# THE BLOOD OF THE FLEXED TAILED MOUSE WITH SOME OBSERVATIONS ON THE EFFECTS OF INBREEDING ON THE FLEXED TAILED STRAIN

THESIS FOR THE DEGREE OF M. S.

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# THE BLOOD OF THE FLARED TAILED MOUSE
# WITH SOME OBSERVATIONS
# ON THE EFFECTS OF
# INBREEDING ON THE FLARED TAILED STRAIN

T H E S I S

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# Introduction

Mutations are generally considered to be any inherited modifications whether large or small. Formerly the term was used to designate a striking variation from the ordinary, like Oenothera gigas, the giant evening primrose which is stouter than Oenothera lamarckiana, the parent type. Frequent mutations which were readily distinguished from the ancestral type, have appeared. De Vries (1) had fifty thousand plants in seven generations which descended from the mutating form, Oenothera lamarckiana, and about eight hundred of these were mutations. These were of seven different types such as O.nannella or the dwarf, O.rubrinervis or the red veined, and O.lata with only pistillate flowers. These changes were caused by a doubling of the number of chromosomes (4n), by an extra chromosome (2n-1) or by a triploid number (3n). Lately, the tendency has been to apply the word mutation to "real changes in a gene" (2) which may reveal themselves as either slight or striking modifications. The Drosophila mutations are examples of the latter type. They are not limited to any part of the body but occur as changes in eye color, bristle number, wing size and shape and numerous other inherited variations. Cytological investigations reveal no change in number or arrangement of the chromosomes so the conclusion seems obvious that the changes are in the chromosomes themselves. As to the nature of these changes, little is known. It is believed to be a minute, perhaps chemical, change.

Mutations have arisen in many different classes of plants and animals. Of the mammals, the rodent has probably

been under more frequent observation than other orders because of the large numbers which may be raised in a short time without great expense or difficulty. The more common mutations among guinea pigs, rabbits, rats and mice are those affecting coat color, such as non-agouti, brown, dilution, non-extension, white spotting, and albinism. Other changes have appeared, reducing the amount of hair and length of ears. The waltzing mouse runs in a circle during most of his active moments because of some inherited defect in his inner ear. Still another change from normal is the flexed tail mutation. With the purpose of contributing to the knowledge of the nature of flexed tailed mice, this paper has been written.

## Historical Account

The flexed tail mutation of the mouse was found in January 1927 by Dr. H.R. Hunt in his albino stock. In appearance it varies from a tail which is stiffened by the fusing of a few vertebrae to a stiff tail bent into several angles in different planes. Not only is the tail stiffened and bent but it may also be shorter than the normal length which is about the same as the length of the body. Drawings of various flexed tails may be found on page , Figure III. At birth, the flexed mouse is paler and smaller in size than a normal new born mouse. This strongly suggested an anemic condition.

There is some question as to the mode of inheritance of the flexed tail mutation. It breeds true in nearly every case. Permar and Mixter (3) crossed flexed males with flexed females and obtained 552 offspring, 549 of which were flexed tailed and three were straight tailed. $P_1$ crosses between flexed and straight tailed mice made by Hunt and Permar yielded 452 straight tailed $F_1$s and three flexed tailed $F_1$s which show that flexed is recessive to normal. But the $F_2$ generation of Hunt's experiment does not give any ordinary Mendelian ratio, for 821 were straight tailed and 163 were flexed, making a ratio of 5.04 straight tailed to 1.00 flexed tailed. If one pair of factors is concerned, a back cross of the $F_1$ generation with the recessive flexed tailed animals should give a 1 to 1 ratio. Hunt, however, found 1.46 straight tailed to 1.00 flexed tailed when he

crossed $F_1$s back onto flexed (564:448). It is clear, then, that flexed tail breeds practically true like a recessive character but the number of factors concerned is yet to be discovered.

The work to be reviewed in this paper was done between June 26, 1929 and June 16, 1930. Part I is concerned with blood findings of flexed mice and their controls at different ages; Part II reports an attempt to fix different grades of flexure by inbreeding.

# PART I

## The Blood of Flexed and Straight Tailed Mice

Purpose: This investigation was undertaken to ascertain whether the apparently anemic condition of the flexed mouse at birth is real. A paler skin, especially noticeable on the top of the head, around the thighs and shoulders, distinguishes the new born flexed from its normal litter mates in back crosses or in $F_2$ litters. Mice are hairless at birth so any difference in the color of the blood can readily be seen. Since anemia in general manifests itself by a smaller number of red blood cells per cubic millimeter than normal, or by a decrease in the percentage of the oxygen carrying pigment, hemoglobin, or by a lessened amount of both, it was decided to make blood counts and hemoglobin tests on flexed mice and compare these with results from normal mice. In order to see whether the flexed mice recover from this anemia, their blood was compared with straight tailed mice harboring no factors for flexed tail. If the blood of flexed mice becomes equal in quality to that of normal mice, the former have recovered from their defective blood condition. From these data, the rate of change in quality of the blood of these three varieties could be calculated.

Previous Work by Other Investigators: The cellular composition of blood in normal mice has been determined by several investigators. Simonds (4) finds 6,000,000 to 8,000,000 red cells per cubic millimeter, Woodall (5) 6,000,00 to 10,000,000. According to Simonds there are

6000 to 11,000 white cells, according to Murphy and Sturm (6) 10,800 to 24,000 whites, while Young (7) gives an average of 5000 per cu. mm., and Goodall lists 8000 to 10,000. Goodall reports that the hemoglobin content of mouse blood is 90% that of normal human blood. These figures are in general consistent with the results obtained in my investigation of adult mice, tho Goodall's hemoglobin estimate is higher by 22% than my findings in the present work.

There are two types of anemia which may be compared with the kind found associated with flexed tail. The first, a type from which there may be recovery, is reported by Doyle (8) in young pigs deprived of vitamins; the animals recovered at 6 weeks if they did not die before then. It was shown that the kind of ration used was not responsible for this anemia. The incidence of anemia, and the death rate from it were four times as great in pigs kept inside. The hemoglobin content was 38% less than normal in anemic pigs, but after 95 days the red cell count and hemoglobin percentage of anemics and non-anemics were about the same.

The second type of anemia was found by de Aberle (9) in homozygous dominant white mice. These were obtained from matings of parents both heterozygous for the dominant spotting gene, W, which yielded mice with the genetic formula WW. The course of the anemia was from the 16th day of intra-uterine life until death, which always occurred a week or ten days after birth. She finds the cellular content of the blood at birth to be as follows:

Cells

Anemic 663,009 red cells, 1192 white cells per cu. mm.

Normal 4,740,020 red cells, 5551 white cells per cu. mm.

Hemoglobin

Anemic 13% to 39% of human standard

Normal 60% to 106% of human standard

Normal human blood is considered to have 100% hemoglobin. Most investigations of hemoglobin in animals are compared with this as a standard, hence, the hemoglobin percentages given in this paper follow this custom.

After presenting the data of the flexed tailed anemic condition, it will be compared with these varieties found by other investigators and the findings of investigators on human anemia. No attempt has been made to report various anemias artificially produced by blood letting, parasites or injected poisons, as these seem irrelevant to the present type.

Human anemia is classified with as much difficulty as that found in animals. Lazarus and Barlow (10)distinguish between anemias in which marked leucocytic changes are absent and those in which marked leucocytic changes are present. The first type would be called anemia and the second leuchemia by Lee and Minot (11). Anemia means a reduction in the oxygen carrying constituent of the blood, hemoglobin, usually by loss of cells tho some anemias, like chlorosis, may be due to insufficient hemoglobin formation. Leuchemia is a blood condition where the number of white blood cells is greatly increased and the proportions of lymphocytes to granulocytes altered. If the lymphocytes are

increased, sometimes as high as 100,000 to 500,000 per cubic millimeter, it is lymphocytic leuchemia; the other type is myeloid leuchemia, in which the granulocytes are present in excess. Either kind of leuchemia may cause the blood to have a lower percentage of hemoglobin.

Anemias have been subdivided into primary and secondary anemias (12). The former are apparently not caused by some other disease, but exist as a distinct clinical disease such as pernicious anemia or chlorosis. Secondary anemias follow such conditions as hemorrhages, parasitic infections, chemical poisoning, malnutrition, malaria or tumors. This classification does not indicate the chief pathological characteristic of the blood and blood forming organs. So Lee and Minot (11) and Evans (13) distinguish anemias with defective blood formation, e.g., aplastic anemia, and those with increased blood destruction, like pernicious anemia, and increased blood loss, either acute or chronic, e.g. anemia from gastric and duodenal ulcers.

Another useful grouping is that made by use of the color index (13). The index is obtained by dividing the percent that the hemoglobin of an animal is of the normal percentage for that animal by the percent the blood cells are of the normal amount. If a woman has 25% of the normal hemoglobin content and 600,000 red cells or 13% of the normal number of 4,500,000, her color index is 25 divided by 13 or 1.9. This was actually true in a case of pernicious anemia of pregnancy (14). If the color index were less than one it might be a case of chlorosis, an anemia in young girls who

have deficient hemoglobin. This classification, using the color index, is the one which will be used in considering the anemia to be described.

Proceedure: For counting the blood I used a Will certified pipette when white and red cells were counted together and a Trenner pipette when white cells only were counted. A 1% salt solution tinged with a small quantity of Gentian Violet is satisfactory for counting both types of cells together, while use of a 1½% acetic acid solution tinged with Gentian Violet is better for only white cell counts, as the red cells are dissolved by the acid and the white cells are colored purple. The blood is diluted 200 times by the salt solution or only 20 times by the acid solution. The first counts were made with a Levy-Hauser single counting chamber. Two drops of diluted blood from the animal were observed and the average of the two constituted the count for that individual. Most of the counts came from a Levy-Hauser double counting chamber: both drops could then be observed at one filling of the chamber. Hemoglobin was determined by use of a Tallquist color scale. This is accurate within 5%. If a drop of blood was darker than 40% but lighter than 50% it was recorded as 45%.

The source of blood was not the same in all cases. At birth the blood was taken from the severed neck of decapitated animals, hence, no counts at later dates were ever made on animals counted at birth. Sometimes the count at one week was from the neck, more often from blood obtained by cutting the femoral vein. From two weeks onward, I usually obtained

the blood from the tip of the tail, cutting off several millimeters each time a count was made. Occasionally the blood came from the leg vein if the tail would not bleed. The flexed and normals were treated the same at one week and thereafter; if the count was made with blood from the leg vein of one, it was taken from the same place on the other. If lymph was mixed with the blood taken at birth, it obviously diluted that from both flexed and straight mice to the same extent. It does not seem, however, that this dilution made any appreciable difference for the change in quality of blood from birth to one week is not appreciably greater than the change during later weeks when the blood was drawn by a method which greatly decreased the chance of dilution by lymph. The number of red blood cells in the flexed mice increased 54% the first week and 32% the second week. A slight decrease is expected as a mouse grows further toward maturity because they are nearing the maximum number which is present at maturity. If the increase continued at the same rate from week to week as during the first week a mouse would have a hundred million blood cells in a few months. To avoid this the rate decreases rapidly.

As already stated, the counting was done at weekly and fortnightly intervals, beginning at birth. Wherever possible, the same mouse was used throughout the whole series of counts. After four weeks the intervals became two weeks until the mouse was twelve weeks old, when counting was discontinued. That is, flexed mice and their controls were counted at birth, at one, two, three and four weeks after birth, and further at six, eight, ten and twelve weeks. The adults

counted are mainly the parents of those used from birth to twelve weeks. Four of the flexed adults (male #18 and females #14, #17, #16) were not parents of the mice used in the blood problem, but of those recorded in the inbreeding experiment. These adults varied, in age, from six months of age to nearly two years.

To determine whether flexed mice differ from others, normal controls were used. These were of two kinds. One was the heterozygous straight mouse. Flexed x straight mice yield straight tailed mice which carry flexed. These $F_1$s were back-crossed on flexed, giving both flexed and straight offspring. So the straight offspring in the back-cross litters are satisfactory controls for flexed mice. Usually the count of a flexed was paired with the count for a normal litter mate at all ages, so that effects of feeding, temperature, or health of the mother might be the same on both controls and flexed. Reciprocal crosses were made to get these litters. Seven heterozygous straight tailed males ($F_1$) were mated with 14 flexed females; their offspring are recorded as crosses 8a, 8b, 9a, etc., to 14b. One flexed male x six heterozygous straight females gave the results recorded in crosses 36 a-g.

The other type of control is the normal mouse carrying no flexed factor. One homozygous straight male was mated to eight straight females in crosses 44 a-h. Their offspring lived under the same conditions as the flexed and heterozygous straight young, hence any differences may be attributed to the absence of the flexed factor or factors. Nearly all colors of mice were used: albinos, pink eyed black and

brown agoutis, dilute brown and dilute blacks.

Data: Tables I and II on page 46 give all of the blood determinations made. Table I shows the individual hemoglobin determinations and the red cell counts with the cross from which they came. Table II contains besides white cell counts, a list of hemoglobin percentages made at the same time of the white cell counts and not listed in Table I.

Averages and probable errors are not given under each column but in a special table, IIa, so one may have all the averages from all the groups easily at hand when comparing averages.

Two series of graphs from these data show the content and the changes in the blood at different ages. Figure I on page 67 contains graphs of white cells, hemoglobin and red cells for each variety of mouse plotted according to averages at different ages. But only actual values can be read from this figure. The relative rates of change are best shown in Figure II on page 69 which shows the plotted logarithms of the actual values. "If relative rather than absolute variations are of chief concern, the chart employed should be of the semilogarithmic type, scaled logarithmically on the y-axis and arithmetically on the x-axis. In such a chart, equal percentage variations are represented by equal vertical distances, as opposed to the ordinary arithmetic type in which equal absolute variations are represented by equal vertical distances." Mills, in "Statistical Methods" (15). By using the logarithmic

charts, we are able to judge comparative rates of change: by the absolute chart the actual differences may be told. Comparison between the graphs made by the two methods shows scant difference in comparative results, to be sure, yet one may be used as a check on the other.

Discussion of Data: The flexed are anemic at birth. This is shown by the difference between their averages for red cells and hemoglobin, and the corresponding averages for the heterozygous and homozygous straights. Compare first the difference between the red cell counts for the flexed and heterozygous straight mice at birth. This difference is 1,560,000 red cells per cubic millimeter (4,880,000 - 3,320,000) with a probable error of 151,600. This difference is 10.29 times its probable error so there is a significant difference between the red cell numbers of the two types of mice at birth. The odds are over 69 billion to 1 that this difference is due to chance. The flexed are anemic as compared with the normal heterozygous straight mice. The same is found to be true when the flexed are compared with the homozygous straights. The difference between them is 690000 ± 152000. This difference is 4.5 the size of its probable error, so is not as significant, statistically, as the first difference was. Here the odds are 415 to 1 against the difference being due to chance.

The evidence from hemoglobin comparisons is even more convincing. The average hemoglobin percentage for the heterozygous straights at birth, minus the percentage for the flexed animals is 1.2 ± .07. This difference is

22 times its probable error or odds of over 69 billion to 1. Hence the low concentration of hemoglobin in the flexed mouse causes its anemia. This fact is equally well demonstrated by differencing the homozygous straight and flexed mice at birth. The hemoglobin of the former exceeds the latter by 17.5% ± .97 or 18 times the probable error. Anemia at birth, then, is plainly observed.

The anemia in "dominant white" mice is decidedly more pronounced (14). They show only 663,009 red cells per cubic millimeter at birth as compared with the 3,220,000 of flexed mice and 4,740,000 for normal mice reported by De Aberle or 4,880,000 as found in the present investigation. Nor do the flexed mice die necessarily from their mild anemia, for many have lived beyond 12 weeks even the sustaining five or six losses of blood when it was counted.

When this anemia is classified according to the color index, it is found to be one of those with a color index less than 1. If we use the averages of the heterozygous straight at birth as the normal condition for a mouse at birth, we find that the flexed mouse has 64% of normal percent hemoglobin for mice (39.4 flexed percentage at birth / 60.7 heterozygous straight percentage at birth) and 68% of the normal number of red cells (3,220,000/4,680,000). The color index is hemoglobin in % of normal/ red cells are of normal or 64/68 = .94. This fact makes it the anemia similar to chlorosis.

The white cell content of the flexed animals' blood is not one of the causes for the anemic appearance. In the flexed, they are neither so numerous as to constitute leukemia nor are they less than the number in normal mice. At birth, the flexed have a white cell count of 4,297 per cubic millimeter, the heterozygous straights have 4,129. The difference of 168 ± 312 is not significant since the probable error exceeds the difference. Between the flexed and the homozygous straight whose average is 3,993 is a difference of 304 ± 305. Again, no significant difference. Thus only red cell and hemoglobin deficiency are responsible for anemia in the flexed tailed mouse.

The fact must be taken into account that I have lumped together lymphocytes, monocytes and granulocytes in making white cell determinations. There may have been marked changes in the number of one type of white cell, compensated by changes in the opposite direction for other types of white cells, without my detecting it.

Recovery: At the end of the first week, the flexed mice have practically recovered from their anemia, so far as the red cells are concerned, but the hemoglobin lags behind, to catch up with normal mice at two weeks. The red cell average for the heterozygous straights at 1 week is 5,510,000, for the flexed it is 5,120,000, and the difference is 390,000 ± 153,000. This difference is 2.9 times the size of its probable error so it is questionably significant since the odds are only 15 to 1. There is a mere difference

of 20,000 between the flexed and homozygous straights which suggests hardly any distinction at all. The difference between the hemoglobin averages at one week is still pronounced. The heterozygous straight exceed the flexed by 8.8 ± .90 and the homozygous exceed the flexed by 4.6 ± .94 . The first is 9.7, and the second 4.8 the size of the probable error. The odds are over 730 million to 1 in the first case and 828 to 1 in the second case. At two weeks the flexed are equal to their normal controls as may be seen by contrasting the averages: flexed 55.8 ± .58 ; heterozygous straight 55.6 ± .73 ; homozygous straights 56 ± .57 . The differences between the averages do not exceed 2.7 times their probable errors in any case. Anemia is over.

Nor does anemia return to the adult flexed mouse. There is no way of differentiating a flexed adult from a heterozygous straight one by his blood cell count. The flexed equal the heterozygous straights and surpass the homozygous straights in red cells: they surpass both in hemoglobin, tho not significantly. (The color index for flexed adults is 1.04.) This is plain from differencing the averages for red cell counts. The flexed adults have 11, 200,000 red cells per cubic millimeter, the heterozygous straight adults 11,050,000 cells. The difference is 150,000 ± 510,000. Here the probable error exceeds the difference so the averages are certainly not different. Between the averages for flexed adults and homozygous straight adults there is a difference of 1,510,000 ±

244,000 red blood cells per cubic millimeter. This difference exceeds its probable error by 6.4 times. The odds against the difference being due to chance are over 19,000 to 1. Hence the flexed adults surpass the homozygous straight adults significantly.

Between the averages for adult hemoglobin percentages, there are no significant differences. The flexed adults' average minus that of the heterozygous straight adults (68.7% - 64%) is 4.7% ± 1.83 . The difference is 2.5 times its probable error. Since the odds are only 9.9 to 1, the averages are not significantly different. The flexed adults' average minus the homozygous straights' adult average (68.7% - 65.8%) is 2.9% ± 1.86 ; the difference is only 1.6 times its probable error. The odds are only 2.5 to 1 hence the averages are not significant. It is clear then, that flexed mice are not anemic when they become adults.

The recovery parallels that in young pigs observed by Doyle ( 8 ) that, as would be expected, mice recover more swiftly. The blood of each variety of mice is on the same level by 14 days, pigs by 90 days if they recover at all.

Comparison of Blood at Different Ages: After two weeks from birth there is no conspicuous difference in red cell counts between flexed and heterozygous straight mice. No difference is more than 3.5 times the magnitude of its probable error. This is evident from Figure 1 ,p.67 where

the vertical distance between the curves for the two varieties is never as great after two weeks as at birth. The adults differ by only 150,000 ± 510,000. Since the probable error exceeds the difference it may be considered that when flexed mice are mature their red blood cell content is approximately the same as that of their highest control. It is noticeable that the flexed curve is consistently but not significantly higher than that of the heterozygous normals after the second week.

There is some indication that the homozygous straight mice have a significantly lower red blood count than the flexed, beginning at three weeks from birth. Below are the differences, probable errors and number of times the differences exceeded their prob. errors(all in favor of the flexed) at ages beyond two weeks:

Differences between flexed and homozygous straights

| | | Difference / Probable error | Odds |
|---|---|---|---|
| 3 Weeks | 1,370,000 ± 250,000 | 5.48 | About 1350 to 1 |
| 4 Weeks | 1,100,000 ± 159,000 | 6.90 | About 427,000 to 1 |
| 6 Weeks | 640,000 ± 204,000 | 3.10 | About 26.3 to 1 |
| Adults | 1,510,000 ± 244,000 | 6.40 | About 19,300 to 1 |

The graphs show that the lowest curve belongs to the straights which do not carry flexed. The two kinds of straights show a considerable difference only at birth of 870,000 ± 159,000. The difference is 5.4 times its probable error and the odds are about 1350 to 1 against the difference being due to chance. The lack of sufficient data

for the homozygous straights at 6, 8, 10, and 12 weeks limits the possibilities for drawing reliable conclusions, but the evidence seems to indicate clearly that once the flexed animals have recovered from their anemia their red cell count is higher than for homozygous straight animals, the heterozygous straights being intermediate.

The white cell condition throughout life is similar. The high probable errors of the averages make fairly large intervals between averages inconsequential. The largest gap is from the homozygous straight mice at six weeks of age to the heterozygous straight mice of the same age; it is 3500 but the average for the former was determined by only four counts, hence the gap may not have been nearly so large as it would have been had many more counts been taken. In general one cannot distinguish these mice of the same age by their white cell count.

Likewise, after one week from birth the types of mice investigated could not be distinguished from each other by their hemoglobin percentage. There is no significant difference between the adults of flexed and either type of straight tailed mice, as an examination of the table of differences on page 63 will show. The same is true of differences between the two types of straight tailed mice. None of the hemoglobin differences between the three types of mice were as great when the mice were compared after a week old as they were when compared at birth. So it may be concluded that the hemoglobin percentages of flexed and straight mice do not differ significantly after a week from birth.

Rate of Increase from Birth: An inspection of the log charts (Fig. 2) will convince one that there is a marked change in the red cell averages within a variety as the mice become older. Considered mathematically, the flexed increase 54% in the first week, 32% in the second, 19% in the third week and 26% during the fourth week of life. An increase of only 8% is gained between an age of one month and maturity. The climax is at four weeks, from then on change is slight. The graph indicates the same rapid progress for the straight mice with the exception of the homozygous straights between two and three weeks. An explanation for this exception is lacking.

The following table shows the rate of increase in red blood cells in percent by weeks of the three kinds of mice.

| | Flexed | Hetz. St. | Homoz. St. |
|---|---|---|---|
| 1st Week | 54% | 12.9% | 27.1% |
| 2nd Week | 32% | 23.5% | 29.4% |
| 3rd Week | 19% | 10.9% | 2.2% |
| 4th Week | 26% | 23.1% | 36.3% |
| 4th Week to Adult | 8% | 16.1% | 5.3% |

Note that each kind increases more rapidly during the fourth week than during the third week. Perhaps this is the result of the change in diet for during the first three weeks the young are with the mother but she was removed when the young were three weeks old so they had to live on grain instead of milk after she was taken from them.

Hemoglobin behaves differently. The flexed show a rapid rise while the straight mice decline at first then rise slowly. The rate of increase* in the flexed blood pigment is as follows: 1st week, 24% over birth; 2nd week, 9% over 1st week; 3rd week, 8% over 2nd week; 4th week, a decrease of .9% over 3rd week. The adults show an increase of 18% over the hemoglobin percentage of mice 4 weeks old. But the heterozygous straight mice decrease at the rate of 4.7% the first week and 3.8% the second altho the difference between the actual counts is not statistically significant. Then the curve starts upward. Between the 60.7% hemoglobin at birth and the 64 at maturity there is a difference of 3.3% ± 1.5 which is hardly significant. So the heterozygous mice neither improve nor decline in hemoglobin significantly. This is evidently true for the homozygous mice also, as an inspection of the log chart shows.

The only statement that seems obvious from the white cell curves is that there is an increase in number between birth and maturity but no regular rate of change. The flexed at maturity and at birth differ in cells per cubic millimeter by 5,703 ± 858, (difference 6.6 times its probable error) a significant difference. There is an increase of

*The percentages given in this paragraph are not the absolute increases from week to week but the percent that each week is over that of the preceding week, e.g. 24% is the difference between the hemoglobin averages for flexed mice at birth and at one week divided by the flexed average at birth 49-39.4/39.4 . This shows the rate of increase from week to

132% over the number at birth. The heterozygous mice increase by 5471 ± 1008 cells (difference, 5.4 times its probable error) an increase of 131%. And the homozygous straight mice differ by 7707 ± 772 from birth to adult ages, a gain of 175%. Hence, there is no improvement shown in white cell and red cell counts in each kind of mice but the flexed alone show marked improvement in hemoglobin percentage.

Dr. Hunt suggests that: constant hemoglobin percentage with increasing number of erythrocytes in the young straight tailed animals indicates that the straights are born with erythrocytes richer in hemoglobin than the adults. On the other hand, the increase in hemoglobin percentage in the flexed animals paralleling the increase in erythrocytes suggests that the flexed are born with erythrocytes having the adult endowment of hemoglobin. The flexed at birth have 39.4% hemoglobin and 3,820,000 red cells. Adult flexed mice have 68.7% hemoglobin and 11,200,000 red cells or 74% (68.7%/39.4% - 1) increase in hemoglobin and 193% increase in red cells over birth. That is, while the hemoglobin increases once the red cells increase 3.2 times (74:193::1:3.2). The heterozygous straights at birth have 60.7% hemoglobin and 4,280,000 red cells. These figures increase to 64% and 11,000,000 at adult ages. The hemoglobin shows an increase of 5.4% (64%/60.7% - 1) and the red cells an increase of 136% over birth; in other words, while the hemoglobin increases once the red cells increase 25 times. The homozygous straight mice have 60.9% hemoglobin at birth and 4,010,000 red cells per cubic millimeter. When adults

they have 85.6% hemoglobin and 5,650,000 red cells. This is an increase of 10% in hemoglobin and 141% in red cells. The ratio of increase of hemoglobin to cells is 1 to 9.4. The flexed show a ratio of only 1 to 2.2; they have increased their amount of hemoglobin nearly as much as their cell number. The straight mice, however, have increased their cell number much more rapidly than their hemoglobin percentage.

At birth in each kind of mouse the ratio of hemoglobin to red cells may be taken as 1 to 1. The flexed as adults have not departed as far from this ratio as have the straights, for they then have a 1 to 1.92 ratio (174%, the percentage of hemoglobin at adult ages as compared with 100% at birth, to 337%, the percent of red cells as compared with 100% at birth), while the heterozygous straight mice have 1 to 2.14 ratio and the homozygous straights a 1 to 2.09 ratio. It is evident that the increase in hemoglobin percentage parallels the increase in number of red cells more closely in the flexed mice than in the straight mice, hence the flexed mice are born with a closer approximation to the adult endowment of hemoglobin than are the straights. The adults of both flexed and straight mice have less hemoglobin per cell than do mice at birth, since the cells increase more rapidly than does the hemoglobin.

The preceding observations are necessarily paralleled by data from individual mice: one example from each type will suffice to illustrate this:

1 Week

| | | | |
|---|---|---|---|
| #1 | Flexed from cross | 36f | 45 % - 5,650,000 |
| #2 | Metz. St. from cross | 36f | 55 % - 5,940,000 |
| #2 | Homo. St. From cross | 44a | |

2 Weeks

| | | | |
|---|---|---|---|
| #3* | Flexed from cross | 36f | 55 % - 6,370,000 |
| #2 | Metz. St. from cross | 36f | 55 % - 7,760,000 |
| #2 | Homo. St. from cross | 44a | 55 % - 6,710,000 |

3 Weeks

| | | |
|---|---|---|
| #3 | Flexed | 55 % - 7,810,000 |
| #2 | Metz. St. | 55 % - 7,810,000 |
| #2 | Homo. St. | 50 % - 6,540,000 |

4 Weeks

| | | |
|---|---|---|
| #4** | Flexed | 60 % - 10,900,000 |
| #2 | Metz. St. | 55 % - 8,200,000 |
| #2 | Homo. St. | 60 % - 9,180,000 |

6 Weeks

| | | |
|---|---|---|
| #5" | Flexed | 65 % - 11,340,000 |
| #2 | Metz. St. | 60 % - 9,820,000 |
| #2 | Homo. St. | 60 % - 9,560,000 |

8 Weeks

| | | |
|---|---|---|
| #5 | Flexed | 60 % - 10,170,000 |
| #2 | Metz. St. | 60 % - 10,640,000 |
| #2 | Homo. St. | 60 % - 9,400,000 |

10 Weeks

| | | |
|---|---|---|
| #5 | Flexed | 60 % - 10,960,000 |
| #2 | Metz. St. | 60 % - 10,480,000 |
| #2 | Homo. St. | |

*Substituted for #1 who died after the 1st week.
**Substituted for #3 who died after the 3rd week.
"Substituted for #4 who died after the 4th week.

Those substituted were from the same cross as the ones whose places they took.

The irregularities in the graphs would probably be smoothed out if time had permitted the counting of larger numbers in each case. However, I believe the general trend of any component of the blood may be fairly well seen by the numbers given. Of the 84 points plotted all but 8 were made from averages taken from 1% or more counts.

Discussion : What is the cause of the anemia? No positive answer can be given. Certainly it is not due to loss of blood by hemorrhage, accidental cutting or the purposeful cutting when counts are made. Only rarely have any blood clots shown at birth on the flexed mice. And if loss of blood had caused anemia at birth, it should continue to maintain anemia as blood is taken week after week.

A possible cause is that some genetic factor inhibits the blood forming organs during late fetal and early extra-uterine life. De Aberle found early blood cells in the circular sinus and surrounding mesenchyme at the 8th day after insemination. The bone marrow begins to function at the 16th day of fetal life, but assumes the whole burden of producing erythrocytes a few days after birth. Some here in the blood forming organs something impairs the production of red blood cells and hemoglobin in the flexed mouse but allows normal production in the straight mice, even in straight mice known to carry flexed genes. If the flexed gene (or genes) causes both flexed tail and anemia it obviously does so only in a homozygous condition of the heterozygous mice having flexed genes would be anemic also.

Hence, the supposed gene for anemia is recessive. Perhaps the gene is not the same as the flexed gene but linked with it very closely. Of 415 offspring from flexed by flexed crosses, I found three which were apparently straight tailed and anemic. At 21 days old they proved to be actually without stiffness in the tail or flexure of any sort. Here is anemia without somatic flexed tail. Further, Hunt found 2 mice in his cross #9a which were flexed tailed but normally red at birth. One showed 55% hemoglobin and 5,890,000 red cells, the other 65% hemoglobin and 5,700,000 red cells, both being far from the flexed averages at birth of 39.4% hemoglobin and 3,320,000 erythrocytes. Such cases suggest that flexed tail and anemia might be due to closely linked genes which crossovers sometimes separate. It remains to be seen whether flexed tail and anemia are due to the same gene, or to closely linked genes.

No investigation was made to discover whether there is any correlation between degree of flexure and severity of the anemia. All grades of flexure were used in obtaining records and no striking correlations were noticed. This might be a profitable topic for research.

Summary:

A. The flexed tailed mouse is anemic at birth.

B. This anemia wholly disappears by the second week of age.

C. There is a rapid increase in red blood cells and hemoglobin percentage in the flexed mouse during the first four weeks after birth. From then on to adult life the

increase is slight . The straight tailed mice show improvement in the red cell count alone.

D. An increase in number of white cells is certain in each variety, but the rate of change follows no such regular course as for the erythrocytes.

## PART II

### Inbreeding in the Flexed Tailed Mouse

Purpose: The flexed tail characteristic varies greatly. Dr. H.H. Hunt originated the idea of selecting different grades of flexure and mating similar grades together with the purpose of fixing if possible these differences. If inbreeding could establish different true breeding types, then there would be evidence of numerous factors which modify the extent and type of flexure. The work of inbreeding here reported covers three generations. The animals first selected under Dr. Hunt's supervision for the original matings are called the first generation, their offspring constitute the second generation, and matings from selected second generation mice have yielded a third generation. A few third generation mice have been selected as parents, but had produced no offspring at the date of writing, July 10, 1930. The inbreeding work commenced June 26,1929.

Procedure: Seven types of mice were selected which differed sufficiently from each other to be considered separate grades. One is a short tailed variety in which the tail is less than half the length of the body. It is easily recognized since the normal tail is about the same length as the body. The tail length and body length appear to be positively correlated. The other six grades are separated by the amount of bending in the tail. Figure III shows several drawings of each variety. These drawings are of the parents which bred the second generation offspring herein mentioned.

Grade I has no, or almost no, visible flexure in the tail but the stiffness is readily felt by grasping the tail between the thumb and fore finger. This grade might be mistaken for a normal mouse unless the tail were palpated to discover the vertebral fusions.

In Grade II are included those mice whose tails show only one slight flexure. Slight flexure is a bend of about 30° or less from the usual straight, horizontal position. As with other flexures it may be flexed in a vertical or horizontal plane.

Two or more slight flexures were classed as Grade III. One pronounced flexure, forming more than a 30° angle with the line the tail would have formed had it been extended straight out from the base, is considered Grade IV. The most common group is Grade V. Here are gathered those mice with 2 or more pronounced flexures in their tails. Grade VI has the proverbial characteristic of the pig tail, a spiral loosely or tightly coiled. So it may be called the cork-screw tail.

These grades are usually distinguishable at birth. One can at least tell a short tailed mouse from one with several pronounced flexures. Yet no stiffness is apparent: however, by moving the tail sideways it may be seen whether the bend can be straightened so that it does not reappear when the pressure is removed. If the tail of a newborn animal cannot be straightened in this manner, it is recorded as flexed.

These grades overlap. The variability is continuous. For example a mouse with two slight flexures, if they be more pronounced than usual for Grade I, would appear to be of Grade V. Grades II and IV are likewise not clearly separable. One could construct a series without pronounced breaks, beginning with no visible flexure and by small gradations arrive at a pronounced corkscrew.

Methods of breeding: The mating cages were inspected twice a week for pregnant females. These were isolated in separate cages so the date of birth might be found by looking at the female each day until the litter was born. At intervals of three days after birth the litter was checked to see when deaths occurred. When the young were 21 to 25 days old the mother was removed from them and returned to the breeding cage. The litter was graded and recorded usually when the mother was removed. A view of the tail, sometimes two views if the flexures were in different planes, was drawn and the sex and color of each mouse recorded. A mark was placed across the drawing of each tail at the farthest point from the body to which the stiffness extended, because it was possible that I might subsequently need to reclassify tails according to the amount of stiffness they had. Reference may be made to Figure III where the marks are shown on the pictures of the tails.

From these offspring were chosen mice of the same grade as the parents to breed a new generation. Brothers were always mated with sisters. Several times I have obtained

males like the ancestors but no females to mate with them, and vice versa. Since flared mice from the general stock seem to breed less rapidly than some normal mice, only the healthy offspring seemed desirable as next generation parents. For this reason fewer matings than possible have been made.

Only one female of the last generation, from the short-tailed variety, was sterile. A young mouse when first mated, she had no litter nor gave any sign of pregnancy for the years of the experiment. All of the other 81 females had one or more litters, the one having five litters failed to raise any of them to 21 days of age.

Progress: In Table III are the grades of the parents and the offspring of the first and second generation animals recorded by grades. The first vertical column on the left lists the parental grades. Reading horizontally to the right of any one grade, one can see how the offspring of that grade were spread among the various grades. Notice Grade I. There were 69 offspring from five females x one male. Seven were of Grade I like the parents, three of Grade II, eight of Grade III, nine of Grade IV, thirty-seven of Grade V, four in Grade VI and one short tailed. Only 10.1% are like the parents. Seven offspring of Grade II parents belonged to Grade II or 13.9%. Seventeen of the Grade III offspring belonged to the parental group or 22.6%. Grade IV matings yielded 16 Grade IV mice out of eighty-six offspring or 18.6%. Grade V matings yielded 49 Grade V mice out of ninety offspring or 54.4%. This is the highest

percentage found in any group. Grade VI parents had eleven corkscrew offspring or 27.5% of the forty mice from the cross.

The distributions of the offspring have been plotted in Figure IV. It will be noticed that parents with the same grade of flexure have offspring of all the different grades. For example, the line for the offspring of Grade I parents ascends quite regularly to the node at Grade V. There were only seven second generation mice like their parents and sixty-two unlike them. Grade V parents produced forty-nine mice of Grade V and forty-one spread among the other groups.

In some cases the offspring tend to resemble the parents more often than not. A high grade of flexure crossed with a high grade yields more mice with pronounced flexure than with slight flexure. There are more offspring of low grade when the parents are low grade. Considering all but the short tailed group, Grades I to III may be classed as low flexure and IV to VI as high flexure. The table below has the offspring grouped into low grades and high grades, and the percents the low and high grades are of the total offspring. It is noticed that of the 91 low grade offspring 58 or 63.7% came from the low grade crosses while the low grade crosses gave only 45.6% of the total offspring. So the conclusion seems apparent that a breeder is liable to get more low grade mice from low grade parents than from high grade. Otherwise the low grade crosses would have yielded only about 45% of the low grade offspring instead of 63% as they did.

Offspring of First Generation Parents

| Grade of Parents (1st Generation) | | Grade of Offspring (2nd Generation) Low | High |
|---|---|---|---|
| Low | I | 18 = 26.5% | 50 = 73.5% |
| Grade | II | 18 = 41.9% | 25 = 58.1% |
| Crosses | III | 22 = 36.7% | 38 = 63.3% |
| High | IV | 16 = 18.9% | 69 = 81.1% |
| Grade | V | 7 = 8.9% | 72 = 91.1% |
| Crosses | VI | 10 = 25.0% | 30 = 75.0% |
| Total | | 91 | 264 |

Turning our attention to the high grade crosses we find that 60% of the high grade offspring came from high grade crosses. When we note that from the high grade crosses came 54.4% of the total offspring we may conclude that the offspring of high grade crosses tend to have pronounced flexures more often than slight flexures.

However, high grades of flexure tend to appear more frequently than low grades whether the parents are high grade or low grade. In Grade I crosses, those with very slight or no flexure, there were 37 offspring with two or more pronounced flexures and only seven of the same grade as the parents; there were 18 low grade and 50 high grade mice from Grade I matings. Grade II crosses yielded 18 low grade and 25 high grade offspring. Grade III crosses yield 22 low grade and 38 high grade offspring. Reference to the table on page 65 will convince one that the high

grades are greatly in excess of the low grades. 75.7% of all the offspring of the six types of crosses fall in the three highest grades.

Thus far, the short tailed variety has not been considered. Grade I crosses gave only one short tailed out of 69, Grade II, one out of 44 and Grade IV, one out of 86. Both Grade V parents and short tailed parents yielded equal numbers of short tailed offspring, eleven in each group of matings. 12.8% of Grade V offspring were short tailed. 33.3% of the offspring of short tailed parents were like themselves. This suggests the possibility that after a number of generations short tail, like flexed tail, will breed true. Tho the 3rd generation numbers are small, they confirm this supposition for of 25 progeny of short tailed parents 12 are short tailed, or 48%.

Table III contains a report on 3rd generation mice also. Following the plan on page 33 of grouping high and low grades together, the following table is made:

Offspring of Second Generation Parents

| Grade of Parent (2nd Generation) | | Grade of Offspring (3rd Generation) | |
|---|---|---|---|
| | | Low | High |
| Low Grades | I | 5 | 1 |
| | II | 1 | 3 |
| | III | | 3 |
| High Grades | IV | | 4 |
| | V | 6 | 44 |
| | VI | | |
| Totals | | 12 | 55 |

Inbreeding in the second generation seems to increase the tendency for the low grades and high grades to breed true. Among the 3rd generation mice produced by the first three parental grades, six are of low grade, seven of high grade. Among second generation mice from low grade parents, 58 were low grade and 11 high grade. Stated in a ratio, the low grade parents of the 2nd generation mice have about one low grade to two high grade offspring: the parents of the third generation, about one low grade to one high grade. If future ratios continue to improve as the latter has over the former, before many generations low grade mice will have only low grade offspring.

Compare the second and third generation descendants of the high grade crosses. There are 33 low grade mice to 171 high grade mice from high grade parents in the second generation, 83.3% of these are high grade. Offspring of high grade second generation mice were six low grade to 46 high grade; 88.8% of these are high grade. A slight improvement is indicated. The small numbers in the 3rd generation allow us to conclude nothing, but it looks as though low grades and high grades of flexure may become fixed as the amount of inbreeding increases.

Furthermore that high flexure tends to dominate over low is indicated by breeding experiments with apparently straight tailed mice which have come from flexed parents. A straight flexible tailed animal may have modifying factors as ARBBCCDD which would throw, say, AaBbCcDd, etc., when bred with flexed.

Occurrence of Straight Tailed Mice From Flexed Parents: Out of 552 mice raised from flexed by flexed matings 549 were flexed tailed but 3 were straight tailed with no stiff areas in the tail. These three merit investigation. All were males. One female has been observed since the three males were found, so this outcropping of straight tail in flexed matings is not limited to males. Male #135 is from Grade II parents, those with one slight flexure in the tail, and belonging to the first generation. Male #141 came from Grade I parents of the first generation. Male #149 is derived from parents of the first generation with two or more slight flexures in the tail. No stiffness can be felt in their tails; from all appearances they are normal mice except that all were anemic at birth and were considered then as straight tailed or doubtfully flexed.

These apparently straight tailed mice are genetically flexed. Other mice believed to be homozygous straight tailed, when crossed with flexed have yielded straight tailed mice, (again with three exceptions out of 455 mice raised by Hunt and Permar (1) ). If these three males are homozygous straight tailed they should yield when crossed onto flexed only straight offspring. But they have to date had only flexed offspring. If they were heterozygous straights, they should have about one flexed to 1.54 straight offspring (Hunt's ratio for a backcross of $F_1$ straight by flexed) if mated to flexed females. But they have had only flexed offspring when so mated. Male #135 x flexed females #133 and #134 yielded 20 offspring, flexed at birth. The only one to

live 21 days was definitely flexed at that time. Male #131 x flexed female #132 yielded 11 young which were flexed at birth; the four alive at 21 days were highly flexed. Since these apparently straight tailed mice have produced only flexed offspring when crossed with flexed they can be considered genetically flexed.

While thinning out his flexed stock cages on Oct. 12, 1929, Dr. Hunt found five mice which seemed to be straight tailed, two males and three females. A summary of breeding experiments with them is suggestive altho one cannot be absolutely sure of their parentage. Three types of crosses were made. The first type was a mating between a straight male found in the flexed stock cages and three straight females, also from flexed stock cages, (crosses 28a,b,c) which yielded ten straight offspring and 17 flexed offspring. Each female yielded both flexed and straight offspring. For the second kind of cross I took one of the straight males descended from the first type of cross (one of the ten straight offspring of crosses 28a,b,c) and mated him with two flexed females, obtaining eight flexed offspring. Evidently the male was genetically flexed, tho apparently straight tailed. Finally, I mated the other straight male found by Dr. Hunt in the flexed stock cages with two flexed females; this yielded 17 flexed offspring. Since straight is dominant the male must have carried flexed factors or all of his offspring would have been straight tailed.

Perhaps we are running into low grade by low grade matings in crosses 2c4,b,c. These crosses give a 1:1.7 ratio of low to high (if the tails without flexure and no stiffness may be considered as of low grade). This ratio was approximated 58:113 for the second generation offspring of first generation low grade mice. One at least of these apparently straight offspring from the mice found in flexed stock cages, was genetically flexed for he gave all flexed offspring when mated by pronouncedly flexed females.

Discussion: The genetic explanation of flexed tailed mice is not evident. The gradation from low to high degrees of flexure suggests a case of multiple factors which modify the degree of flexure. Dr. Hunt suggests the following hypothesis. He feels that flexed is a simple recessive to normal, but that the degree of flexure is modified by secondary subsidiary factors. Let F represent the factor for straight tail and f the factor for flexed tail. Flexed x straight (ffxFF) yield straight offspring. (Ff) flexed x flexed (ff x ff) yield flexed offspring (ff). But several dominant factors decrease the degree of flexure and all of them must be present to produce a marked result. Most of the low grade parents are ff AaBbCcDd, therefore, 81 out of every 256 offspring of low grade parents should have ABCD, or 32%. The table on page 33 shows that where the parents are of low grade 34% of the offspring (58 out of 171) are low grade. High grade parents carry a variable number of the above dominant factors, but never one from each pair. Thus some of the offspring will be ABCD, but not as many as among the

offspring of low grade parents. If AABBCC or something similar might make a flexed animal genetically straight.

Segregation in the $F_2$ generation may formally be reconciled with the view that one pair of factors is concerned. Jerner's ratio is 7.23 straight : 1.00 flexed with 1065 $F_2$ animals. Hunt's ratio is 5.01 straight : 1.00 flexed with 904 $F_2$ animals. Possibly environmental inhibitors are causing some genetically flexed offspring to appear straight. A normal Mendelian ratio of 3:1 might be changed to 5:1 (which is similar to 5.04:1) by some agency increasing the early mortality of flexed mice. The angels at birth may constitute such an agency. Some force at work may be keeping mice which are genetically flexed from appearing so, as were the three males found in flexed x flexed crosses. Yet three out of over 500 could scarcely make such a difference in the ratio for 1000 animals. Any agency which keeps offspring of flexed animals from appearing flexed could work as efficiently in keeping flexed $F_2$ mice from having their flexed character, since flexed mice in either case may, perhaps, be homozygous recessives. Dr. Hunt tested a considerable number of straight progeny from the $F_1$ x flexed type of mating to see if any of them were genetically flexed, but none of them threw 100% of flexed offspring when crossed with flexed males, so none of them, apparently, were homozygous flexed. Hence genetically straight mice which are genetically flexed are infrequent.

More experiments are needed to demonstrate whether

multiple factors are involved or not. If a high grade of flexure can be inbred for several generations then crossed with homozygous straight mice the $F_1$'s might then show mild flexure and the $F_2$'s all grades of flexure such as are found at present. If it be possible to fix different grades of flexure by inbreeding the case for multiple factors will have another foot in its favor. Supposing that AABBCCDd mice are low grade flexed if the large letters stand for factors tending to make the tail straight and small letters those causing it to be flexed, then it should be possible to fix animals having that formula. At the same time high grade flexures should be fixed, then crosses between the two grades should yield the intermediate offspring which demonstrate multiple factors.

One is tempted to stop after figuring thus far for an explanation that we have ridden a merry-go-round, arriving at the opening statement that "there is some question as to the genetic nature of the flexed tailed mutation." We are sure that it really always breeds true and is nearly always recessive; beyond this our conclusions are reachings after truth which is still beyond our grasp. As we extend our ladder of experimentation we may eventually grasp the assured result of science.

Deaths among Offspring of First Generation Mice: One other matter has been under observation, namely, the death rate among the offspring of the first generation parents selected for the inbreeding experiment. Table IV lists the

grades of the parents vertically on the left. The next vertical column to the right gives the number of mice born to each grade. When reading horizontally to the right are shown the number of the offspring dying at different periods up to 28 days. Litters were examined every three or four days to see if any young had died, and the number dying was recorded.

The deaths were due to several causes. Some young mice were found dead which did not appear to have been injured by the mother, the food mice, or handling. These died presumably from weakness or some disease, or by a lethal factor genetically inherited such as anemia. Some of these young had bloated and transparent abdomens: upon puncturing them a bit of gas escaped. Others showed some yellowish material in the intestines. The other general cause of death is by the mothers' eating their young. Parts of bodies were found, the other part evidently chewed off. She may have killed them, or merely eaten those which died, the many dead bodies were found which had not been eaten at all. Often the brain had been eaten out leaving the sides of the immature skull as a silent testimony. No attempt was made to record the manner of death, hence no conclusion as to the natural viability could be drawn.

Nor were there any controls to check the fluxed death rate against normals. However, the rather large number which died among fluxed mice is worthy of note and may serve as a basis for comparison with data from normal mice if it can

be assumed that normal mice would destroy [illegible] eating them as do flexed mice.

Of 615 young born from June 25, 1930 to June 15, 1930 only 438 lived to be from 21 to 28 days old, the age at which they were recorded. The 423 are those used as data in the inbreeding experiment as given in Table III on p.65 32.8% of the young born died within 28 days. 12.6% from one to three days after birth: 9.6% from four to seven days: 5.1% from eight to fourteen days: 2.2% from fifteen to twenty-one days and 2.7% from twenty-one to twenty-eight days. 45% of the 32% died during the first week--the anemic period. Does this not give you a clue as to the probable cause of most of the deaths? 68.9% of the young who died were dead in the first week after birth. This is expected, both from anemia and by the mother's appetite for real young mice offer more attractions to the taste of a "carnivorous" mother. 45% of the young born (not considering the short tailed group) were from parents with slight flexures (Grades I, II, III) and 45% of the deaths were in these groups. So low or high flexure does not influence the infant mortality of the flexed mouse. The short tailed mice have about the same death rate as the others.

Summary of part II :

A. The possibility that different grades of flexure may be fixed is suggested from the observation that more low grade offspring are produced when the parents are low grade than when they are high grade and high grade parents tend to

have more high grade than low grade offspring.

b. High grades of flexure seem to occur more frequently in all matings than low grades.

c. Flexed pigs in these crosses out of sows have yielded apparently straight tailed offspring which breed as though they were genetically flexed.

d. Data on deaths among flexed pigs show that about 1/3 died from disease, weaknesses or killing by mother between birth and 28 days. The greatest factor may be anemia.

# BIBLIOGRAPHY

(1) Evolution, Genetics and Eugenics, Revised Edition. p. 486. By M.F. Guyer, U. of Chicago Press.

(2) "Mutation" By H.J. Muller from Evolution, Genetics and Eugenics. p. 495.

(3) The Inheritance of Colored Veil in the Race By H.E. Jaap, paper read at Michigan Academy of Science, Ann Arbor, Michigan, March 27, 1920.

(4) The Blood of Normal Mice By J.P. Simonds in Anatomical Record Vol. 33. pp. 93-105

(5) Numbers, Proportions and Character of the Red and White Cells in certain Animals By A. Goodall in Journal of Pathology and Bacteriology. 1909. Vol. 14 pp. 195 - 199.

(6) Murphy and Sturm 1919 in Jr. Exper. Med. Vol. 29, p. 1.

(7) Young in Min. Mal. Jour. Vol. 21, p. 83, 1922

(8) Anemia in Young Pigs By L.P. Doyle, E.B. Hoffhers and H.H. Kitting in Journal of American Veterinary Med. Assn. Vol. LXII. June 1 23

(9) A Study of the Hereditary Anemia of Mice By Sophia Wehmoe de Aberle in American Journal of Anatomy, Vol. 40. No. 2, Nov. 15, 1924

(10) Manual of General Pathology
by Lecount and Hurlow, 1914

(11) Nelson's Loose Leaf Medicine
Vol. 4, pp. 1-39

(12) Textbook of Pathology
by Beattie and Dickson, 1927

(13) Pernicious Anemia
by Frank J. Lewis
Williams and Wilkins Co., Baltimore (1926)

(14) Pernicious Anemia or Hemolytic Anemia of
Pregnancy
F.C. Norland in Journal of American Medical Asso.
p. 372 84, 1924

(15) Statistical Methods
by F.C. Mills. pp. 36-39
Published by Henry Holt and Co., N.Y. 1924.

# TABLE I

## RED BLOOD CELLS AND HEMOGLOBIN OF FLEXED AND STRAIGHT TAILED MICE DETERMINED AT WEEKLY INTERVALS

| Birth | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Flexed | | | Hetz. St. | | | Homoz. St. | | |
| * H.b | Red Cells | Cross | H.b | Red Cells | Cross | H.b | Red Cells | Cross |
| 30% | | 13b | 60% | | 13b | 60% | 3,630,000 | 44c |
| 30% | 2,620,000 | 13b | 60% | 3,940,000 | 10a | 60% | 4,050,000 | 44c |
| 30% | 2,690,000 | 13b | 70% | 4,660,000 | 12a | 55% | 4,900,000 | 44c |
| 45% | 3,850,000 | 10a | 65% | 4,100,000 | 11c | 60% | 3,960,000 | 44c |
| 35% | 2,690,000 | 10a | 65% | | 8a | 55% | 4,570,000 | 44c |
| 30% | 2,480,000 | 12a | 65% | 5,000,000 | 10b | 55% | | 44c |
| 35% | 2,880,000 | 11c | 60% | 3,540,000 | 13a | 60% | | 44b |
| 55% | 4,000,000 | 11c | 60% | 4,080,000 | 14a | 55% | | 44b |
| 45% | 3,240,000 | 8b | 60% | | 8b | 60% | | 44b |
| 30% | 2,460,000 | 13b | 60% | 4,290,000 | 8b | 60% | | 44d |
| 35% | 4,770,000 | 11b | 55% | 4,680,000 | 13b | 70% | | 44d |
| 45% | 4,390,000 | 9b | 60% | 4,500,000 | 10a | 60% | | 44d |
| 40% | 4,320,000 | 9a | 60% | 3,930,000 | 10a | 60% | | 41d |
| 30% | 2,660,000 | 8a | 40% | 4,260,000 | 12a | 55% | | 44d |
| 30% | 2,610,000 | 8a | 60% | 5,330,000 | 12a | 60% | | 44d |
| 30% | 3,110,000 | 10b | 50% | 4,020,000 | 14b | 60% | | 44d |
| 50% | 2,960,000 | 12a | 40% | 5,220,000 | 11b | 60% | 4,920,000 | 44h |
| 45% | 3,870,000 | 14c | 55% | 5,750,000 | 9b | 60% | 4,950,000 | 44c |
| 40% | 3,980,000 | 10a | 60% | 6,870,000 | 9a | 60% | 4,310,000 | 44c |
| 35% | 3,090,000 | 10a | 55% | 5,250,000 | 8a | 45% | 4,060,000 | 44f |
| 30% | 4,500,000 | 12a | 60% | 5,050,000 | 12a | 45% | 3,220,000 | 44f |
| 50% | 4,250,000 | 12a | 60% | 5,160,000 | 10b | 55% | 2,990,000 | 44c |
| 30% | 3,540,000 | 14b | 60% | 5,160,000 | 36a | 55% | 3,070,000 | 44c |
| 40% | 3,300,000 | 13a | 60% | 5,920,000 | 36c | 55% | 3,550,000 | 44c |
| 40% | 4,840,000 | 10b | 60% | 6,060,000 | 8a | 50% | 3,670,000 | 44c |
| 35% | 4,640,000 | 36a | | | | 50% | 4,370,000 | 44c |
| 30% | 4,560,000 | 36c | | | | | | |
| 30% | 3,820,000 | 8a | | | | | | |

*H.b = hemoglobin

RED BLOOD CELLS AND HEMOGLOBIN OF FLEXED AND STRAIGHT TAILED MICE DETERMINED AT WEEKLY INTERVALS

| 1 Week | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Flexed | | | Hetz. St. | | | Homoz. St. | | |
| Hab. | Red Cells | Cross | Hab. | Red Cells | Cross | Hab. | Red Cells | Cross |
| ~~25%~~ | | 13b | 65% | 4,690,000 | 10a* | 50% | 4,950,000 | 44e* |
| 40% | 4,500,000 | 13b | 60% | 4,790,000 | 10a | 50% | 4,950,000 | 44c |
| 45% | | 10a | 55% | 4,690,000 | 10a | 55% | 5,000,000 | 44c |
| 50% | 4,780,000 | 12b | 64% | 5,470,000 | 12a | 50% | 4,500,000 | 44c |
| 40% | 3,920,000 | 11c | 65% | 4,250,000 | 12b | 50% | 4,840,000 | 44c |
| 60% | 5,000,000 | 8a | 60% | 5,000,000 | 11b | 55% | 5,230,000 | 44d |
| 55% | 3,760,000 | 13a | 65% | 5,470,000 | 8a | 55% | 4,250,000 | 44d |
| 50% | 4,810,000 | 14a | 80% | 5,500,000 | 10b | 50% | 4,000,000 | 44d |
| 60% | 4,450,000 | 13b | 60% | 5,250,000 | 10b | 55% | 5,080,000 | 44d |
| 45% | 5,110,000 | 13b | 60% | 4,330,000 | 13a | 55% | 5,650,000 | 44c |
| 35% | 3,780,000 | 12a | 80% | 5,100,000 | 14a | 50% | 4,900,000 | 44d |
| 40% | 4,740,000 | 14b | 50% | 5,410,000 | 13b | 60% | 5,600,000 | 44d |
| 50% | 5,400,000 | 11b | 55% | 5,330,000 | 13b | 50% | 6,560,000 | 44f |
| 40% | 3,950,000 | 9b | 50% | 4,900,000 | 12a | 60% | 5,380,000 | 44f |
| 40% | 3,370,000 | 9a | 50% | 4,640,000 | 14b | 55% | 5,460,000 | 44f |
| 45% | 4,590,000 | 8a | 60% | 6,400,000 | 11b | | | |
| 50% | 5,250,000 | 13a | 60% | 4,980,000 | 9b | | | |
| 50% | 6,230,000 | 10b | 60% | 4,720,000 | 11c | | | |
| 45% | 6,110,000 | 36b | 55% | 5,490,000 | 8a | | | |
| 45% | 5,920,000 | 36e | 50% | 5,060,000 | 13a | | | |
| 45% | 5,850,000 | 36f | 60% | 6,940,000 | 10b | | | |
| 50% | 6,160,000 | 9a | 55% | 6,460,000 | 36b | | | |
| 50% | 6,860,000 | 11b | 50% | 6,070,000 | 36e | | | |
| 45% | 4,600,000 | 14b | 55% | 5,940,000 | 36f | | | |
| 60% | 7,000,000 | 36a | 50% | 5,800,000 | 9a | | | |
| 45% | 5,330,000 | 36d | 60% | 6,520,000 | 11b | | | |
| 55% | 5,300,000 | 36c | 50% | 4,900,000 | 14b | | | |
| 55% | 6,460,000 | 36f | 50% | 6,080,000 | 36a | | | |
| | | | 55% | 6,150,000 | 36d | | | |
| | | | 50% | 4,690,000 | 36c | | | |
| | | | 55% | 6,900,000 | 36e | | | |

* Omit this horizontal row.

## 2 Weeks

| Flexed | | | Hetz. St. | | | Homoz. St. | | |
|---|---|---|---|---|---|---|---|---|
| H.b. | Red Cells | Cross | H.b. | Red Cells | Cross | H.b. | Red Cells | Cross |
| 50% | | 13b | | 6,050,000 | 8b | 60% | 6,590,000 | 44a |
| | 6,730,000 | 13b | | 6,380,000 | 8b | 55% | 6,710,000 | 44a |
| 40% | 5,580,000 | 10a | 70% | 8,150,000 | 10a | 55% | 6,350,000 | 44a |
| 50% | 5,880,000 | 12a | 50% | 6,460,000 | 11c | 60% | 6,160,000 | 44a |
| 60% | 6,380,000 | 12a | 60% | 6,090,000 | 10b | 60% | 8,480,000 | 44c |
| 60% | 6,570,000 | 12b | 55% | 7,350,000 | 10b | 55% | 7,460,000 | 44c |
| 50% | 6,000,000 | 11c | 50% | 5,820,000 | 13a | 55% | 6,060,000 | 44c |
| 55% | 6,630,000 | 8a | 50% | 7,470,000 | 12a | 60% | 7,240,000 | 44c |
| 55% | 6,660,000 | 13a | 60% | 7,840,000 | 9b | 55% | 7,340,000 | 44d |
| 55% | 7,660,000 | 12a | 50% | 6,650,000 | 8a | 60% | 6,360,000 | 44d |
| 50% | 7,670,000 | 13b | 40% | 6,940,000 | 10b | 55% | 6,550,000 | 44d |
| 40% | 7,030,000 | 9b | 60% | 8,300,000 | 12b | 50% | 5,400,000 | 44d |
| 60% | 7,040,000 | 8a | 55% | 7,760,000 | 36f | 50% | 6,250,000 | 44d |
| 50% | 7,680,000 | 10b | 55% | 7,660,000 | 36e | 55% | 5,500,000 | 44d |
| 50% | 6,850,000 | 12b | 50% | 6,880,000 | 11b | 55% | 6,500,000 | 44d |
| 55% | 6,470,000 | 36f | 50% | 7,290,000 | 36a | | | |
| 50% | 7,660,000 | 36e | 60% | 7,950,000 | 36d | | | |
| 50% | 7,560,000 | 11b | 55% | 4,100,000 | 36c | | | |
| 55% | 7,200,000 | 36d | 55% | 8,150,000 | 36g | | | |
| 50% | 7,150,000 | 36c | 60% | 5,600,000 | 9a | | | |
| 55% | 7,200,000 | 36g | 50% | 6,280,000 | 9b | | | |
| 60% | 7,120,000 | 9a | 50% | 5,940,000 | 12a | | | |
| 60% | 6,450,000 | 9b | | | | | | |
| 60% | 5,040,000 | 12a | | | | | | |

## 3 Weeks

| Flexed | | | Hetz. St. | | | Homoz. St. | | |
|---|---|---|---|---|---|---|---|---|
| H.b. | Red Cells | Cross | H.b. | Red Cells | Cross | H.b. | Red Cells | Cross |
| | 6,850,000 | 8b | | 6,600,000 | 8b | 50% | 6,000,000 | 44a |
| | 6,740,000 | 14b | | 7,570,000 | 14b | 50% | 6,840,000 | 44a |
| 70% | 6,590,000 | 10a | 60% | 7,510,000 | 13b | 45% | 5,850,000 | 44a |
| 75% | | 12a | 55% | 6,240,000 | 10a | 45% | 6,380,000 | 44a |
| 80% | 7,720,000 | 12a | 60% | 7,050,000 | 11c | 60% | 8,900,000 | 44c |
| 50% | 10,460,000 | 12b | 55% | 7,050,000 | 10b | 50% | 7,620,000 | 44c |
| 80% | | 11c | 50% | 6,690,000 | 13a | 60% | 6,880,000 | 44c |
| 60% | | 11c | 55% | 7,570,000 | 13b | 50% | 8,100,000 | 44c |
| 55% | 9,040,000 | 8a | 55% | 8,130,000 | 9a | 50% | 4,760,000 | 44d |
| 50% | 7,340,000 | 13a | 55% | 8,310,000 | 12a | 45% | 4,650,000 | 44d |
| 45% | 7,400,000 | 13b | 50% | 8,410,000 | 9b | 55% | 6,680,000 | 44d |
| 60% | 8,600,000 | 9a | 60% | 9,590,000 | 8a | 55% | 7,520,000 | 44d |
| 55% | 9,620,000 | 12a | 55% | 7,950,000 | 10b | 50% | 6,240,000 | 44d |
| 50% | 7,030,000 | 9b | 60% | 7,750,000 | 36e | 60% | 7,780,000 | 44d |
| 60% | 9,730,000 | 8a | 55% | 7,810,000 | 36f | 55% | 7,080,000 | 44d |
| 55% | 8,660,000 | 10b | 60% | 8,000,000 | 11b | | | |
| 55% | 7,710,000 | 36e | 50% | 7,660,000 | 14b | | | |
| 60% | 7,280,000 | 36f | 55% | 7,980,000 | 36d | | | |
| 55% | 8,080,000 | 11b | 50% | 8,120,000 | 36c | | | |
| 50% | 8,080,000 | 14b | 60% | 7,600,000 | 36g | | | |
| 55% | 9,000,000 | 36d | | | | | | |
| 50% | 8,000,000 | 36c | | | | | | |
| 50% | 8,620,000 | 36g | | | | | | |

## 4 Weeks

| Flexed | | | Hetz. St. | | | Homoz. St. | | |
|---|---|---|---|---|---|---|---|---|
| H.b. | Red Cells | Cross | H.b. | Red Cells | Cross | H.b. | Red Cells | Cross |
| 65% | 9,660,000 | 8b | 80% | 9,560,000 | 8b | 60% | 9,360,000 | 44a |
| 60% | | 14b | 70% | | 8b | 60% | 9,180,000 | 44a |
| 60% | | 14b | 60% | 9,300,000 | 14b | 60% | 9,760,000 | 44a |
| 50% | 9,8[illegible],000 | 14b | 60% | 8,520,000 | 10a | 60% | 9,[illegible]88,000 | 44a |
| 50% | 8,[illegible]60,000 | 11c | 60% | 8,710,000 | 11c | 60% | 9,840,000 | 44c |
| 55% | 10,110,000 | 8a | 65% | 10,160,000 | 1[illegible]b | 60% | 9,040,000 | 44c |
| 55% | 9,730,000 | 13a | 60% | 10,060,000 | 9a | 60% | 8,200,000 | 44c |
| 60% | 9,570,000 | 12b | 55% | 10,770,000 | 8a | 60% | 8,700,000 | 44d |
| 60% | 10,170,000 | 9a | 55% | 11,520,000 | 9b | 60% | 8,640,000 | 44d |
| 55% | 10,[illegible]30,000 | 8a | 65% | 9,560,000 | 36e | 70% | 8,620,000 | 44d |
| 60% | 11,980,000 | 9b | 55% | 8,260,000 | 36f | 60% | 9,640,000 | 44d |
| 55% | 10,440,000 | 10b | 60% | 9,200,000 | 14b | 60% | 9,580,000 | 44d |
| 60% | 10,300,000 | 36e | 55% | 11,000,000 | 11b | | | |
| 60% | 10,900,000 | 36g | 70% | 10,040,000 | 36d | | | |
| 60% | 9,[illegible]00,000 | 14b | 60% | 9,1[illegible]0,000 | 36c | | | |
| 55% | 11,000,000 | 11b | 55% | 9,670,000 | 36g | | | |
| 70% | 10,070,000 | 36d | 60% | 9,870,000 | 10b | | | |
| 60% | 9,180,000 | 36c | 55% | 6,[illegible]60,000 | 13a | | | |
| 55% | 9,670,000 | 36g | | | | | | |

## 6 Weeks

| Flexed | | | Hetz. St. | | | Homoz. St. | | |
|---|---|---|---|---|---|---|---|---|
| H.b. | Red Cells | Cross | H.b. | Red Cells | Cross | H.b. | Red Cells | Cross |
| 60% | 8,690,000 | 13b | 70% | 10,300,000 | 12b | 55% | 10,040,000 | 44a |
| 65% | 11,320,000 | 9a | 60% | 10,400,000 | 9a | 60% | 9,560,000 | 44a |
| 70% | 10,260,000 | 36d | 60% | 9,620,000 | 36f | 70% | 9,620,000 | 44a |
| 60% | 10,460,000 | 36g | 60% | 11,520,000 | 11b | 60% | 10,260,000 | 44a |
| 70% | 8,680,000 | 36c | 60% | 9,400,000 | 14b | | | |
| 60% | 11,240,000 | 9a | 70% | 9,390,000 | 36d | | | |
| 60% | 9,000,000 | 12a | 55% | 11,040,000 | 9a | | | |
| 60% | 10,940,000 | 36g | 60% | 11,360,000 | 12a | | | |
| 55% | 9,820,000 | 36g | 60% | 10,080,000 | 36g | | | |
| 55% | 11,000,000 | 36g | 55% | 9,120,000 | 36g | | | |
| 60% | 10,080,000 | 9a | 60% | 10,260,000 | 36g | | | |
| 60% | 11,900,000 | 8a | 60% | 11,260,000 | 8a | | | |
| 55% | 11,340,000 | 36f | 55% | 8,820,000 | 9a | | | |
| 60% | 10,680,000 | 11b | 70% | 9,630,000 | 36c | | | |
| 60% | 12,000,000 | 14b | 60% | 9,240,000 | 36g | | | |

| Flexed | | | Retz. St. | | | Homoz. St. | | |
|---|---|---|---|---|---|---|---|---|
| H.b. | Red Cells | Cross | H.b. | Red Cells | Cross | H.b. | Red Cells | Cross |
| 70% | 11,440,000 | | | | | 60% | 10,600,000 | 44a |
| 80% | 10,600,000 | 36g | 45% | 5,380,000 | 36a | 60% | 9,400,000 | 44a |
| 60% | 12,640,000 | 36g | 80% | 10,880,000 | 36g | | | |
| 70% | 12,210,000 | 36g | 80% | 11,440,000 | 36g | | | |
| 60% | 10,360,000 | 36g | 60% | 10,120,000 | 36g | | | |
| 70% | 11,250,000 | 36g | 60% | 10,220,000 | 36g | | | |
| 65% | 10,740,000 | 36g | 60% | 10,560,000 | 36g | | | |
| 70% | 10,780,000 | 13b | 60% | 10,320,000 | 36g | | | |
| 65% | 12,580,000 | 9a | 80% | 11,600,000 | 13b | | | |
| 60% | 11,840,000 | 8a | 60% | 11,990,000 | 9a | | | |
| 60% | 10,170,000 | 36f | 60% | 10,780,000 | 8a | | | |
| 60% | 11,120,000 | 11b | 60% | 10,650,000 | 36f | | | |
| 60% | 11,940,000 | 14b | 80% | 11,000,000 | 11b | | | |
| | | | 60% | 9,060,000 | 14b | | | |

10 Weeks

| Flexed | | | Retz. St. | | | Homoz. St. | | |
|---|---|---|---|---|---|---|---|---|
| H.b. | Red Cells | Cross | H.b. | Red Cells | Cross | H.b. | Red Cells | Cross |
| 60% | 11,110,000 | 8a | 60% | 10,480,000 | 8a | | | |
| 55% | 10,820,000 | 13b | 70% | 10,920,000 | 13b | | | |
| 70% | 11,850,000 | 9a | 60% | 10,200,000 | 9a | | | |
| 60% | 10,940,000 | 36f | 80% | 10,480,000 | 36a | | | |
| 60% | 11,760,000 | 11b | 60% | 11,440,000 | 11b | | | |
| 70% | 11,760,000 | 14b | 60% | 11,400,000 | 14b | | | |
| 60% | 10,560,000 | 14b | 60% | 11,840,000 | 14b | | | |
| 70% | 11,220,000 | 36c | 80% | 7,820,000 | 36c | No counts made | | |
| 60% | 11,240,000 | 36g | 80% | 11,260,000 | 36g | | | |
| 60% | 12,000,000 | 36g | 60% | 11,400,000 | 14b | | | |
| 60% | 11,760,000 | 14b | 70% | 12,280,000 | 9a | | | |
| 70% | 11,480,000 | 9a | 60% | 10,800,000 | 9a | | | |
| 70% | 10,480,000 | 36g | 60% | 10,200,000 | 36g | | | |
| 80% | 11,460,000 | 36g | 70% | 9,120,000 | 36g | | | |
| 70% | 9,120,000 | 36g | | | | | | |

12 Weeks

| Flexed | | | Retz. St. | | | Homoz. St. | | |
|---|---|---|---|---|---|---|---|---|
| H.b. | Red Cells | Cross | H.b. | Red Cells | Cross | H.b. | Red Cells | Cross |
| 70% | 11,400,000 | 13b | 60% | 11,100,000 | 13b | | | |
| 60% | 11,920,000 | 8a | 60% | 11,140,000 | 8a | | | |
| 70% | 12,000,000 | 13b | 70% | 11,700,000 | 13b | | | |
| 70% | 11,560,000 | 11b | 65% | 10,520,000 | 36f | | | |
| 70% | 12,400,000 | 36g | 65% | 11,440,000 | 11b | | | |
| 70% | 11,840,000 | 36g | 80% | 11,400,000 | 36g | | | |
| 80% | 12,460,000 | 36g | 80% | 10,600,000 | 36g | | | |
| 60% | 11,140,000 | 14b | 60% | 10,440,000 | 14b | | | |
| 55% | 11,440,000 | 14b | 70% | 11,300,000 | 14b | | | |
| 65% | 10,900,000 | 36c | 65% | 8,470,000 | 36c | | | |
| 60% | 9,820,000 | 9a | 60% | 10,900,000 | 9a | | | |

12 Weeks

| Flexed | | | Hetz. St. | | | Homoz. St. | | |
|---|---|---|---|---|---|---|---|---|
| H.b. | Red Cells | Cross | H.b. | Red Cells | Cross | H.b. | Red Cells | Cross |
| 60% | 11,340,000 | 36g | 60% | 10,400,000 | 9a | | | |
| 75% | 11,400,000 | 36g | 70% | 10,960,000 | 36g | | | |
| 75% | 11,920,000 | 36g | 80% | 10,640,000 | 36g | | | |

Adults

| Flexed | | | Hetz. St. | | | Homoz. St. | | |
|---|---|---|---|---|---|---|---|---|
| H.b. | Red Cells | No. | H.b. | Red Cells | No. | H.b. | Red Cells | No. |
| 70% | 12,200,000 | ♀ 44 | 55% | 11,900,000 | ♂ 43 | 65% | 10,080,000 | ♀ 175 |
| 70% | 10,840,000 | ♀ 41 | 70% | 11,740,000 | ♂ 60 | 80% | 9,500,000 | ♀ 174 |
| 70% | 11,720,000 | ♀ 47 | 55% | 11,550,000 | ♂ 42 | 60% | 11,840,000 | ♀ 167 |
| 60% | 10,800,000 | ♀ 61 | 60% | 11,360,000 | ♂ 46 | 70% | 10,400,000 | ♂ 168 |
| 75% | 11,920,000 | ♀ 50 | 60% | 10,530,000 | ♂ 51 | 60% | 10,360,000 | ♀ 182 |
| 60% | 12,320,000 | ♀ 52 | 60% | 10,860,000 | ♂ 54 | 65% | 9,140,000 | ♀ 168 |
| 60% | 11,400,000 | ♀ 53 | 55% | 11,520,000 | ♂ 57 | 60% | 8,940,000 | ♂ 171 |
| 55% | 9,560,000 | ♀ 55 | 70% | 12,260,000 | ♀163 | 70% | 9,760,000 | ♀ 176 |
| 80% | 10,940,000 | ♀ 45 | 55% | 9,800,000 | ♀172 | 55% | 7,200,000 | ♀ 175 |
| 60% | 5,400,000 | ♀169 | 60% | 12,040,000 | ♀212 | 60% | 11,150,000 | ♀ 176 |
| 60% | 10,160,000 | ♀194 | 70% | 12,080,000 | ♀215 | 60% | 9,560,000 | ♀ 174 |
| 70% | 11,360,000 | ♂ 87 | 70% | 11,200,000 | ♂191 | 65% | 8,460,000 | ♀ 172 |
| 60% | 11,400,000 | ♀ 6 | 60% | 10,600,000 | ♂195 | | | |
| 70% | 12,400,000 | ♀ 17 | 60% | 8,800,000 | ♀192 | | | |
| 80% | 12,080,000 | ♀ 14 | 65% | 7,700,000 | ♀193 | | | |
| 60% | 10,600,000 | ♂ 18 | | | | | | |

TABLE II

[illegible]

Birth

| Phased | | | Hetz. St. | | | Homoz. St. | |
|---|---|---|---|---|---|---|---|
| *H.b | White Cells | Cross | H.b | White Cells | Cross | H.b | White Cells | Cross |
| 45% | 2,980 | 9a | 60% | 3,560 | 14b | | 2,000 | 44c |
| 40% | 4,980 | 36a | 55% | 4,200 | 14b | | 2,000 | 44c |
| 45% | 2,560 | 8a | 70% | 6,000 | 36e | | 1,000 | 44c |
| 45% | 3,[illegible] | 8a | 60% | 3,860 | 8a | | 1,000 | 44c |
| 40% | 4,840 | [illegible] | 65% | 4,600 | 8a | | 4,000 | 44c |
| [illegible] | 3,200 | [illegible] | 65% | 4,000 | [illegible] | | 2,400 | 44c |
| 35% | 2,920 | [illegible] | 60% | 4,140 | [illegible] | | 4,840 | 44c |
| 40% | 3,[illegible] | [illegible] | 55% | 3,600 | [illegible] | | 6,400 | 44c |
| 40% | 2,800 | [illegible] | 60% | 3,200 | 36e | | 4,800 | 44c |
| 46% | 3,000 | [illegible] | 60% | 3,600 | 9a | | 4,700 | 44c |
| 45% | 4,800 | [illegible] | 60% | 2,800 | 9a | | 4,000 | 44c |
| 45% | 6,240 | [illegible] | 70% | 6,040 | 9a | | 5,240 | 44c |
| 40% | 4,000 | [illegible] | 65% | 3,000 | 9a | | 3,000 | 44d |
| 40% | 4,200 | [illegible] | 60% | 4,[illegible] | 9a | | 3,400 | 44d |
| 45% | 5,040 | 9a | 60% | 3,920 | 12b | | 5,100 | 44c |
| 45% | 3,[illegible] | 9a | 60% | 1,000 | 12b | | 3,000 | 44c |
| | | | | | | | 2,000 | 44c |
| | | | | | | | 2,000 | 44c |
| | | | | | | | 4,000 | 44c |
| | | | | | | | 7,000 | 44c |
| | | | | | | | 5,000 | 44c |
| | | | | | | | 6,000 | 44c |
| | | | | | | | 4,000 | 44c |
| | | | | | | | 2,000 | 44c |
| | | | | | | | 5,000 | 44c |
| | | | | | | | 4,000 | 44c |

* H.b = hemoglobin

1 week

| Fixed | | | Beta. st. | | | Homoz. st. | | |
|---|---|---|---|---|---|---|---|---|
| N.b | White cells | Cross | N.b | White cells | Cross | N.b | White cells | Cross |
| 55 | 3,000 | 13a | 60 | 7,1[illegible] | 1[illegible] | | 8,000 | 41c |
| 50 | 4,400 | 1[illegible] | 55 | 4,[illegible]0 | 1[illegible] | | 4,000 | 41c |
| 45 | 1,800 | [illegible] | 50 | 5,000 | 50f | | 5,000 | 41[illegible] |
| 60 | 1,600 | 11b | 60 | 4,1[illegible]0 | [illegible] | | 5,000 | 44c |
| 55 | 2,400 | 13b | 60 | [illegible],1[illegible]0 | 1[illegible]b | | 4,000 | 44[illegible] |
| 45 | [illegible],300 | [illegible]1[illegible] | [illegible]0 | 2,7[illegible]0 | [illegible]1[illegible] | | 5,000 | 441 |
| 50 | 4,600 | 50a | 55 | 4,7[illegible]0 | 50[illegible] | | 5,000 | 44d |
| 60 | 2,[illegible]00 | [illegible]0[illegible] | 60 | 3,[illegible]00 | 50[illegible] | | 8,000 | 41[illegible] |
| 55 | 5,000 | 13[illegible] | 60 | 4,640 | 1[illegible]a | | 4,000 | 41[illegible] |
| 45 | [illegible],000 | 1[illegible] | 60 | [illegible],1[illegible]0 | 1[illegible] | | 8,000 | 41[illegible] |
| 45 | 1,1[illegible]0 | 45a | 60 | [illegible],[illegible]40 | 45[illegible] | | 8,000 | 44[illegible] |
| 50 | 4,7[illegible]0 | [illegible]' | 60 | 4,1[illegible]0 | 50[illegible] | | [illegible],000 | 441 |
| 60 | [illegible],000 | [illegible]b' | 60 | [illegible],000 | 50[illegible] | | 4,000 | 44f |
| 45 | 1,1[illegible]0 | 1[illegible] | 60 | 1,5[illegible]0 | 1[illegible] | | 4,000 | 441 |
| 45 | 4,[illegible]00 | 1[illegible] | 55 | [illegible],4[illegible]0 | 11b | | | |
| 50 | [illegible],440 | 1[illegible] | | | | | | |

2 weeks

| Fixed | | | Beta. st. | | | Homoz. st. | | |
|---|---|---|---|---|---|---|---|---|
| N.b | White cells | Cross | N.b | White cells | Cross | N.b | White cells | Cross |
| 60 | [illegible],240 | [illegible]a | 5[illegible] | [illegible],1[illegible]0 | 11b | | [illegible],000 | 44[illegible] |
| 55 | 3,5[illegible]0 | 4[illegible] | 55 | 2,4[illegible]0 | 51a | | [illegible],000 | 44[illegible] |
| 55 | [illegible],1[illegible]0 | 4[illegible] | 55 | [illegible],7[illegible]0 | 50a | | [illegible],000 | 41[illegible] |
| 60 | 1,7[illegible]0 | 1[illegible] | 60 | 3,[illegible]40 | 50b | | [illegible],000 | 44[illegible] |
| 55 | 6,560 | 1[illegible] | 65 | 4,640 | 4[illegible]c | | [illegible],000 | 41c |
| 50 | [illegible],100 | 1[illegible]a | 60 | [illegible],1[illegible]0 | 4[illegible] | | [illegible],000 | 44c |
| 50 | 4,[illegible]00 | 1[illegible]a | 60 | [illegible],[illegible]00 | 4[illegible] | | [illegible],000 | 44c |
| | 6,000 | [illegible]a | 50 | 4,1[illegible]0 | 50b | | [illegible],000 | 41c |
| | [illegible],000 | 5b | 60 | [illegible],[illegible]00 | [illegible]0b | | [illegible],000 | 41[illegible] |
| 55 | [illegible],[illegible]50 | 11c | 60 | 4,[illegible]00 | 11b | | 7,000 | 41[illegible] |
| 55 | [illegible],[illegible]00 | [illegible]a | 50 | [illegible],7[illegible]0 | 11c | | [illegible],000 | [illegible] |
| 55 | 4,[illegible]00 | [illegible]0a | | | | | [illegible],000 | 441 |
| 60 | [illegible],[illegible]00 | [illegible]0a | | | | | 1,000 | 41[illegible] |
| 55 | [illegible],[illegible]00 | 1[illegible] | | | | | [illegible],000 | 44[illegible] |
| 60 | [illegible],[illegible]40 | 1[illegible] | | | | | 5,000 | 441 |

3 weeks

| Flexed | | | Ketz. st. | | | Homoz. st. | | |
|---|---|---|---|---|---|---|---|---|
| No. | White cells | Gross | No. | White cells | Gross | No. | White cells | Gross |
| 50 | 6,000 | | 60 | 8,000 | 12c | 14 | 14,000 | 44c |
| 65 | 8,000 | 2c | 60 | 8,000 | 12c | 10 | 10,000 | 44c |
| 70 | 8,400 | 2c | 80 | 9,000 | 2c | 6 | 6,000 | 44c |
| 55 | 4,120 | 12c | 80 | 4,120 | 2c | 9 | 9,000 | 44c |
| 60 | 5,000 | 11c | 60 | 4,000 | 12c | 5 | 5,000 | 44c |
| 66 | 8,000 | 2c | 80 | 8,000 | 11c | 7 | 7,000 | 44 |
| 66 | 7,640 | 2c | 60 | 7,440 | 2c | 5 | 5,000 | 44c |
| 55 | 9,860 | 2c | 60 | 8,000 | 2c | 7 | 7,000 | 44c |
| 55 | 7,000 | 4c | 60 | 7,680 | 4c | 7 | 7,000 | 44c |
| 60 | 8,800 | 4c | 60 | 7,760 | 4c | 4 | 4,000 | 44c |
| 55 | 6,400 | 4c | 60 | 6,000 | 4c | 5 | 5,000 | 44c |
| 60 | 9,000 | 2c | 70 | 6,000 | 2c | 4 | 4,000 | 44c |
| 60 | 7,000 | 2c | 66 | 7,000 | 2c | 6 | 6,000 | 44c |
| 55 | 4,640 | 2c | 55 | 8,700 | 11c | 3 | 3,000 | 44c |
| 65 | 8,400 | 1c | 60 | 8,000 | 11c | 6 | 6,000 | 44c |
| | | | | | | 3 | 3,000 | 44c |
| | | | | | | 3 | 3,000 | 44c |

4 weeks

| Flexed | | | Ketz. st. | | | Homoz. st. | | |
|---|---|---|---|---|---|---|---|---|
| No. | White cells | Gross | No. | White cells | Gross | No. | White cells | Gross |
| 55 | 8,000 | 3c | 60 | 8,000 | | 2 | 2,000 | 44c |
| 60 | 8,000 | 3c | 65 | 8,000 | 2c | 6 | 6,000 | 44c |
| 70 | 9,000 | 2c | 75 | 9,000 | 2c | 4 | 4,000 | 44c |
| 55 | 12,000 | 1c | 60 | 4,000 | 3c | 2 | 2,000 | 44c |
| 60 | 9,000 | 2c | 60 | 8,000 | 2c | 1 | 1,000 | 44c |
| 65 | 8,000 | 4c | 60 | 8,000 | 1c | 5 | 5,000 | 44c |
| 55 | 6,000 | 1c | 60 | 4,000 | 1c | 6 | 6,000 | 44c |
| 55 | 8,000 | 4c | 60 | 1,000 | 2c | 12 | 12,000 | 44c |
| 60 | 8,000 | 9c | 60 | 7,000 | 12c | 4 | 4,000 | 44c |
| 55 | 8,000 | 12c | 60 | 8,000 | 12c | 2 | 2,000 | 44c |
| 60 | 8,000 | 12c | 70 | 4,000 | 12c | 1 | 1,000 | 44c |
| 60 | 7,000 | 1c | 60 | 4,000 | 12c | 8 | 8,000 | 44c |

6 Weeks

| Flexed | | | Metz. St. | | | Homoz. St. | |
|---|---|---|---|---|---|---|---|
| H.b | White Cells | Cross | H.b | White Cells | Cross | Hb | White Cells | Cross |
| | 4,000 | 36d | | 16,000 | 36d | | 4,000 | 44a |
| | 6,000 | 36g | | 7,000 | 9a | | 5,000 | 44a |
| | 6,000 | 36c | | 6,720 | 12a | | 3,000 | 44a |
| | 6,000 | 9a | | 6,000 | 36g | | 6,000 | 44a |
| | 5,000 | 12a | | 6,000 | 36c | | | |
| | 9,000 | 36g | | 5,000 | 36g | | | |
| | 10,000 | 36g | | 12,000 | 36c | | | |
| | 7,000 | 36c | | 5,000 | 36c | | | |

8 Weeks

| Flexed | | | Metz. St. | | | Homoz. St. | |
|---|---|---|---|---|---|---|---|
| H.b | White Cells | Cross | H.b | White Cells | Cross | Hb | White Cells | Cross |
| | 12,000 | 36c | | 5,000 | 36c | | 9,000 | 44a |
| | 10,000 | 36c | | 10,000 | 36c | | 7,000 | 41a |
| | 10,000 | 36c | | 6,000 | 36c | | | |
| | 6,000 | 36c | | 6,000 | 36c | | | |
| | 26,000 | 36c | | 8,000 | 36c | | | |
| | 10,000 | 36g | | 8,000 | 36c | | | |
| | 15,000 | 36g | | 11,000 | 36c | | | |
| | 5,000 | 36f | | 6,000 | 36f | | | |
| | 5,000 | 14b | | 15,000 | 11b | | | |
| | | | | 10,000 | 14b | | | |

10 Weeks

| Flexed | | | Metz. St. | | | Homoz. St. | |
|---|---|---|---|---|---|---|---|
| H.b | White Cells | Cross | H.b | White Cells | Cross | Hb | White Cells | Cross |
| | 6,000 | 36f | | 8,000 | 36f | | | |
| | 11,000 | 11b | | 6,000 | 11b | | | |
| | 14,000 | 14b | | 14,000 | 11b | | | |
| | 6,000 | 14b | | 6,000 | 14b | | | |
| | 7,000 | 36c | | 6,000 | 36c | | | |
| | 6,000 | 36g | | 4,000 | 36g | | | |
| | 4,000 | 36c | | 14,000 | 14b | | | |
| | 6,000 | 14b | | 20,000 | 9a | | | |
| | 16,000 | 9a | | 20,000 | 9a | | | |
| | 7,000 | 36c | | 10,000 | 36c | | | |
| | 8,000 | 36g | | 10,000 | 36g | | | |
| | 12,000 | 36c | | | | | | |

12 Weeks

| Flexed | | | Hetz. St. | | | Homoz. St. | | |
|---|---|---|---|---|---|---|---|---|
| H.b | White Cells | Cross | H.b | White Cells | Cross | Hb | White Cells | Cross |
| | 8,000 | 8a | | 8,000 | 8a | | | |
| | 18,000 | 11b | | 10,000 | 36f | | | |
| | 19,000 | 36e | | 12,000 | 11b | | | |
| | 7,000 | 36e | | 20,000 | 36e | | | |
| | 13,000 | 36e | | 12,000 | 36e | | | |
| | 14,000 | 14b | | 12,000 | 14b | | | |
| | 14,000 | 11b | | 16,000 | 14b | | | |
| | 6,000 | 36e | | 10,000 | 36e | | | |
| | 12,000 | 9a | | 11,000 | 9a | | | |
| | 16,000 | 36e | | 8,000 | 9a | | | |
| | 14,000 | 36e | | 12,000 | 36e | | | |
| | 8,000 | 36e | | 12,000 | 36e | | | |

Adults

| Flexed | | | Hetz. St. | | | Homoz. St. | | |
|---|---|---|---|---|---|---|---|---|
| H.b | White Cells | Cross | H.b | White Cells | Cross | Hb | White Cells | Cross |
| | 12,000 | 41♀ | | 8,000 | 42♂ | | 16,000 | 175♀ |
| | 8,000 | 47♀ | | 11,000 | 48♂ | | 5,000 | 174♀ |
| | 4,000 | 61♀ | | 10,000 | 51♂ | | 12,000 | 167♀ |
| | 4,000 | 50♀ | | 8,000 | 54♂ | | 12,000 | 168♂ |
| | 5,000 | 52♀ | | 9,000 | 57♂ | | 14,000 | 162♀ |
| | 14,000 | 53♀ | | 8,000 | H163 ♀ | | 9,000 | 165♀ |
| | 10,000 | 55♀ | | 5,000 | H172♀ | | 9,000 | 171♂ |
| | 7,000 | 45♀ | | 4,000 | H212♀ | | 16,000 | 178♀ |
| | 6,000 | 189♀ | | 14,000 | H213♀ | | 18,000 | 173♀ |
| | 6,000 | 194♀ | | 16,000 | 191♂ | | 8,000 | 176♀ |
| | 15,000 | 87♂ | | 11,000 | 195♂ | | 10,000 | 179♀ |
| | 7,000 | 6♀ | | 10,000 | 192♀ | | 14,000 | 172♀ |
| | 6,000 | 17♀ | | 16,000 | 193♀ | | | |
| | 23,000 | 14♀ | | | | | | |
| | 15,000 | 18♂ | | | | | | |

TABLE II a

* TABLE OF AVERAGES [illegible] OF MICE

| Time of counting | Flexed | |
|---|---|---|
| Birth | (27)(20) 3,551,000 | ± 101,700 |
| 1 wk | (26)(20) [illegible] | ± 116,000 |
| 2 weeks | (20) [illegible] | ± 86,100 |
| 3 weeks | (22) [illegible] | ± 152,000 |
| 4 weeks | (17)13,[illegible] | ± 119,000 |
| 6 weeks | (15)13,[illegible] | ± 71,000 |
| 8 weeks | (14)11,[illegible] | ± 140,000 |
| 10 weeks | (14)11,[illegible] | ± 120,400 |
| 12 weeks | (14)11,[illegible] | ± 117,000 |
| Adults | (16)11,[illegible] | ± 141,000 |

| Time of counting | Extended or straight | |
|---|---|---|
| Birth | (22) 4,925,000 | ± 111,700 |
| 1 wk | (30) [illegible] | ± [illegible] |
| 2 weeks | (22) 6,[illegible] | ± 116,000 |
| 3 weeks | (20) 7,[illegible] | ± 107,100 |
| 4 weeks | (17) 9,[illegible] | ± 150,000 |
| 6 weeks | (15)10,[illegible] | ± 130,000 |
| 8 weeks | (14)10,[illegible] | ± 760,000 |
| 10 weeks | (14)10,[illegible] | ± 276,000 |
| 12 weeks | (14)10,[illegible] | ± 140,400 |
| Adults | (16)11,[illegible] | ± 140,000 |

*Number in parentheses is number of mice counted to get the average.

| Time of counting | Homozygous straight | |
|---|---|---|
| Birth | (15) 4,[illegible] | ± 111,700 |
| 1 wk | (11) [illegible] | ± 111,800 |
| 2 weeks | (15) [illegible] | ± 86,100 |
| 3 weeks | (15) [illegible] | ± 137,000 |
| 4 weeks | (12) [illegible] | ± 150,000 |
| 6 weeks | ( 4) [illegible] | ± 80,200 |
| 8 weeks | ( 2)10,000,000 | ± |
| 10 weeks | | |
| 12 weeks | | |
| Adults | [illegible] | 200,000 |

TABLE II b

TABLE OF AVERAGES FOR RED CELLS

per cu. mm

| Time of Counting | Flexed | Hetz. St. | Homoz. St. |
|---|---|---|---|
| Birth | (16) 4207 ± 202 | (16) 4159 ± 139 | (26) 3993 ± 229 |
| 1 Week | (15) 4152 ± 179 | (13) 4481 ± 201 | (14) 5000 ± 326 |
| 2 Weeks | (16) 5136 ± 334 | (16) 5167 ± 340 | (16) 5000 ± 360 |
| 3 Weeks | (15) 5615 ± 333 | (16) 6538 ± 324 | (17) 5610 ± 647 |
| 4 Weeks | (12) 7116 ± 441 | (12) 6812 ± 477 | (12) 5600 ± 667 |
| 6 Weeks | ( 8) 7700 ± 436 | ( 6) 6150 ± 759 | ( 4) 4500 ± 370 |
| 8 Weeks | (10)11200 ± 1055 | (10) 8700 ± 905 | ( 2) 6000 ± |
| 10 Weeks | (12) 8700 ± 650 | (11)10000 ± 1196 | |
| 12 Weeks | (10)12700 ± 800 | (10)10600 ± 906 | |
| Adults | (15)10000 ± 654 | (13) 9600 ± 718 | (12)11000 ± 726 |

TABLE OF AVERAGES FOR RED CORPUSCLES

Percent of Human Standard

| Time of Determination | Flexed | Hetz. St. | Homoz. St. |
|---|---|---|---|
| Birth | (44) 59.4 ± .68 | (40) 60.7 ± .64 | (26) 58.9 ± .70 |
| 1 Week | (43) 62.0 ± .708 | (43) 67.9 ± .67 | (14) 62.6 ± .85 |
| 2 Weeks | (36) 64.8 ± .8804 | (36) 66.6 ± .709 | (15) 66.0 ± .87 |
| 3 Weeks | (36) 69.4 ± .81 | (34) 67.0 ± .86 | (15) 65.0 ± .... |
| 4 Weeks | (31) 67.. ± .436 | (29) 71.9 ± .81 | (12) 69.0 ± .82 |
| 6 Weeks | (15) 69.6 ± .82 | (13) 71.3 ± .87 | ( 4) 71.2 ± 1.93 |
| 8 Weeks | (13) 69.4 ± 1.13 | (13) 69.3 ± 1.12 | ( 2) 69.0 |
| 10 Weeks | (13) 69.3 ± 1.15 | (14) 71.3 ± 1.32 | |
| 12 Weeks | (14) 67.1 ± 1.27 | (14) 67.3 ± 1.32 | |
| Adults | (12) 68.7 ± 1.41 | (13) 64.2 ± 1.16 | (12) 65.8 ± 1.35 |

[illegible] OF DIFFERENCES

[illegible] Class

Figure in ( ) shows age of mouse B = birth ad = adult 1 = 1 week

| Difference between Averages | Number of Times Difference Exceeds its Probable Error |
|---|---|
| **Flexed and Heterozygous Straight** | |
| Hetz. St. (B) - Flexed (B) or [illegible] = 1,510,000 ± 151,600 | 10.39 |
| Hetz. St. (1) - Flexed (1) or [illegible] = [illegible] ± [illegible] | 2.9 |
| Hetz. St. (2) - Flexed (2) or 6,270,000 - 6,000,000 = 270,000 ± 194,000 | 1.1 |
| Flexed (3) - Hetz. St. (3) or 8,100,000 - 7,700,000 = [illegible] ± 137,000 | 1.9 |
| Flexed (4) - Hetz. St. (4) or [illegible] = 750,000 ± 201,000 | 3.8 |
| Flexed (5) - Hetz. St. (5) or 10,810,000 - 10,000,000 = [illegible] ± [illegible] | 1.6 |
| Flexed (6) - Hetz. St. (6) or [illegible] = 1,040,000 ± 707,000 | 1.4 |
| Flexed (10) - Hetz. St. (10) or 11,170,000 - 10,670,000 = [illegible] ± [illegible] | 1.5 |
| Flexed (11) - Hetz. St.(11) [illegible] = 84[illegible] ± 179,000 | 3.8 |
| Flexed (11) - Hetz. St. (11) or 11,[illegible] = [illegible] ± 310,000 | [illegible] exceeds difference |
| **Flexed and Homozygous Straight** | |
| Ho St (B) - Flexed (B) or 4,010,000 - [illegible] = [illegible] ± [illegible] | 4.6 |
| Flexed (1 - [illegible] (1) or [illegible] = 20,000 | |
| Flexed (2) - Ho St (2) or [illegible] = [illegible] ± [illegible] | 1.9 |
| Flexed (3) - Ho St (3) or [illegible] = 1,470,000 ± [illegible] | 3.48 |
| Flexed (4) - Ho St (4) or 10,[illegible] = 1,130,000 ± [illegible] | [illegible] |
| Flexed (6) - Ho St (6) or 10,810,000 - [illegible] = [illegible] ± [illegible] | [illegible] |
| Flexed (11) - Ho St (11) or 11,000,000 - [illegible] = 1,310,000 ± [illegible] | [illegible] |

| Difference between averages | Number of times difference exceeds its probable error |
|---|---|
| **Arteries straight as compared with** | |
| Retz St (5) - No St (2) or 4,[illegible],000) - 3,330,000 = 670,000 ± 130,000) | 5.4 |
| Retz St (1) - No St (1) or 3,[illegible],000 - 2,[illegible],000 = 810,000 ± 148,000 | 2.6 |
| Retz St (4) - No St (4) or 2,[illegible],000 - 2,[illegible],000 = 70,000 ± 127,000 | 2.5 |
| Retz St (3) - No St (3) or 7,700,000 - 6,700,000 = [illegible],000 ± 681,000 | 1.4 |
| Retz St (4) - No St (4) or 3,81[illegible],000 - 3,[illegible],000 = 510,000 ± 117,000 | 1.4 |
| Retz St (11) - No St (11) or 11,000,000 - 9,[illegible],000 = 1[illegible],000 ± 526,000 | 2.5 |
| **Flexed at Different Ages** | |
| Flexed (1) - Flexed (7) or 6,110,000 - 5,[illegible],000 = 1,[illegible],000 ± 188,000 | 11 |
| Flexed (8) - Flexed (1) or 6,600,000 - 5,110,000 = 1,[illegible],000 ± 188,000 | 10.8 |
| Flexed (4) - Flexed (2) or 8,110,000 - 6,[illegible],000 = 1,[illegible],000 ± 136,000 | 7 |
| Flexed (4) - Flexed (9) or 10,[illegible],000 - 7,110,000 = 2,[illegible],000 ± 124,000 | 13.7 |
| Flexed (5) - Flexed (4) or 10,[illegible],000 - 10,000,000 = [illegible],000 ± 214,000 | |
| Flexed (6) - Flexed (5) or 11,200,000 - 10,[illegible],000 = [illegible],000 ± 122,000 | 3.6 |
| Flexed (7) - Flexed (10) or 11,[illegible],000 - 11,[illegible],000 = [illegible],000 ± 114,000 | |
| Flexed (12) - Flexed (13) or 11,[illegible],000 - 11,170,000 = [illegible],000 ± 172,000 | 1.5 |
| Flexed (8) - Flexed (14) or 11,[illegible],000 - 11,200,000 = 100,000 ± 136,000 | |
| **Limits when Full Term** | |
| Flexed (14) - Flexed (2) or 11,500,000 - 3,[illegible],000 = 7,[illegible],000 ± 172,000 | 45 |
| Retz St (14) - Retz St (1) or 11,000,000 - 1,[illegible],000 = 8,170,000 ± [illegible],000 | 13.5 |
| No St (14) - No St (1) or 5,000,000 - 4,010,000 = [illegible],000 ± 130,000 | 24.7 |

# TABLE OF DIFFERENCES

## WHITE CELLS

| Difference between Averages | Number of Times Difference Exceeds its Probable Error |
|---|---|
| **Flexed and Heterozygous Straight** | |
| Hetz St (1) - Flexed (1) or 4481 - 4152 = 329 ± 344 | 1.1 |
| Hetz St (2) - Flexed (2) or 6167 - 5966 = 1201 ± 682 | 1.5 |
| Hetz St (3) - Flexed (3) or 6502 - 5805 = 697 ± 502 | 1.3 |
| Flexed (4) - Hetz St (4) or 7435 - 5240 = 2015 ± 614 | 3.2 |
| Hetz St (6) - Flexed (6) or 8040 - 7700 = 300 ± 564 | |
| Flexed (8) - Hetz St (8) or 11200 - 8700 = 2500 ± 1388 | 1.8 |
| Hetz St (10) - Flexed (10) or 10500 - 8700 = 1800 ± 1305 | 1.4 |
| Flexed (12) - Hetz St (12) or 12700 - 11600 = 900 = 1078 | PE exceeds Difference |
| Flexed (ad) - Hetz St (ad) or 10,000 - 9600 = 400 ± 1120 | PE exceeds Difference |
| **Flexed and Homozygous Straight** | |
| Flexed (3) - Ho St (3) or 4297 - 3993 = 304 ± 505 | Error equals Difference |
| Ho St (1) - Flexed (1) or 5000 - 4192 = 808 ± 354 | 2.3 |
| Flexed (2) - Ho St (2) or 5066 - 5000 = 66 ± 504 | Error exceeds Difference |
| Flexed (3) - Ho St (3) or 5498 - 5000 = 498 ± 668 | Error Exceeds Difference |
| Flexed (4) - Ho St (4) or 7435 - 5600 = 1835 ± 793 | 2.3 |
| Ho St (ad) - Flexed (ad) or 11,000 - 10,000 = 1,000 ± 1113 | PE exceeds Difference |

| Difference between Averages | Number of Times Difference Exceeds its Probable Error |
|---|---|
| **Heterozygous and Homozygous Straight** | |
| Hetz St (1) - Ho St (1) or 4129 - 3963 = 166 ± 330 | PE = Difference |
| Ho St (1) - Hetz St (1) or 5000 - 4181 = 819 ± 365 | 1.4 |
| Hetz St (2) - Ho St (2) or 6167 - 5000 = 1167 ± 666 | 1.7 |
| Hetz St (3) - Ho St (3) or 6502 - 5600 = 902 ± 585 | 1.5 |
| Ho St (4) - Hetz St (4) or 5600 - 4940 = 660 ± 611 | PE exceeds Diff. |
| Ho St (ad) - Hetz St (ad) or 11000 - 9600 = 1400 ± 1050 | 1.3 |
| **Comparison between Adults and New Born** | |
| Flexed (ad) - Flexed (B) or 10000 - 4297 = 5703 ± 858 | 6.6 |
| Hetz St (ad) - Hetz St (B) or 9000 - 4129 = 4871 ± 1008 | 5.4 |
| Ho St (ad) - Ho St (B) or 11000 - 3993 = 7007 ± 772 | 9.07 |

# TABLE OF DIFFERENCES

## HEMOGLOBIN

| Difference between Averages | Number of Times Difference Exceeds its Probable Error |
|---|---|
| **Flexed and Heterozygous Straight** | |
| Hetz St (5) - Flexed (5) or 60.7 - 39.4 = 21.3 ± .93 | 22 |
| Hetz St (1) - Flexed (1) or 57.8 - 49.0 = 8.8 ± .902 | 9.7 |
| Hetz St (2) - Flexed (2) or 56.8 - 55.[illegible] = 1.8 ± .93 | 1.9 |
| Flexed (3) - Hetz St (3) or 58.1 - 57.0 = 1.1 ± .62 | 1.7 |
| Hetz St (4) - Flexed (4) or 61.8 - 57.[illegible] = 5.[illegible] ± .92 | 4.2 |
| Hetz St (6) - Flexed (6) or 61.0 - 60.6 = 4.0 ± 1.19 | |
| Hetz St (8) - Flexed (8) or 66.6 - 64.6 = 1.9 ± 2.4 | |
| Flexed (10) - Hetz St (10) or 65.0 - 64.3 = .7 ± 1.96 | |
| Hetz St (12) - Flexed (12) or 67.[illegible] - 67.1 = .4 ± 1.8 | |
| Flexed (ad) - Hetz St (ad) or 68.7 - 64.0 = 4.7 ± 1.83 | 2.5 |
| **Flexed and Homozygous Straight** | |
| Ho St (5) - Flexed (5) or 56.[illegible] - [illegible].1 = 17.5 ± .97 | 18 |
| Ho St (1) - Flexed (1) or 54.6 - 49.0 = 4.6 ± .94 | [illegible].8 |
| Ho St (2) - Flexed (2) or 56.0 - 54.[illegible] = 2.[illegible] ± .81 | [illegible].7 |
| Flexed (3) - Ho St (3) or 58.4 - 52.0 = 6.4 ± 1.07 | 5.9 |
| Ho St (4) - Flexed (4) or 63.0 - 57.9 = 2.1 ± .51 | 4.1 |
| Ho St (6) - Flexed (6) or 61.2 - 60.6 = .6 | |
| Flexed (ad) - Ho St (ad) or 68.7 - 65.8 = 2.9 ± 1.66 | 1.6 |
| **Heterozygous Straight and Homozygous Straight** | |
| Hetz St (5) - Ho St (5) 60.7 - 56.9 = 3.8 ± .94 | 4.0 |
| Hetz St (1) - Ho St (1) or 57.8 - [illegible].0 = 4.8 ± .84 | 5.0 |
| Ho St (2) - Hetz St (2) or 56.0 - [illegible].6 = .4 ± .92 | |
| Hetz St (3) - Ho St (3) or 57.0 - 52.0 = 5 ± 1.04 | 4.8 |
| Hetz St (4) - Ho St (4) or 61.8 - 60.0 = 1.8 ± .84 | 2.1 |
| Ho St (6) - Hetz St (6) or 61.2 - 61.[illegible] = .2 | |
| Ho St (ad) - Hetz St (ad) or 68.9 - 64 = 1.9 ± 1.25 | |

# TABLE OF DIFFERENCES

## HEMOGLOBIN

| Difference between Averages | Number of Times Difference Exceeds its Probable Error |
|---|---|
| **Flexed at Different Ages** | |
| Flexed (1) - Flexed (3) or 49. - 39.4 = 9.6 ± .97 | 9.9 |
| Flexed (2) - Flexed (1) or 53.8 - 49 = 4.8 ± .90 | 5.3 |
| Flexed (3) - Flexed (2) or 58.4 - 53.8 = 4.6 ± .84 | 5.4 |
| Flexed (5) - Flexed (4) or 58.4 - 57.9 = .5 ± .75 | |
| Flexed (6) - Flexed (4) or 60.6 - 57.9 = 2.7 ± .98 | 2.9 |
| Flexed (8) - Flexed (6) or 64.6 - 60.6 = 4.0 ± 1.39 | 2.9 |
| Flexed (10) - Flexed(8) or 65.0 - 64.6 = .4 ± 1.60 | |
| Flexed (12) - Flexed(10) or 67.1 - 65 = 2.1 ± 1 | |
| Flexed (ad) - Flexed(a1) or 68.7 - 67.1 = 1.6 ± 1.6 | |
| **Adults and New born** | |
| Flexed (ad) - Flexed (5) or 68.7 - 39.4 = 29.3 ± 1.55 | 18.7 |
| No St (ad) - No St (5) or 65.8 - 56.9 = 8.9 ± 1.43 | 6.2 |
| Hetz St (ad) - Hetz St(5) or 64 - 60.7 = 3.3 ± 1.50 | 2.2 |

## TABLE III

### DISTRIBUTION OF THE OFFSPRING IN THE INBREEDING EXPERIMENT

**First Generation Crosses**

| Grades of Parents Generation 1 | Grades of Offspring (Generation 2) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | Short | Total |
| I | 7 | 3 | 8 | 9 | 37 | 4 | 1 | 69 |
| II | 4 | 7 | 7 | 3 | 21 | 1 | 1 | 44 |
| III | 3 | 2 | 17 | 11 | 25 | 2 | | 60 |
| IV | 4 | 2 | 10 | 15 | 42 | 11 | 1 | 86 |
| V | | 1 | 6 | 14 | 49 | 9 | 11 | 90 |
| VI | | 2 | 8 | 4 | 15 | 11 | | 40 |
| Short | | | 3 | 5 | 14 | | 11 | 33 |
| Total | 18 | 17 | 59 | 62 | 203 | 25 | 25 | 422 |

**Second Generation Crosses**

| Grades of Parents | Grades of Offspring (Generation 3) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | Short | Total |
| I | 2 | 1 | 2 | | 1 | | | 6 |
| II | | | 1 | 1 | 2 | | 1 | 5 |
| III | | | | | 2 | 1 | | 3 |
| IV | | | | 1 | 3 | | | 4 |
| V | 1 | 1 | 4 | 12 | 28 | 4 | 1 | 51 |
| VI | | | | | | | | |
| Short | | 1 | 1 | 1 | 9 | 1 | 12 | 25 |
| Total | 3 | 3 | 8 | 15 | 45 | 6 | 14 | 94 |

TABLE IV

DEATHS IN OFFSPRING OF FIRST GENERATION PAIRINGS

From 6/26/29 to 6/16/30

| Grade of Parents | No. of Offspring | Number of Offspring dying from birth to 28 days | | | | | |
|---|---|---|---|---|---|---|---|
| | Born | 1-3 days | 4-7d | 8-14d | 15-21d | 22-28d | Total |
| 1 | 89 | 13 | 2 | 2 | 2 | 1 | 20 |
| 2 | 51 | 2 | 3 | 2 | | | 7 |
| 3 | 115 | 22 | 15 | 13 | 1 | 3 | 54 + 1* |
| 4 | 118 | 12 | 12 | 2 | 3 | 3 | 32 |
| 5 | 125 | 14 | 8 | 3 | 4 | 6 | 35 |
| 6 | 68 | 5 | 11 | 6 | 4 | 2 | 28 |
| Short tailed | 59 | 11 | 9 | 4 | | 2 | 26 |
| Total | 625 | 79 | 60 | 32 | 14 | 17 | 202 + 1* |

*Escaped

FIGURE I

CHARTS SHOWING ACTUAL VALUES
OF AVERAGES OF BLOOD DETERMINATIONS

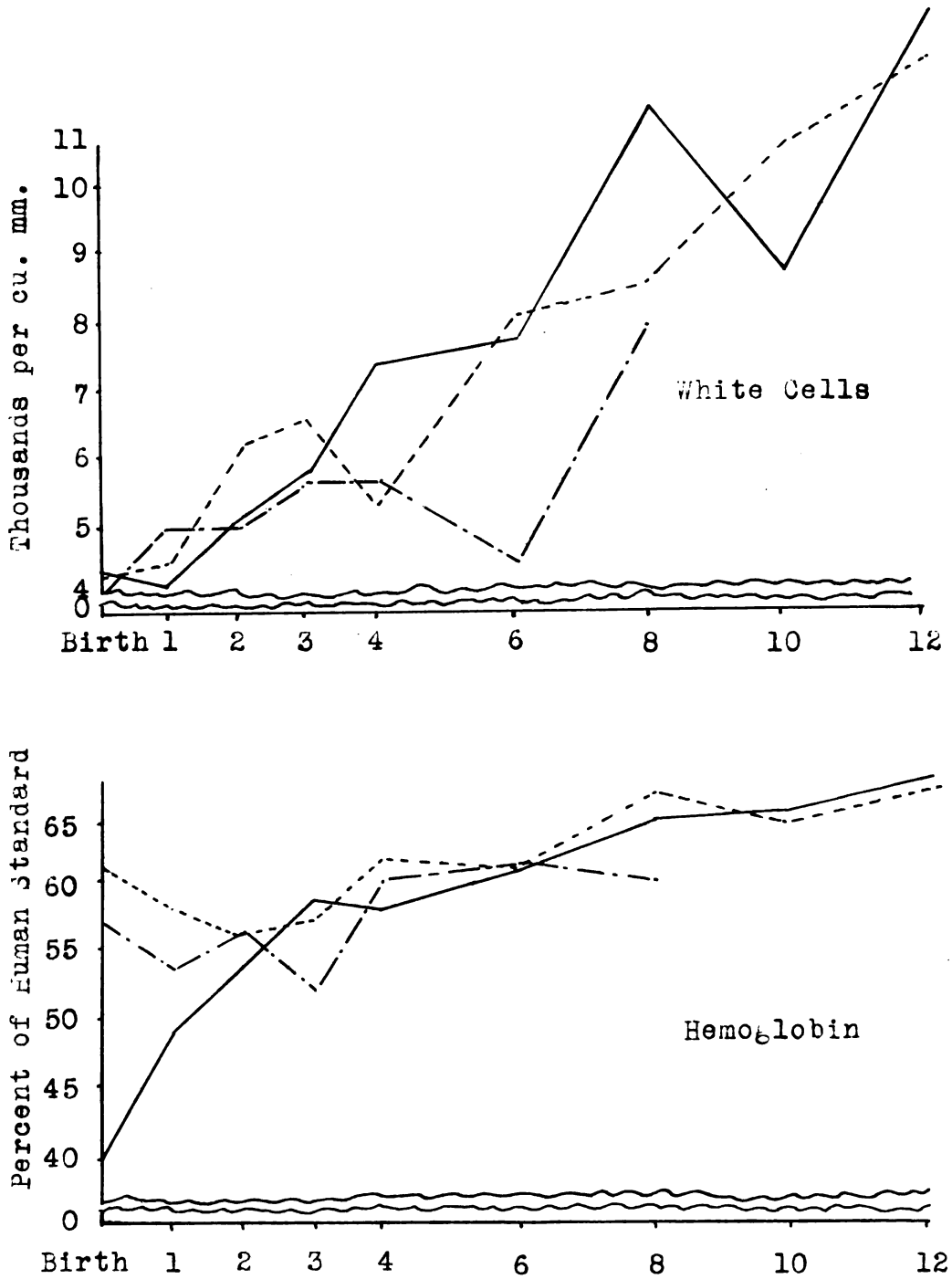
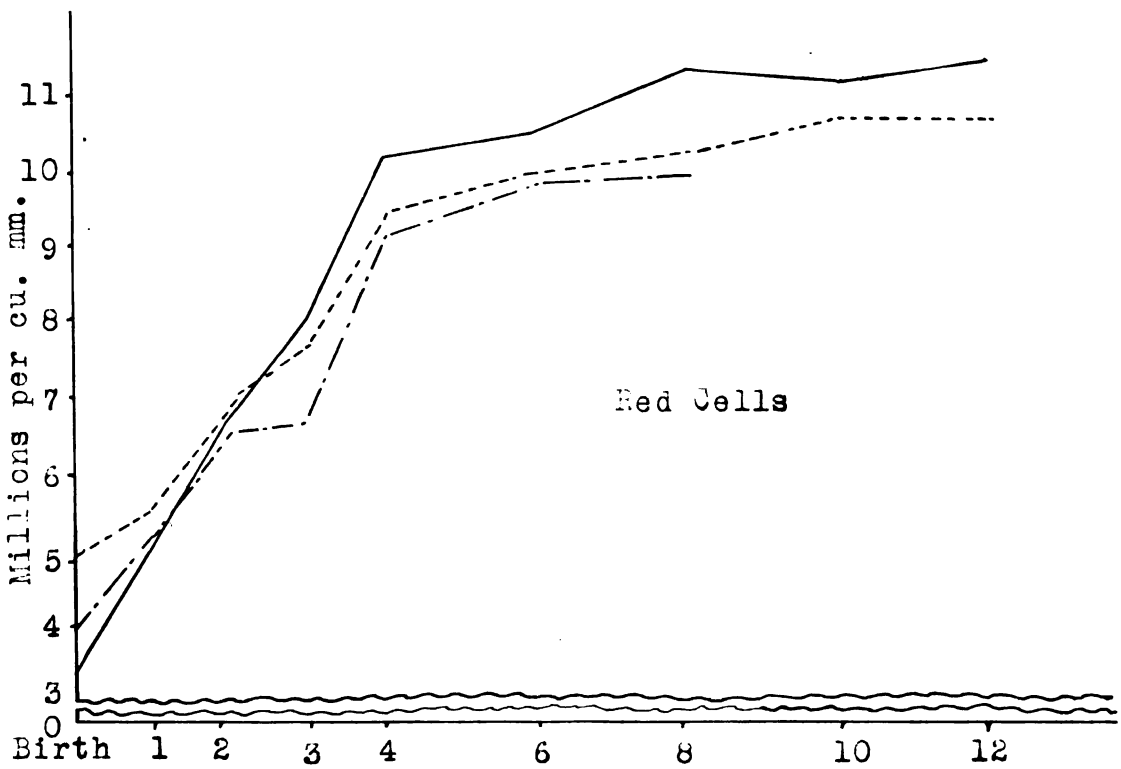


CHART SHOWING ACTUAL VALUES

OF AVERAGES OF BLOOD DETERMINATIONS




Flexed
Hetz. Straight
Homoz. Straight

FIGURE II

RATIO CHARTS OF BLOOD DETERMINATIONS

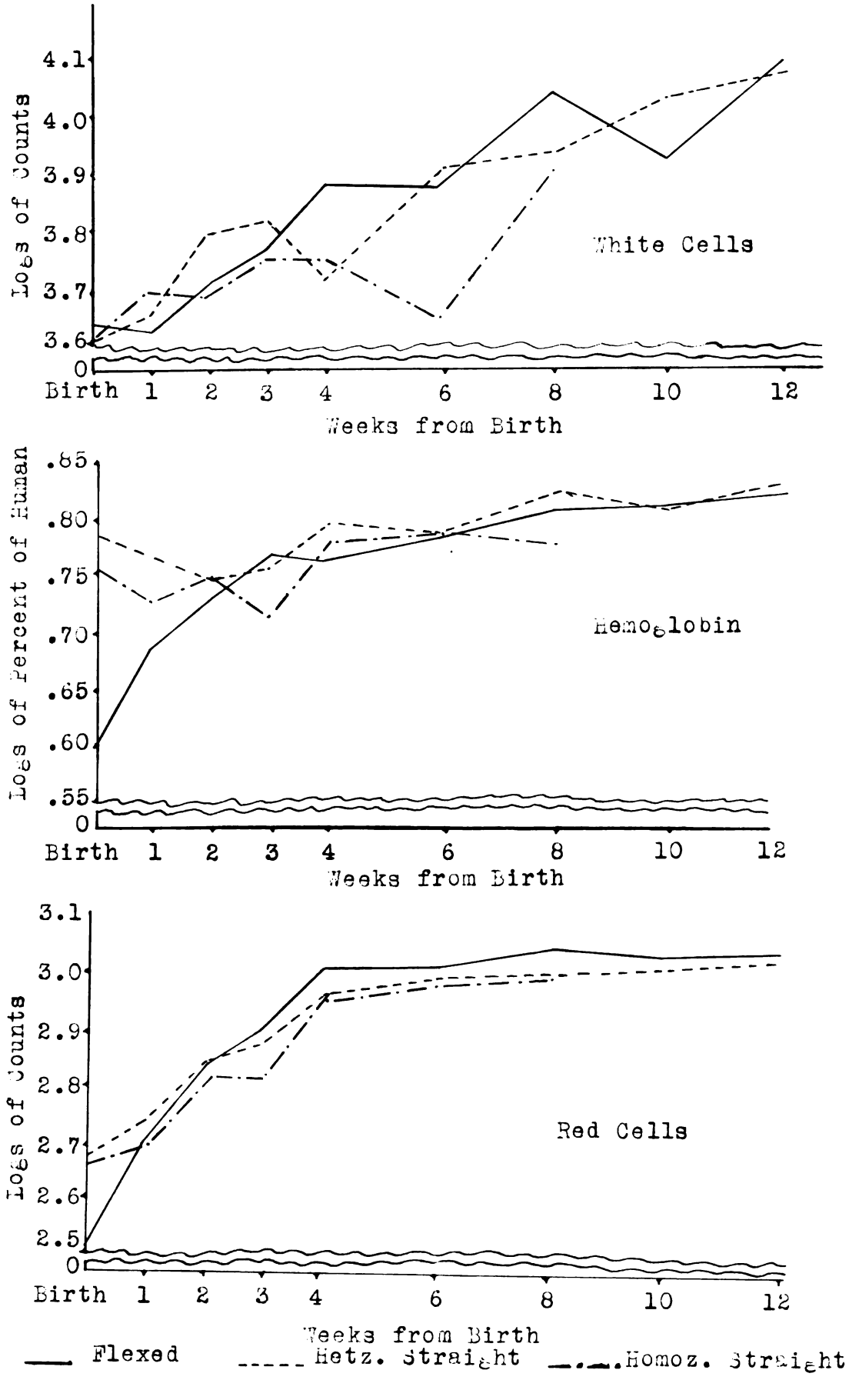
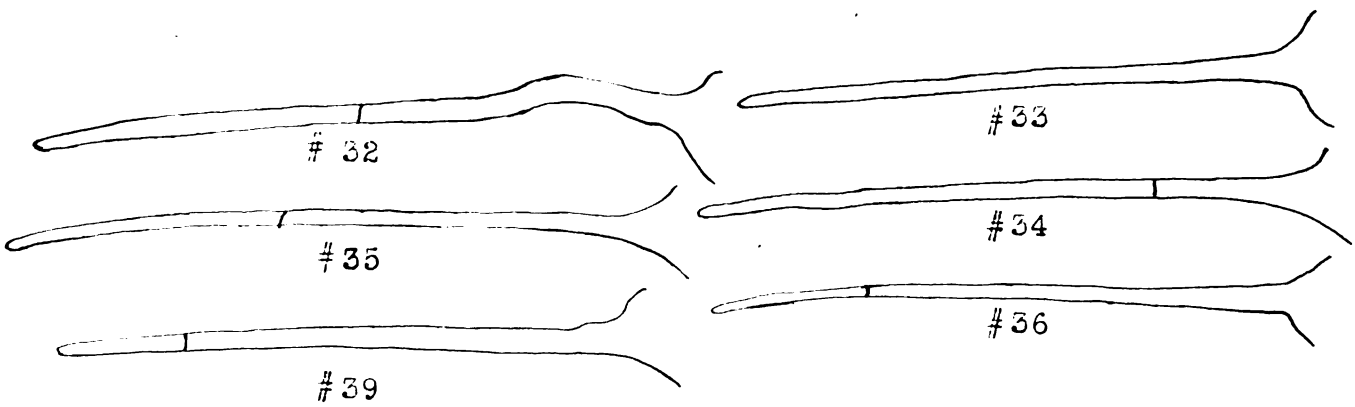
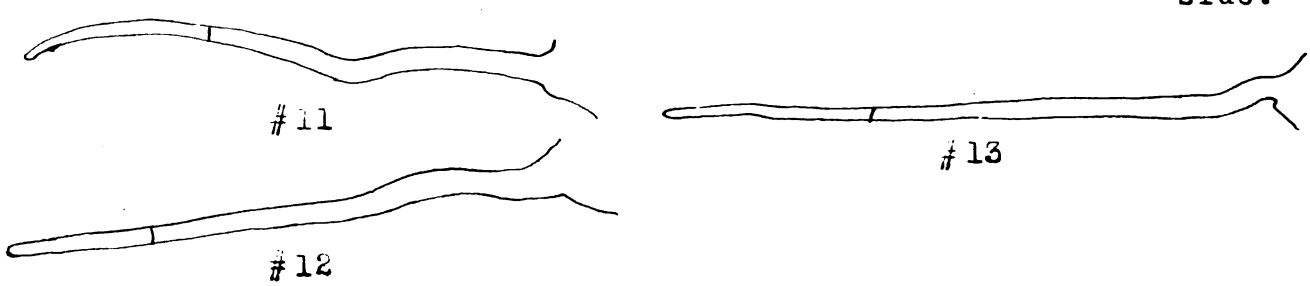


FIGURE III

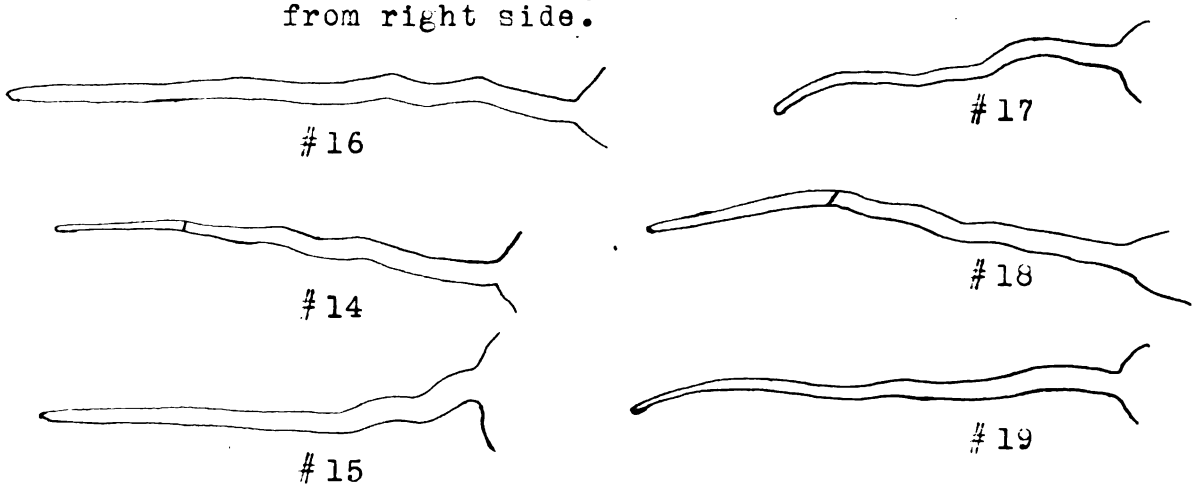
Grade I. No, or almost no, visible flexure. Stiffness easily detected in the tail. All views from right side.



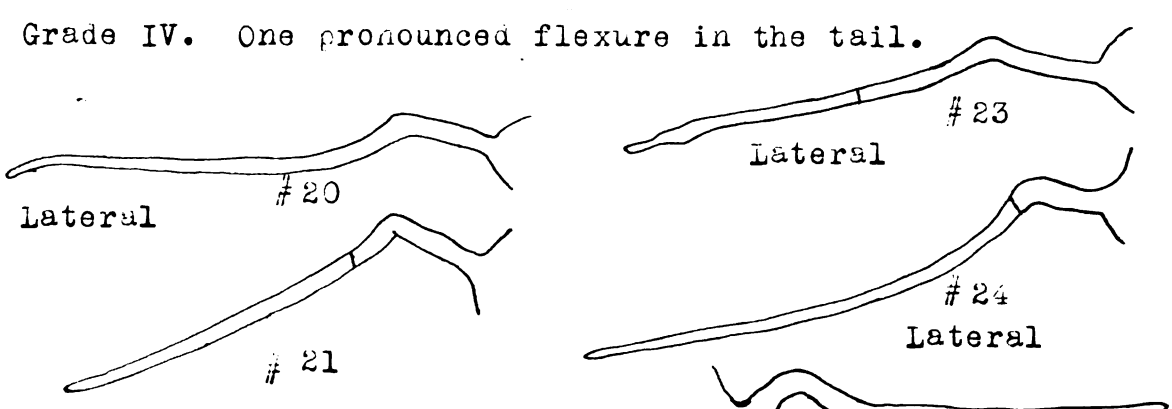

Grade II. One slight flexure in the tail. All views from right side.



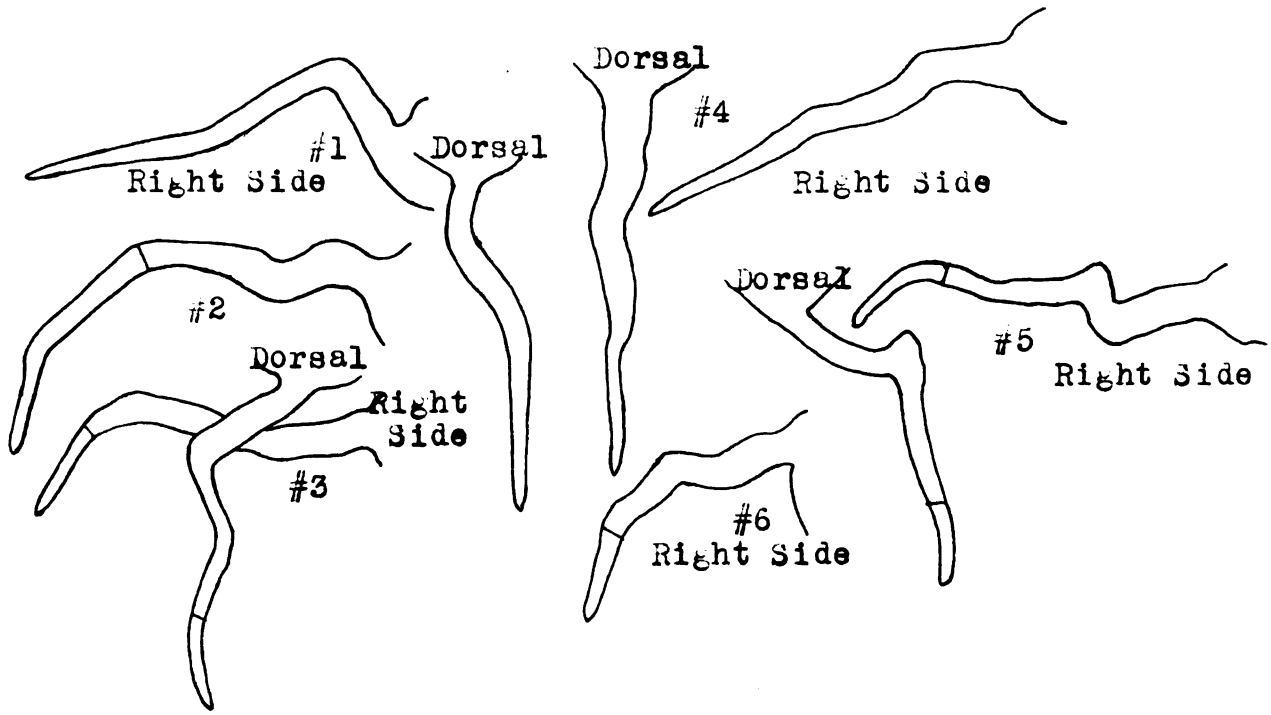

Grade III. Two or more slight flexures in the tail. All views from right side.



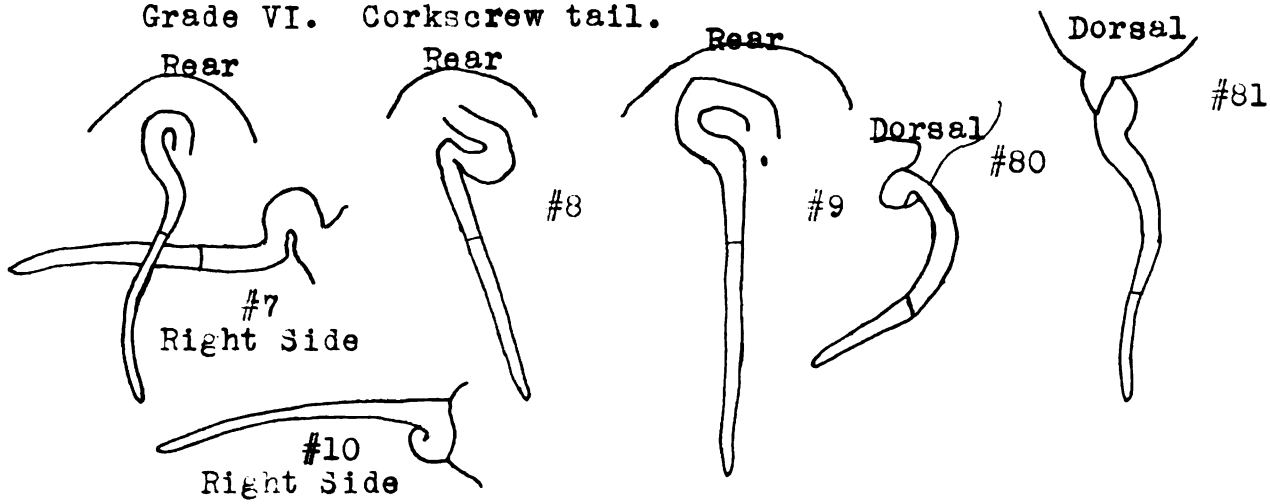

Grade IV. One pronounced flexure in the tail.



Grade V. Two or more pronounced flexures in the tail.




Grade VI. Corkscrew tail.

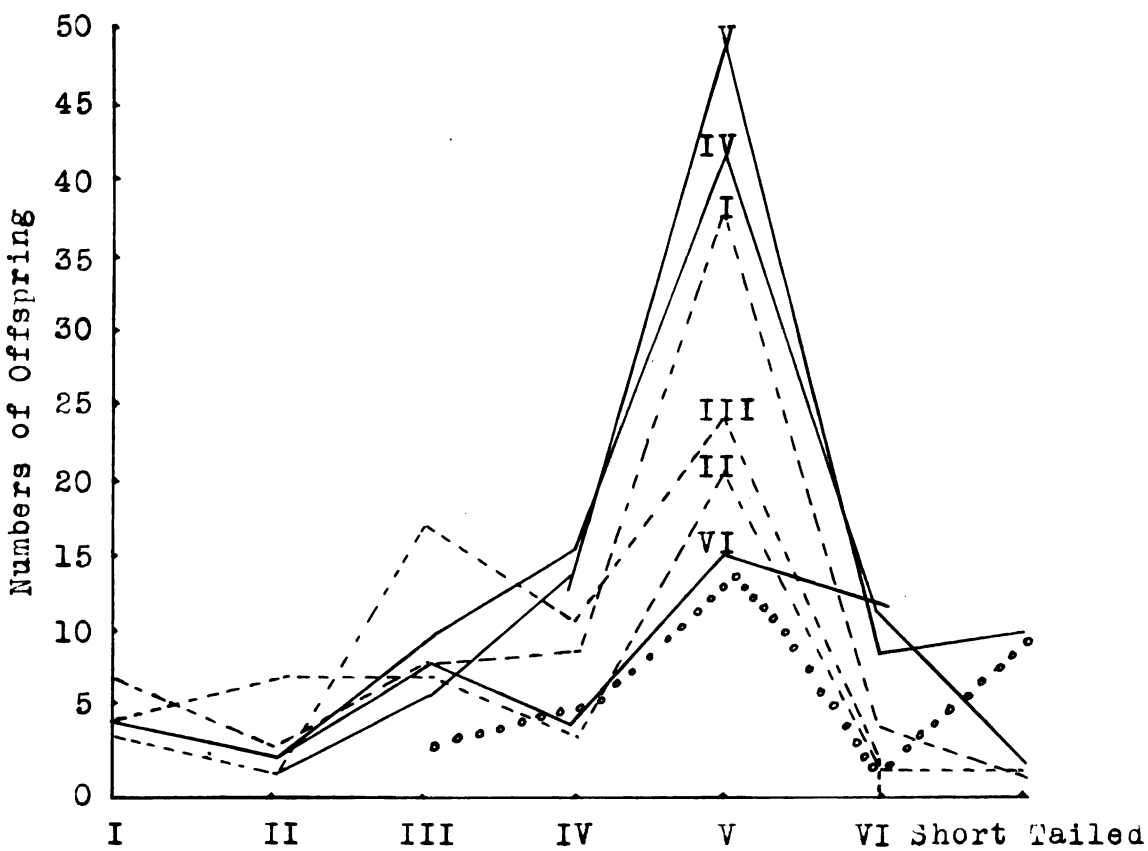



Short-tailed Grade. Tail is less than one half the length of the body.

FIGURE IV

DISTRIBUTION OF FIRST GENERATION OFFSPRING

ACCORDING TO GRADES




Grades of Offspring

——— High Grade
----- Low Grade
..... Short Tailed

Roman numerals on peaks of lines show grade of parents

ACKNOWLEDGMENT

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