
"	A	c	b	D	p	W	F	S
"	A	c	b	D	P	w	F	S
"	A	c	b	D	P	W	f	S
"	A	c	b	D	P	W	F	s
"	A	c	B	d	p	W	F	S
"	A	c	B	d	P	w	F	S
"	A	c	B	d	P	W	f	S
"	A	c	B	d	P	W	F	s
"	A	c	B	D	p	w	F	S
"	A	c	B	D	p	W	f	S
"	A	c	B	D	p	W	F	s
"	A	c	B	D	P	w	f	S
"	A	c	B	D	P	w	F	s
"	A	c	B	D	P	W	f	s
"	A	C	b	d	p	W	F	S
"	A	C	b	d	P	w	F	S
"	A	C	b	d	P	W	f	S
"	A	C	b	d	P	W	F	s
"	A	C	b	D	p	w	F	S

243....	A	C	b	D	p	W	f	S
"	A	C	b	D	p	W	F	s
"	A	C	b	D	P	w	f	S
"	A	C	b	D	P	w	F	s
"	A	C	b	D	P	W	f	s
"	A	C	B	d	p	w	F	S
"	A	C	B	d	p	W	f	S
"	A	C	B	d	p	W	F	s
"	A	C	B	d	P	w	f	S
"	A	C	B	d	P	w	F	s
"	A	C	B	d	P	W	f	s
"	A	C	B	D	p	w	f	S
"	A	C	B	D	p	W	f	s
"	A	C	B	D	p	w	F	s
"	A	C	B	D	P	w	f	s

81....	a	c	b	d	P	W	F	S
"	a	c	b	D	p	W	F	S
"	a	c	b	D	P	W	f	S
"	a	c	b	D	P	w	F	S
"	a	c	b	D	P	W	F	s
"	a	c	B	d	p	W	F	S
"	a	c	B	d	P	w	F	S
"	a	c	B	d	P	W	f	S
"	a	c	B	d	P	W	F	s
"	a	c	B	D	p	w	F	S
"	a	c	B	D	p	W	f	S
"	a	c	B	D	p	W	F	s
"	a	c	B	D	P	w	f	S
"	a	c	B	D	P	w	F	s
"	a	c	B	D	P	W	f	s
"	a	C	b	d	p	W	F	S
"	a	C	b	d	P	w	F	S
"	a	C	b	d	P	W	f	S
"	a	C	b	d	P	W	F	s
"	a	C	b	D	p	w	F	S
"	a	C	b	D	p	W	f	S
"	a	C	b	D	p	W	F	s
"	a	C	b	D	P	w	f	S
"	a	C	b	D	P	w	F	s
"	a	C	b	D	P	W	f	s
"	A	c	b	d	p	W	F	S
"	A	c	b	d	P	w	F	S
"	A	c	b	d	P	W	f	S
"	A	c	b	d	P	W	F	s
"	A	c	b	D	p	w	F	S
"	A	c	b	D	p	W	f	S
"	A	c	b	D	p	W	F	s
"	A	c	b	D	P	w	f	S
"	A	c	b	D	P	w	F	s

81....	A	c	b	D	P	W	f	s
"	a	C	B	d	p	w	F	S
"	a	C	B	d	p	W	f	S
"	a	C	B	d	p	W	F	s
"	a	C	B	d	P	w	f	S
"	a	C	B	d	P	w	F	s
"	a	C	B	d	P	W	f	s
"	a	C	B	D	p	w	f	S
"	a	C	B	D	p	w	F	s
"	a	C	B	D	p	W	f	s
"	a	C	B	D	P	w	f	s
"	A	c	B	d	p	w	F	S
"	A	c	B	d	p	W	f	S
"	A	c	B	d	p	W	F	s
"	A	c	B	d	P	w	f	S
"	A	c	B	d	P	w	F	s
"	A	c	B	d	P	W	f	s
"	A	c	B	D	p	w	f	S
"	A	c	B	D	p	w	F	s
"	A	c	B	D	p	W	f	s
"	A	c	B	D	P	w	f	s
"	A	C	b	d	p	w	F	S
"	A	C	b	d	p	W	f	S
"	A	C	b	d	p	W	F	s
"	A	C	b	d	P	w	f	S
"	A	C	b	d	P	w	F	s
"	A	C	b	d	P	W	f	s
"	A	C	b	D	p	w	f	S
"	A	C	b	D	p	W	f	s
"	A	C	b	D	p	w	F	s
"	A	C	b	D	P	w	f	s
"	A	C	B	d	p	w	f	S
"	A	C	B	d	p	w	F	s
"	A	C	B	d	p	W	f	s
"	A	C	B	d	P	w	f	s
"	A	C	B	D	p	w	f	s

27....	A	C	B	d	p	w	f	s
"	A	c	B	D	p	w	f	s
"	A	c	B	d	P	w	f	s
"	A	c	B	d	p	W	f	s
"	A	c	B	d	p	w	F	s
"	A	c	B	d	p	w	f	S
"	A	C	b	D	p	w	f	s
"	A	C	b	d	P	w	f	s
"	A	C	b	d	p	W	f	s
"	A	C	b	d	p	w	F	s
"	A	C	b	d	p	w	f	S
"	A	c	b	D	P	w	f	s
"	A	c	b	D	p	W	f	s

27....	A	c	b	D	p	w	F	s.
"....	A	c	b	D	p	w	f	S.
"....	A	c	b	d	P	W	f	s.
"....	A	c	b	d	P	w	F	s
"....	A	c	b	d	P	w	f	S.
"....	A	c	b	d	p	W	F	s.
"....	A	c	b	d	p	W	f	S.
"....	A	c	b	d	p	w	F	S.
"....	a	C	B	D	p	w	f	s
"....	a	C	B	d	P	w	f	s.
"....	a	C	B	d	p	W	f	s.
"....	a	C	B	d	p	w	F	s
"....	a	C	B	d	p	w	f	S.
"....	a	C	b	D	P	w	f	s.
"....	a	C	b	D	p	W	f	s.
"....	a	C	b	D	p	w	F	s
"....	a	C	b	D	p	w	f	S.
"....	a	C	b	d	P	W	f	s
"....	a	C	b	d	P	w	F	s
"....	a	C	b	d	P	w	f	S.
"....	a	C	b	d	p	W	F	s
"....	a	C	b	d	p	W	f	S.
"....	a	C	b	d	p	w	F	S.
"....	a	c	B	D	P	w	f	s
"....	a	c	B	D	p	W	f	s
"....	a	c	B	D	p	w	F	s.
"....	a	c	B	D	p	w	f	S.
"....	a	c	B	d	P	W	f	s.
"....	a	c	B	d	P	w	F	s
"....	a	c	B	d	P	w	f	S.
"....	a	c	B	d	p	W	F	s.
"....	a	c	B	d	p	W	f	S
"....	a	c	B	d	p	w	F	S
"....	a	c	b	D	P	W	f	s.
"....	a	c	b	D	P	w	F	s
"....	a	c	b	D	P	w	f	S
"....	a	c	b	D	p	W	F	s.
"....	a	c	b	D	p	W	f	S
"....	a	c	b	D	p	w	F	S.
"....	a	c	b	d	P	W	F	s
"....	a	c	b	d	P	W	f	S.
"....	a	c	b	d	P	w	F	S
"....	a	c	b	d	p	W	F	S.

9....	A	c	B	d	p	w	f	s.
"....	A	C	b	d	p	w	f	s
"....	A	c	b	D	p	w	f	s
"....	A	c	b	d	P	w	f	s
"....	A	c	b	d	p	W	f	s.
"....	A	c	b	d	p	w	F	s.

9....	A	c	b	d	p	w	f	S
"....	a	C	B	d	p	w	f	s
"....	a	C	b	D	p	w	f	s
"....	a	C	b	d	P	w	f	s
"....	a	C	b	d	p	W	f	s
"....	a	C	b	d	p	w	F	s
"....	a	C	b	d	p	w	f	S
"....	a	c	B	D	p	w	f	s
"....	a	c	B	d	P	w	f	s
"....	a	c	B	d	p	W	f	s
"....	a	c	B	d	p	w	F	s
"....	a	c	B	d	p	w	f	S
"....	a	c	b	D	P	w	f	s
"....	a	c	b	D	p	W	f	s
"....	a	c	b	D	p	w	F	s
"....	a	c	b	D	p	w	f	S
"....	a	b	c	d	P	W	f	s
"....	a	b	c	d	P	w	F	s
"....	a	b	c	d	P	w	f	S
"....	a	b	c	d	p	W	F	s
"....	a	b	c	d	p	W	f	S
"....	a	b	c	d	p	w	F	S

3....	A	b	c	d	p	w	f	s
"....	a	B	c	d	p	w	f	s
"....	a	b	C	d	p	w	f	s
"....	a	b	c	D	p	w	f	s
"....	a	b	c	d	P	w	f	s
"....	a	b	c	d	p	W	f	s
"....	a	b	c	d	p	w	F	s
"....	a	b	c	d	p	w	f	S

1....	a	b	c	d	p	w	f	s	albino (pink eyed dilute brown blz-spot waltz).

1 x 1	1
8 x 3	24
28 x 9	252
56 x 27	1512
70 x 81	5670
56 x 243	13608
28 x 729	20412
8 x 2187	17496
1 x 6561	6561
	65536

CHARTS.

The following charts present the data obtained in the present series of experiments.

A carcinoma (J. w. A.) of the Japanese waltzing mouse was used in all instances.

Experiments A 1 to A 5 were carried out on mice of the *brown agouti* stock described elsewhere and their hybrids with the waltzing mice.

In Experiments B 1 to B 3 the *dilute brown* stock and their hybrids were employed.

The tumors are represented at approximately one-seventh of their actual diameter. In some instances the weight of the tumor is given at the time of death, which is otherwise indicated by the symbol †.

SUMMARY — EXPERIMENT A 1.

Eleven F_2 hybrids. — Two weeks after inoculation five show small nodules. Subsequently all negative.

Twelve F_2 hybrids (three died after six days) — Two and three weeks after inoculation three show nodules. Subsequently all retrogress, although one grows for five weeks and persists for over seven weeks.

Eleven (F_1 *x Br. Ag.*)^1 *hybrids.* — No appreciable growth of tumor.

Eleven Br Ag. stock mice. — No growth.

Twelve (F_1 *x J. w*)^1 *hybrids* (one died early). — Eleven grew large tumors.

Eleven F_1 hybrids. — All grew large tumors.

Eleven J. w. mice. — All positive.

SUMMARY — EXPERIMENT A 2.

Fifty F_2 hybrids. — Two weeks after inoculation twelve show nodules. Three weeks after inoculation ten show nodules. Four weeks after inoculation six show nodules. Five weeks after inoculation two show nodules. One of these retrogressed after twelve weeks, the other grew continuously.

Thirty-seven (F_1 *x Br. Ag.*)^1 *hybrids.* — No growth.

Six Br. Ag. stock mice. — No growth.

Twelve (F_1 *x J. w*)^1 *hybrids* (seven died early). — Five grew large tumors.

Six F_1 hybrids. — One died five weeks later. Five positive.

Twelve J. w. mice. — Two weeks after inoculation all showed tumor nodules. Tumors grew until death, which occurred early.

Eight (F_1 *x Br. Ag.*)^2 *hybrids.* — Two weeks after inoculation two showed nodules. Three died on this date. Subsequently all negative.

SUMMARY — EXPERIMENT A 3.

Thirty-seven F_2 hybrids (seven died early). — Two weeks after inoculation eleven show nodules. Three weeks after inoculation five show nodules. Four weeks after inoculation three show nodules. Subsequently two of these retrogressed, but the other grew progressively.

Five F_3 hybrids. — Three weeks after inoculation one shows a minute nodule, but died on this date. All others negative.

Sixteen $(F_1 \times Br.\ Ag.)^1$ *hybrids* (one died early). — Two weeks after inoculation seven show nodules. Three weeks after inoculation three show nodules. Five weeks after inoculation two show nodules. Subsequently both tumors retrogressed.

Forty-one Br. Ag. stock mice. — Two weeks after inoculation five show minute nodules. Three weeks after inoculation one shows minute nodule. Subsequently all negative.

Six $(F_1 \times J.\ w)^1$ *hybrids.* — All positive.

Eleven F_1 hybrids. — All positive.

Three J. w. mice (one died early). — Others positive.

Five $(F_1 \times Br.\ Ag.)^2$ *hybrids.* — Two weeks after inoculation one shows a nodule. Subsequently all negative.

Four $(F_1 \times F_2)^1$ *hybrids.* Three weeks after inoculation two show nodules. One subsequently retrogressed, the other continued to develop until death.

SUMMARY — EXPERIMENT A 4.

Eleven F_2 hybrids (three lost). — Two weeks after inoculation five show nodules. Three weeks after inoculation one shows nodules. Subsequently all negative.

Three F_3 hybrids (one died early). — Others negative.

Four F_1 hybrids. — All positive.

Six J. w. mice. — All positive.

Three $(F_1 \times F_2)^1$ (one died early). — One positive.

SUMMARY — EXPERIMENT A 5.

Thirty-three F_2 hybrids. — Two weeks after inoculation seven show nodules. Three weeks after inoculation seven show nodules. Four weeks after inoculation three show nodules. Five weeks after inoculation two show nodules. Six weeks after inoculation one shows a nodule. Subsequently all negative.

Seven F_3 hybrids. — Two weeks after inoculation one shows a nodule. Subsequently all negative.

Seven $(F_1 \times Br.\ Ag.)^1$ *hybrids.* — No growth.

Twenty-six $(F_1 \times J.\ w)^1$ *hybrids.* — All positive.

Ten F_1 hybrids. — All positive.

Six J. w. mice. — All positive.

Nineteen $(F_1 \times Br.\ Ag.)^2$ *hybrids.* — No growth.

Three $(F_1 \times F_2)^1$ *hybrids.* — Two weeks after inoculation one shows a nodule. Subsequently all negative.

Five $(F_1 \times J.\ w.)^2$ *hybrids.* — Three weeks after inoculation two show nodules. One subsequently retrogressed. One positive.

SUMMARY — EXPERIMENT B 1.

Twenty-six F_2 hybrids (four died early). — Two weeks after inoculation six show nodules. Subsequently all negative.

Five F_3 hybrids (one died early). — Others negative.

Twenty-one d. Br. stock mice. — One showed a nodule for five weeks, then retrogressed. All negative.

Twenty-two F_1 hybrids (two died early). — One negative (not tested by re-inoculation). Nineteen positive.

Ten J. w. mice (two died early). — Others positive.

SUMMARY — EXPERIMENT B 2.

Twenty-three F_2 hybrids. — Eight show temporary growth from two to six weeks after inoculation. One positive — progressively growing tumor.

Nine (F_1 x d. Br.)[1] hybrids. — Two weeks after inoculation one shows a nodule. Subsequently all negative.

Ten d. Br. stock mice. — Three weeks after inoculation one shows a nodule. Subsequently all negative.

Six J. w. mice. — All positive.

SUMMARY — EXPERIMENT B 3.

Thirty-five F_2 hybrids (eight died early). — Eight show temporary growth from one to five weeks after inoculation. Subsequently all negative.

Eleven F_3 hybrids. — Two weeks after inoculation one shows a nodule. Subsequently all negative.

Eleven d. Br. stock mice. — Two weeks after inoculation one shows a nodule. Subsequently all negative.

Nineteen (F_1 x J. w.)[1] hybrids (four died early). — Others positive.

Five (F_1 x d. Br.)[2] hybrids. — Two weeks after inoculation two show nodules. Three weeks after inoculation one shows a nodule. Subsequently all negative.

Eight J. w. mice (one died early). — Others positive.

EXPERIMENT A.I.

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4087	F_2	2Mo.15d.	—	—	—	—	—	—
4088	»	» »	—	—	—	—	—	—
4089	»	» »	—	—	—	—	—	—
4090	»	» »	—	—	—	—	—	—
4091	»	53d.	—	—	—	—	—	—
4092	F_3	2Mo.1d.	—	—	—	—	—	—
4093	»	» »	—	—	—	—	—	—
4094	»	» »	—	—	—	—	—	—
4095	»	19d	†6d.					
4096	»	»	†6d.					
4097	»	»	†6d.					
4098	(F_1×Br.Ag.)'	57d.	—	—	—	—	—	—
4099	»	»	—	—	—	—	—	—
4100	»	»	—	—	—	—	—	—
4101	»	»	—	—	—	—	—	—
4102	»	»	—	—	—	—	—	—
4103	Br.Ag.	19d.	—	—	†			
4104	»	»	—	—	—	—	—	—
4105	»	»	—	—	—	—	—	—
4106	»	»	—	—	—	—	—	—
4107	»	»	—	—	—	—	—	—
4108	(F_1×J.w.)'	57d				1.700		
4109	»	»		†1.540				

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4110	(F_1×J.w.)'	57d.				4.614		
4111	»	»				3.150		
4112	»	»				1.512		
4113	»	»				1.883		
4114	F_1	4Mo.28d.				4.290		
4115	»	» »				7.152		
4116	»	» »				7.900		
4117	»	» »				6.250		
4118	»	5Mo.9d.				2.954		
4119	J.w.	35d.						
4120	»	»		†				
4121	»	»						
4122	»	35d.						1.050
4123	»	»			†.370			
4124	F_2	53d.	—	—	—	—	—	—
4125	»	»		—	—	—	—	—
4126	»	2Mo.24d.	—	—	—	—	—	—
4127	»	» »	—	—	—	—	—	—
4128	»	» »	—	—	—	—	—	—
4129	»	» »	—	—	—	—	—	—
4130	F_3	3Mo.9d.		†.65				
4131	»	19d.			—	—	—	—
4132	»	»	—	—	—	—	—	—

EXPERIMENT A.J. Cont.

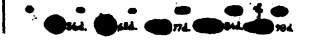
No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4133	F_3	19d	–	– †				
4134	"	"	– †					
4135	"	50d.	●	●	●	● 56d	● —63d	● —70d
4136	$(F_1 \times Br.A_2)^2$	57d.	–	–	†			
4137	"	"	–	–	–	–	–	–
4138	"	"	–	–	–	–	–	–
4139	"	"	–	–	–	–	–	–
4140	"	"	–	–	–	–	–	–
4141	"	24d.	†					
4142	$Br.A_2$	2Mo.29d.	–	–	–	–	–	–
4143	"	" "	–	–	–	–	–	–
4144	"	" "	–	–	–	–	–	–
4145	"	" "	–	–	–	–	–	–
4146.	"	2Mo.29d.	–	–	–	–	–	–
4147	"	" "	–	–	–	–	–	–
4148	$(F_1 \times J.w.)^2$	2Mo.2d.	●	●	●	● 4.565		
4149	"	" "	●	●	●	● 4.514		
4150	"	" "	† 6d.					
4151	"	57d.	●	●	●	● 5.285		
4152	"	"	●	●	●	● 4.390		
4153	"	"	●	●	●	● 1.165		
4154	F_1	5Mo.29d.	●	●	●	● 3.930		
4155	"	" "	●	●	●	● 2.100		

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4156	F_1	5Mo.29d.	●	●	●	● 4.055		
4157	"	4Mo.	●	●	●	● 2.952		
4158	"	4Mo.21d.	●	●	●	● 3.440		
4159	"	" "	●	●	●	● 2.062		
4160	J.w.	35d.	●	● † 248				
4161	"	"	●	●	†			
4162	"	"	●	●	●	●	●	● 2.565
4163	"	"	●	●	●	● † 1.150		
4164	"	"	●	● † 185				
4165	"	"	●	● † 326				

EXPERIMENT A.2.

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4166	F_2	47d.	–	–	–	–	–	–
4167	»	»	–	–	–	–	–	–
4168	»	»	–	–	–	–	–	–
4169	»	»	–	–	–	–	–	–
4170	»	3Mo.3d.	–	–	–	–	–	–
4171	»	» »	–	–	–	–	–	–
4172	»	» 5d	–	–	–	–	–	†
4173	»	2Mo.15d	–	–	–	–	–	–
4174	»	» »	•	•	–	–	–	–
4175	»	» »	–	–	–	–	–	–
4176	»	» »	–	–	–	–	–	–
4177	»	3Mo.28d.	†					
4178	»	» »	–	–	–	–	–	–
4179	»	» 18d.	–	–	–	–	–	–
4180	»	2Mo.12d.	–	–	–	–	–	–
4181	»	» 5d	–	–	–	–	–	–
4182	»	» »	•	•	•	–	–	–
4183	$(F_1 \times Br.A_2)^1$	» 4d.	–	–	–	–	–	–
4184	»	» »	–	–	–	–	–	–
4185	»	» »	–	–	–	–	–	–
4186	»	» »	–	–	–	–	–	–
4187	»	» »	–	–	–	–	–	–
4188	»	» »	–	–	–	–	–	–

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4189	$(F_1 \times Br.A_2)^1$	2Mo.2d.	–	–	–	–	–	–
4190	»	» »	–	–	–	–	–	–
4191	»	» 15d.	–	–	–	–	–	–
4192	»	» »	–	–	–	–	–	–
4193	»	» »	–	–	–	–	–	–
4194	»	» »	–	–	–	–	–	–
4195	»	» 2d.	–	–	–	–	–	–
4196	$(F_1 \times J.w.)^1$	33 d.	† .018					
4197	»	»	† .066					
4198	»	»	† 74 .080					
4199	»	»	† .053					
4200	F_1	8Mo.28d	•	•	•	• 1.725		
4201	»	»	† 84					
4202	»	4Mo.29d.	•	† .307				
4203	»	» »	•	•	•	• 3.180		
4204	»	» »	•	•	•	• 1.047		
4205	»	» »	•	•	•	• 3.858		
4206	F_2	25 d.	•	•	•	–	–	–
4207	»	»	–	–	–	–	–	–
4208	»	»	•	–	–	–	–	–
4209	»	»	•	–	–	–	–	–
4210	»	»	–	–	–	–	–	–
4211	»	»	•	•	•	•	•	•



EXPERIMENT A.2. Cont.

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4212	F_2	25d	†010					
4213	»	»	● 56d	● 63d	● 77d	● 84d	● 98d	●
4214	»	»	–	–	–	–	–	–
4215	»	»	–	–	–	–	–	–
4216	»	»	•	–	–	–	–	–
4217	»	»	–	–	–	–	–	–
4218	»	33d.	●	●	●	–	–	–
4219	»	»	–	–	–	–	–	–
4220	»	»	•	–	–	–	–	–
4221	»	2Mo23d.	–	–	–	–	–	–
4222	»	» »	–	–	–	–	–	–
4223	$(F_1 B \times A_{(g)})^1$	59 d.	–	–	–	–	–	–
4224	»	»	–	–	–	–	–	–
4225	»	»	–	–	–	–	–	–
4226	»	2Mo2d.	–	–	–	–	–	–
4227	»	» »	–	–	–	–	–	–
4228	»	» »	–	†				
4229	»	» »	–	–	–	–	–	–
4230	»	» »	–	–	–	–	–	–
4231	»	» »	–	–	–	–	–	–
4232	»	» »	–	–	–	–	–	–
4233	»	» »	–	–	–	–	–	–
4234	»	» »	–	–	–	–	–	–

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4235	$(F_1 \times J_{(w)})^1$	33 d.	•	●	●	● 3.516		
4236	»	» †						
4237	»	33 d.	•	●	●	● 6500		
4238	»	»	†013					
4239	$(F_1 B \times A_{(g)})^2$	28 d.	†					
4240	»	»	–	†				
4241	»	»	●	•	–	–	–	–
4242	»	»	†					
4243	»	»	–	–	–	–	–	–
4244	»	»	–	–	–	–	–	–
4245	»	»	–	–	–	–	–	–
4246	»	»	†010					
4247	F_2	26 d. †	5d.					
4248	»	»	●	●	•	–	–	–
4249	»	» †	6d.					
4250	»	» †	6d.					
4251	»	38 d.	●	●	–	–	–	–
4252	»	»	–	–	–	–	–	–
4253	»	»	–	–	–	–	–	–
4254	»	»	–	–	–	–	–	–
4255	»	25 d.	●	•	•	•	–	–
4256	»	36 d.	–	–	–	–	–	–
4257	»	»	–	–	–	–	–	–

EXPERIMENT A.2. Cont.

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4258	F_2	36d.	—	—	—	—	—	—
4259	»	»	•	—	—	—	—	—
4260	»	»	—	—	—	—	—	—
4261	»	»	•	•	—	—	—	—
4262	»	»	—	—	—	—	—	—
4263	$(F_1 \times BrA_g)^1$	3Mo.30d.	—	—	—	—	—	—
4264	»	47d.	—	—	—	—	—	—
4265	»	»	—	—	—	—	—	—
4266	»	»	—	—	—	—	—	—
4267	»	»	—	—	—	—	—	—
4268	»	»	—	—	—	—	—	—
4269	»	33 d.	—	—	—	—	—	—
4270	»	»	—	—	—	—	—	—
4271	»	»	—	—	—	—	—	—
4272	»	»	—	—	—	—	—	—
4273	»	»	—	—	—	—	—	—
4274	»	»	—	—	—	—	—	—
4275	$(F_1 \times J.w.)^1$	2Mo.5d.	•	●	●	● 2.320		
4276	»	» »	•	●	●	● .811		
4277	»	3Mo.30d.	●	●	●	● 1.350		
4278	»	2Mo.2d.†						
4279	BrA_g.	31 d.	—	—	—	—	—	—
4280	»	»	—	—	—	—	—	—

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4281	BrA_g.	31d.	—	—	—	—	—	—
4282	»	»	—	—	—	—	—	—
4283	»	»	—	—	—	—	—	—
4284	»	»	—	—	—	—	—	—
4285	J.w.	49 d.	—	●	●	●	● .382	
4286	»	»	● † .066					
4287	»	»	† .068					
4288	»	»	● † .077					
4289	»	»	— † .230					
4290	»	»	● † .035					
4291	»	»	● † .057					
4292	»	»	† .016					
4293	»	»	● † .079					
4294	»	»	● † .180					
4295	»	»	† .033					
4296	»	»	● † .092					

EXPERIMENT A.3.

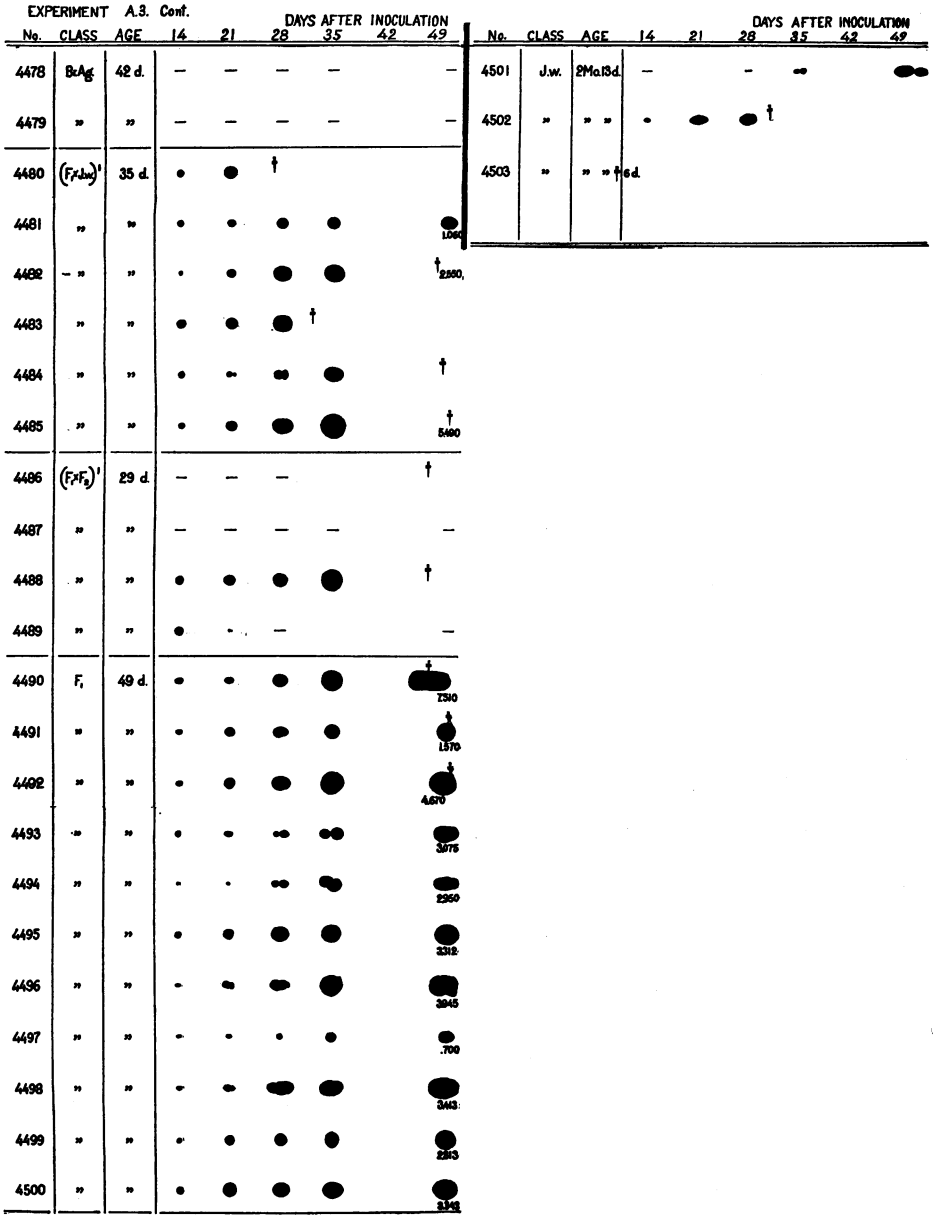
No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	49	56
4386	F_3	24 d.	–	–	–	–	–	
4387	»	»	–	–	–	–	–	
4388	»	»	·	†				
4389	»	»	–	–	–	–	–	
4390	»	»	†					
4391	F_2	32 d.	–	–	–	–	–	
4392	»	20 d.	•	•	•	•	• –	●
4393	»	26 d.	•	–	–	–	–	
4394	»	»	–	–	–	–	–	
4395	»	20 d. † 7d.						
4396	»	31 d.	•	–	–	–	†	
4397	»	»	–	–	–	–	–	
4398	»	»	–	–	–	–	–	
4399	»	»	–	–	–	–	–	
4400	»	»	–	–	–	–	–	
4401	»	»	•	·	–	–	–	
4402	»	»	–	–	–	–	–	
4403	»	»	•	–	–	–	–	
4404	»	»	•	–	–	–	–	
4405	»	38 d.	†					
4406	»	»	•	●	•	–	–	
4407	»	»	•	●	•	–	–	
4408	»	»	–	–	–	–	–	

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	49	56
4409	F_2	38 d.	–	–	–	–	–	
4410	»	»	·	·	– †			
4411	»	»	†					
4412	»	27 d. † 7d.						
4413	»	» † 6d						
4414	»	32 d. † 6d.						
4415	»	23 d. † 9d.						
4416	»	20 d. † 7d.						
4417	»	» † 9d.						
4418	$(F_1 \times B.A_3)^2$	»	•	–	–	–	–	
4419	»	»	–	–	–	–	–	
4420	»	»	–	–	–	–	–	
4421	»	»	–	–	–	–	–	
4422	»	»	–	–	–	–	–	
4423	$(F_1 \times B.A_3)^2$	33 d.	•	–	–	–	–	
4424	»	»	–	–	–	–	–	
4425	»	24 d.	–	–	–	–	–	
4426	»	»	–	–	–	–	–	
4427	»	»	–	–	–	–	–	
4428	»	»	–	–	–	–	–	
4429	»	»	●	●	•	–	–	
4430	»	»	–	–	–	–	–	
4431	»	»	•	●	•	:	–	

EXPERIMENT A.3. Cont.

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	49	56
4432	(F+BcAg)'	24 d	•	•	•	•	—	
4433	»	59 d.	—	—	—	—	—	
4434	»	»	·	—	—	—	—	
4435	»	36 d. † 8 d.						
4436	»	42 d.	·	—	—	—	—	
4437	»	»	—	—	—	—	—	
4438	»	25 d.	·	—	—	—	—	
4439	BcAg.	23 d.	—	—	—	—	—	
4440	»	»	·	—	—	—	—	
4441	»	»	—	—	—	—	—	
4442	»	»	—	—	—	—	—	
4443	»	»	—	—	—	—	—	
4444	»	»	—	—	—	—	—	
4445	»	»	·	—	—	—	—	
4446	»	»	—	—	—	—	—	
4447	»	»	—	—	—	—	—	
4448	»	»	—	—	—	—	—	
4449	»	»	—	—	—	—	—	
4450	»	25 d.	—	—	—	—	—	
4451	»	»	—	—	—	—	—	
4452	»	»	—	—	—	—	—	
4453	»	»	—	—	—	—	—	
4454	»	»	—	—	—	—	—	

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	49	56
4455	BcAg.	25 d.	—	—	—	—	—	
4456	»	»	—	—	—	—	—	
4457	»	»	—	—	—	—	—	
4458	»	»	—	—	—	—	—	
4459	»	»	—	—	—	—	—	
4460	»	42 d.	—	—	—	—	—	
4461	»	»	—	—	—	—	—	
4462	»	»	—	—	—	—	—	
4463	»	»	—	—	—	—	—	
4464	»	»	—	—	—	—	—	
4465	»	»	—	—	—	—	—	
4466	»	»	•	•	—	—	—	
4467	»	»	—	—	—	—	—	
4468	»	»	—	—	—	—	†	
4469	»	» † 8 d.						
4470	»	»	—	—	—	—	—	
4471	»	»	—	—	—	—	—	
4472	»	»	—	—	—	—	—	
4473	»	»	—	—	—	—	—	
4474	»	»	—	—	—	—	† 48 d.	
4475	»	»	—	—	—	—	—	
4476	»	»	·	—	—	—	—	
4477	»	»	·	—	—	—	—	


EXPERIMENT A.3. Conf.
No. CLASS AGE
DAYS AFTER INOCULATION
14 21 28 35 42 49
4478 BtAg 42 d.
4479 »
4480 (F1Fb)1 35 d.
4481 »
4482 »
4483 »
4484 »
4485 »
4486 (F1F2)1 29 d.
4487 »
4488 »
4489 »
4490 F1 49 d.
4491 »
4492 »
4493 »
4494 »
4495 »
4496 »
4497 »
4498 »
4499 »
4500 »
1060
2260
5400
1310
1570
4,670
3975
2950
3312
3045
700
3413
2813
3142
No. CLASS AGE
DAYS AFTER INOCULATION
14 21 28 35 42 49
4501 J.w. 2Mo.13d.
4502 » » »
4503 » » » 6d.

EXPERIMENT A.4.

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	35	42	49	56
4504	F_3	24 d.	–	–	–	–	–	–
4505	»	»	†					
4506	»	»	†					
4507	F_2	7Mo.11d.	•	–	–	–	–	–
4508	»	» »	–	–	–	–	–	–
4509	»	22 d.	Lost					
4510	»	»	Lost					
4511	»	»	–	–	–	–	–	–
4512	»	26 d.	Lost					
4513	»	47 d.	–	–	–	–	–	–
4514	»	22 d.	•	–	–	–	–	–
4515	»	26 d.	•	–	–	–	–	–
4516	»	»	•	–	–	–	–	–
4517	»	»	•	•	–	–	–	–
4518	$(F_1 \times F_2)^1$	25 d.	•	•				5.000 †
4519	»	»	–	–	–	–	–	–
4520	»	»	†					
4521	F_1	10Mo.7d.	•	•				†
4522	»	8Mo.9d.	•	•				5.303 †
4523	»	8Mo.5d.	•	•				†
4524	»	6Mo.14d.	•	•				6.460 †
4525	J.w.	41 d.	•	•				4.507 †
4526	»	»	•	•				5.885 †

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	35	42	49	63
4527	J.w.	41 d.	†					
4528	»	»	•	•				4.100 †
4529	»	»	•	•				2.765 †
4530	»	»	•	•				4.010 †

EXPERIMENT A.5.

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4712	F_2	34 d.	●	•	—	—	—	—
4713	»	»	●	•	—	—	—	—
4714	»	»	●	•	—	—	—	—
4715	»	»	●	•	—	—	—	—
4716	»	49 d.	—	—	—	—	—	—
4717	»	»	—	—	—	—	†	
4718	»	»	—	—	—	—	†	
4719	»	»	●	●	●	●	•	—
4720	»	»	—	—	—	—	—	—
4721	»	»	—	—	—	—	—	—
4722	»	46 d.	—	—	—	—	—	—
4723	»	»	—	—	—	—	—	—
4724	»	»	—	—	—	—	—	—
4725	»	44 d.	—	—	—	—	—	—
4726	»	»	●	•	•	†		
4727	»	»	—	—	—	—	—	—
4728	»	»	●	●	†			
4729	F_2	56 d.	—	—	—	—	—	—
4730	»	»	—	—	—	—	—	—
4731	»	»	—	—	—	—	—	—
4732	»	»	•	—	—	—	†	
4733	»	2Mo5d.	—	—	—	†		
4734	»	»	—	—	—	—	—	—

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4735	F_2	2Mo5d.	—	—	—	—	†	
4736	$(F_1 \times J.w.)^2$	41 d.	—	—	—	—	—	—
4737	»	»	—	—	—	—	—	†
4738	»	»	•	•	—	—	—	†
4739	»	26 d.	●	●	●	●	† .607	
4740	»	»	—	—	—	—	—	†
4741	$(F_1 \times Bc.Ag.)^2$	45 d.	—	—	—	—	—	—
4742	»	»	—	—	—	—	—	—
4743	»	»	—	—	—	—	—	—
4744	»	»	—	—	—	—	—	†
4745	»	»	—	—	—	—	—	†
4746	$(F_1 \times F_2)^1$	41 d.	—	—	—	—	—	†
4747	»	»	●	—	—	—	—	†
4748	»	»	—	—	—	—	†	
4749	$(F_1 \times J.w.)^1$	36 d.	●	●	●	† Eaten		
4750	»	»	•	•	•	•	.075	
4751	»	»	●	●	●	●	.250	
4752	»	»	●	●	●	●	.745	
4753	»	»	—	•	●	●	●	
4754	»	45 d.	●	●	●	●	2.200	
4755	»	»	•	●	●	●	1.055	
4756	»	»	•	●	●	●	1.200	
4757	»	»	•	•	●	●	.765	

EXPERIMENT A.S. Cont.

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4758	F_1	45 d.	•	●	●	●	● .735	
4759	»	»	•	●	●	† Partly eaten		
4760	»	»	•	●	●	● 2.915		
4761	»	»	●	●	●	● 1.342		
4762	»	»	•	●	●	● 1.325		
4763	(♀ B×A)	56 d.	–	–	–	†		
4764	»	»	–	–	–	–	–	†
4765	»	»	–	–	–	–	–	–
4766	»	»	–	–	–	–	–	–
4767	»	»	–	–	–	–	–	–
4768	»	25 d.	–	–	–	–	–	–
4769	»	»	–	–	–	–	–	†
4770	J.w.	58 d.	•	●	●	●	● 2.300	
4771	»	»	•	•	•	•	•	† ● 2.215
4772	»	»	•	•	•	•	•	•
4773	»	»	•	•	•	•	•	† ● 3.467
4774	»	»	•	•	•	•	•	•
4775	»	»	•	•	•	•	•	•
4776	F_2	46 d.	–	–	–	–	–	–
4777	»	60 d.	–	–	–	†		
4778	»	»	–	–	–	†		
4779	»	»	–	–	–	†		
4780	»	»	–	–	–	†		

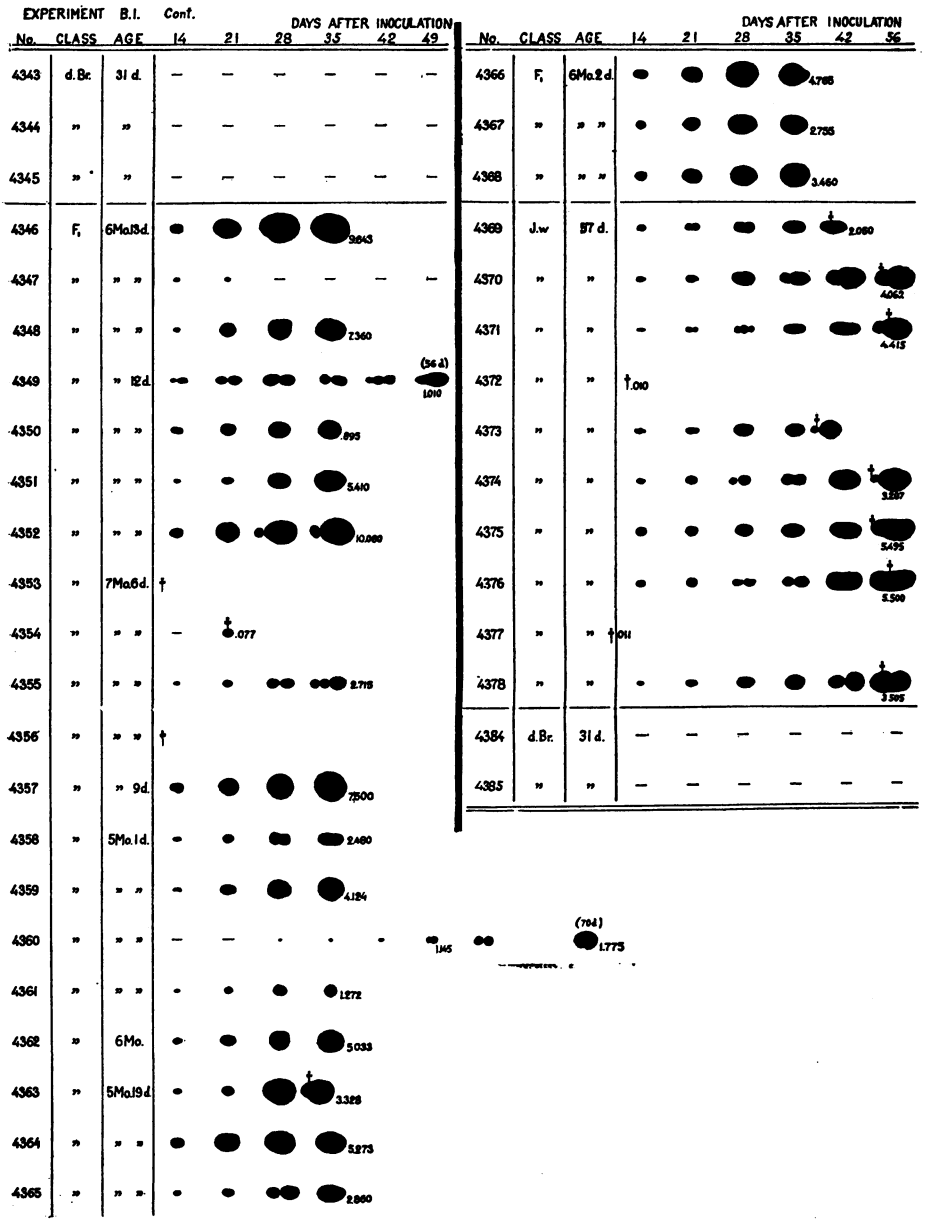
No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4781	F_2	60 d.	–	–	–	–	–	–
4782	»	»	–	–	†			
4783	»	»	–	–	–	–	–	–
4784	»	41 d.	–	–	–	–	–	†
4785	»	»	–	–	–	–	–	–
4786	»	48 d.	–	–	–	–	–	–
4787	»	»	–	–	–	–	–	–
4788	»	»	–	–	–	–	–	–
4789	»	»	–	–	–	–	–	–
4790	»	»	–	–	–	–	†	
4791	»	»	–	–	–	–	–	–
4792	(♀ B×A)	57 d.	–	–	–	–	–	–
4793	»	»	–	–	–	–	†	
4794	»	»	–	–	–	†		
4795	»	30 d.	–	–	–	–	–	–
4796	»	»	–	–	–	–	–	–
4797	»	»	–	–	–	–	–	–
4798	»	»	–	–	–	–	–	–
4799	»	»	–	–	–	–	†	
4800	»	2Mo3d.	–	–	–	–	–	–
4801	»	38 d.	–	–	–	†		
4802	»	»	–	–	–	–	–	–
4803	»	»	–	–	–	–	–	–

EXPERIMENT No.	CLASS	A.S. AGE	Conf. 14	DAYS AFTER INOCULATION 21	28	35	42	49
4804	$(F_1 \times B_{C}A_{B})^{\dagger}$	23 d.	–	–	–	–	–	†
4805	»	»	†					
4806	$(F_1 \times J_{BW})^{\dagger}$	32 d.	•	•	●	● .547		
4807	»	»	▬	† Eaten				
4808	»	»	•	●	●	† Eaten		
4809	»	»	●	●	●	†		
4810	»	»	–	●	† Eaten			
4811	»	»	●	●	●	† ● 2.015		
4812	»	»	•	●	●	● .425		
4813	»	»	●	●	●	† Eaten		
4814	»	43 d.		•	●	● .390		
4815	»	»	▬	•	●●	●● .475		
4816	»	»	●	● †				
4817	»	»	●	●	●	● 1.369		
4818	»	»	●	●	●	● 2.575		
4819	»	»	▬	▬	▬	▬	▬ .575	
4820	»	»	▬	▬	▬	▬	▬ .968	
4821	»	»	▬	▬	▬	▬	▬ .965	
4822	»	»	•	●	●	† ● 1.020		

No.	CLASS	AGE	14	21	28	35	42	49
4823	F_1	45 d.	•	●	●	● .850		
4824	»	»	•	●	●	● .368		
4825	»	»	•	▬	●	† ● .460		
4826	»	»	•	▬	●	● .575		
4827	»	»	–	●	●	● 1.015		

EXPERIMENT No.	CLASS	B.I. AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4297	F_3	41 d.	† 8 d.					
4298	"	"	—	—	—	—	—	—
4299	"	"	—	—	—	—	—	—
4300	"	"	—	—	—	—	—	—
4301	"	"	—	—	—	—	—	—
4302	F_2	5 Mo. 12 d.	•	—	—	—	†	
4303	"	" "	•	—	—	—	—	—
4304	"	" 5 d.	•	—	—	—	—	—
4305	"	" 8 d.	—	—	—	—	—	—
4306	"	2 Mo. 10 d.	—	—	—	—	—	—
4307	"	" "	—	—	—	—	—	—
4308	"	" "	—	—	—	—	—	—
4309	"	" "	—	—	—	—	—	—
4310	"	" "	—	—	—	—	—	—
4311	"	" "	—	—	—	—	—	—
4312	"	23 d.	† 3 d.					
4313	"	"	† 3 d.					
4314	"	"	† 3 d.					
4315	"	"	† 3 d.					
4316	"	2 Mo. 8 d.	—	—	—	—	—	—
4317	"	41 d.	—	—	—	—	—	—
4318	"	"	•	—	—	—	—	—
4319	"	"	—	—	—	—	—	—

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4320	F_2	41 d.	•	—	—	—	—	—
4321	"	31 d.	—	—	—	—	—	—
4322	"	"	—	—	—	—	—	—
4323	"	"	—	—	—	—	—	—
4324	"	"	•	—	—	—	—	—
4325	"	"	—	—	—	—	—	—
4326	"	"	—	—	—	—	—	—
4327	d.Bc.	41 d.	—	—	—	—	—	—
4328	"	"	—	—	—	—	—	—
4329	"	"	—	—	—	—	—	—
4330	"	"	—	—	—	—	—	—
4331	"	"	—	—	—	—	—	—
4332	"	"	—	—	—	—	—	—
4333	"	31 d.	—	—	—	—	—	—
4334	"	"	—	—	—	—	—	—
4335	"	"	—	—	—	—	—	—
4336	"	"	—	—	—	—	—	—
4337	"	"	—	—	—	—	—	—
4338	"	"	•	•	•	•	—	—
4339	"	"	—	—	—	—	—	—
4340	"	"	—	—	—	—	—	—
4341	"	"	—	—	—	—	—	—
4342	"	"	—	—	—	—	—	—


EXPERIMENT No.
CLASS
AGE
B.I. Conf.
DAYS AFTER INOCULATION
14 21 28 35 42 49
4343 d.Br. 31 d.
4344 " "
4345 " "
4346 F, 6Mo.13d. 3643
4347 " " "
4348 " " " 7360
4349 " " 12d. (56 d) 1.010
4350 " " " .895
4351 " " " 5.410
4352 " " " 10.080
4353 " 7Mo.6d. †
4354 " " " .077
4355 " " " 2.715
4356 " " " †
4357 " " 9d. 7500
4358 " 5Mo.1d. 2.480
4359 " " " 4.124
4360 " " " 1.145 (784) 1.775
4361 " " " 1.272
4362 " 6Mo. 5.033
4363 " 5Mo.19d. 3.328
4364 " " " 5.273
4365 " " " 2.860
4366 F, 6Mo.2d. 4.765
4367 " " " 2.755
4368 " " " 3.460
4369 J.w 57 d. 2.080
4370 " " 4.062
4371 " " 4.415
4372 " " †.010
4373 " "
4374 " " 3.257
4375 " " 5.495
4376 " " 5.500
4377 " " †.011
4378 " " 3.595
4384 d.Br. 31 d.
4385 " "

EXPERIMENT B.2.

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	35	42	49	56
4531	F_2	28 d.	●	●	—	—	—	
4532	»	41 d.	··	—	—	—	—	
4533	»	»	●	—	—	—	—	
4534	»	»	—	—	—	—	—	
4535	»	37 d.	·	—	—	—	—	
4536	»	28 d.	●	●	●	●	—	
4537	»	»	—	—	—	—	—	
4538	»	41 d.	·	—	—	—	—	
4539	»	»	—	—	—	—	—	
4540	»	»	—	—	—	—	—	
4541	»	»	—	—	—	—	—	
4542	»	44 d.	●	—	—	—	—	
4543	»	21 d. †						
4544	»	» † 9 d.						
4545	»	44 d.	—	—	—	—	—	
4546	»	»	—	—	—	—	—	
4547	»	»	—	—	—	—	—	
4548	»	»	—	—	—	—	—	
4549	»	37 d.	—	—	—	—	—	
4550	»	»	—	—	—	—	—	
4551	»	»	—	—	—	—	63 d.	72 d. †
4552	»	44 d.	—	—	—	—	—	
4553	»	»	—	—	—	—	—	
4533	$(F_2 d.Br)^1$	46 d.	—	—	—	—	—	

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	35	42	49	56
4555	$(F_2 d.Br)^1$	46 d.	—	—	—	—	—	
4556	»	»	·	—	—	—	—	
4557	»	»	—	—	—	—	—	
4558	»	»	—	—	—	—	—	
4559	»	»	—	—	—	—	—	
4560	»	»	—	—	—	—	—	
4561	»	»	—	—	—	—	—	
4562	»	»	—	—	—	—	—	
4563	d.Br.	5 Mo. 12 d.	—	—	—	—	—	
4564	»	» »	●	●	—	—	—	
4565	»	» »	—	—	—	—	—	
4566	»	12 Mo. 12 d.	—	—	—	—	—	
4567	»	56 d.	—	—	—	—	—	
4568	»	2 Mo. 7 d.	—	—	—	—	—	
4569	»	» »	—	—	—	—	—	
4570	»	» »	—	—	—	—	—	
4571	»	» »	—	—	†	—	—	
4572	»	45 d.	—	—	—	—	—	
4573	J.w.	41 d.	—	—	—	—	—	
4574	»	»	·	·	·	·		3923
4575	»	»	·	·	·	·	3936	
4576	»	»	·	·	·	·		3800
4577	»	»	·	·	·	·	1432	
4578	»	»	·	·	·	·		2418

EXPERIMENT B.3.

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4623	F_2	26 d.	†					
4624	"	"	†Eaten					
4625	"	"	– – – – – – – – – – – – – –					
4626	"	"	†9d					
4627	"	42 d.	· · · · – † –					
4628	"	"	· · – – – – – – – – – – –					
4629	"	37 d.	– – – – – – – – – – – – –					
4630	"	"	– – – ·–† ·					
4631	"	58 d.	†9d					
4632	"	"	– – – – – – – – – – – – –					
4633	"	34 d.	– – – – – – – – – – – – –					
4634	"	"	– – †					
4635	"	"	– – – – – – – – – – – – –					
4636	"	"	†·					
4637	"	"	†4d					
4638	"	"	– – – – – – – – – – – – –					
4639	"	"	– · – – – – – – – – – – –					
4640	"	37 d.	– – – – – – – – – – – – –					
4641	"	"	– – – – – – – – – – – – –					
4642	"	"	– – – – – – – – – – – – –					
4643	"	"	– – – – – – – – – – – – –					
4644	"	52 d.	– – – – – – – – – – – – –					
4645	"	"	– – – – – – – – – – – – –					

No.	CLASS	AGE	DAYS AFTER INOCULATION 14	21	28	35	42	49
4646	F_2	25 d.	– – – – – – – – – – – – –					
4647	"	"	– – – – – – – – – – – – –					
4648	"	"	– – – – – – – – – – – – –					
4649	"	"	– · – – – – – – – – – – –					
4650	"	"	– – – – – – – – – – – – –					
4651	"	"	– – – – – – – – – – † – –					
4652	"	58 d.	– · – – – – – – – – – – –					
4653	"	"	· – – – – – – – – – – – –					
4654	"	"	†					
4655	"	"	†7d					
4656	"	"	– – – – – – – – – – – – –					
4657	"	"	– – – – – – – – – – – – –					
4658	F_3	53 d.	– – – – – – – – – – – – –					
4659	"	"	– – – – – – – – – – – – –					
4660	"	"	– – – – – – – – – – – – –					
4661	"	"	– – – – – – – – – – – – –					
4662	"	2Ma.6d.	– – – – – – – – – – – – –					
4663	"	"	– – – – – – – – – – – – –					
4664	"	"	– – – – – – – – – – – – –					
4665	"	"	· – – – – – – – – – – – –					
4666	"	"	– – – – – – – – – – – – –					
4667	"	27 d.	– – – – – – – – – – – – –					
4668	"	"	– – – – – – – – – – – – –					

EXPERIMENT B.3. Cont.