individuals. The relative abundance of mosaic mutant flies in the male germ line and their absence in the female germ line is also striking.

In cross 1 all sex-linked loci were also exposed to detection, but it is not clear how many might have been observed. Attention was directed only to relatively obvious changes in eye color and shape, body color, wing size and shape, and bristle size and shape. It seems clear that any mutations such as yellow or sable body color, forked or singed bristles, lozenge eyes, miniature, dusky, cut, or rudimentary wings, or prune, white, ruby, carmine, raspberry, vermilion, garnet, or carnation eye colors would have been noticed. Two mutations were observed: one to forked bristles, and another (sterile) to either miniature or dusky wings. The number of individuals examined per locus was about 50,000 (half of the total of 100,414). The mutation rate for sex-linked recessives in the female germ line may, therefore, be estimated as about 2.35×10^{-6}, which is in excellent agreement with the average frequency for the four autosomal loci specifically tested.

Although the data on spontaneous mutability should certainly be extended to include additional loci, the conclusion seems warranted from the present data that in *Drosophila melanogaster* the spontaneous-mutation rate at loci where visible mutants arise is about one order of magnitude larger in males than in females. So large a sex difference in mutability in *Drosophila* makes it imperative to investigate the question of whether a similar difference exists in other species, including the human.

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Goldfish Erythrocyte Antigens and Serology

Incidental to an investigation of tissue-transplantation immunity in goldfish (*Carassius auratus*) (*1*), a preliminary study was aimed at detecting individual differences in the erythrocyte antigens of goldfish. Blood samples were taken and isoimmunization was accomplished by cardiac puncture, a 22-gage needle on a 1.5-ml syringe being most suitable. About 0.5 ml of blood may be safely taken from a 4-inch specimen, while up to 1.5 ml may be withdrawn from a 12-in-fish. Goldfish red cells keep about equally well in 0.7- to 1.0-percent saline but remain intact much longer in concentrated suspensions, especially in homologous plasma. For washing cells and making dilutions, 0.85-percent phosphate-buffered sodium chloride was used. The technique of tagging specimens and the effect of temperature on antibody production in fish have been discussed in full elsewhere (*1*).

Recent investigations of normal hemagglutinins in fish serums and of species differences in red-cell antigens of various fishes have been summarized by Cushing and Sprague (*2*). In the study reported here, normal serums from several different goldfish were checked for natural agglutinins at 1/4 and 1/8 saline dilutions against 2-percent suspensions of washed red cells from 12 other goldfish in standard agglutination tests (*3*). The tests were checked after 30 minutes and after 2 hours at room temperature, with and without centrifugation. No agglutination whatever was found. Normal serums from a variety of other animals were similarly tested for natural antibodies against goldfish red cells. No individual differences were detectable, because the red cells of all fish were agglutinated by a given serum to within one doubling dilution when heteroagglutinins were present. No absorptions of these normal serums were performed.

Proof of the existence of individual differences in goldfish erythrocyte antigens was first achieved by isoimmunization at room temperature. A large specimen was given a course of nine injections, each injection consisting of 0.3 ml of a 20-percent suspension of washed red cells from a particular fish of about the same age (4 years). Three injections were given per week. The agglutination titer checked by trial breedings was only 1/8 6 days after the third injection, but rose to 1/1024 7 days after the ninth injection. The serum was stored frozen and subsequently was used with no further processing.

An absorption analysis of this isoimmune serum was made using red cells from 11 unrelated goldfish. About 1 ml of blood was taken from each fish, and the cells were washed twice in saline. A small aliquot of each sample was then removed to prepare a 2-percent suspension for testing, and the remainder was divided equally in two tubes for absorptions. The isoimmune serum was diluted 1/8 in saline, and 0.5 ml of the diluted serum was thoroughly mixed with the packed cells of each fish for two successive absorptions of 30 minutes each at room temperature. The absorbed serums were then diluted 1/3 in saline for standard agglutination tests. Two fish, including the control recipient, possessed no antigen that reacted with this serum. The erythrocytes of the other nine fish gave positive reactions which revealed the presence of at least five antibody subpopulations recognizing individual antigenic specificities.

Two additional isoimmune serums were prepared as before by nine injections of two unrelated goldfish, respectively, with red cells of two parents from which offspring were being reared. The unabsorbed serums agglutinated the homologous cells to a titer of 1/1024. By the time the F_1 progeny were large enough (2 years old) to provide sufficient blood for an absorption analysis the P_1 ♂ had died. Nevertheless, 2-percent suspensions of the washed red cells of 11 F_1 siblings were tested against doubling dilutions of both unabsorbed isoimmune serums. All of the F_1 cells were agglutinated within two doubling dilutions of each other by both serums; hence, no differences were demonstrable among the F_1 siblings by this method. However, it is apparent that one or more antigenic specificities shared by the parents and their progeny are absent in the individuals that developed these isoimmune antibodies. These specificities represent inherited individual differences in the antigens of goldfish red cells.

Several rabbit antigoldfish red-cell serums were prepared by giving a series of injections of washed red cells in the marginal ear veins. Cross-absorption analyses were made with one such antiserum, using red cells from ten goldfish in addition to the donor. Washed cells prepared from 1-ml blood samples taken from each fish were divided among four tubes for absorptions. To each of the first absorption tubes 0.5 ml of antiserum at 1/8 dilution was added. Each of the first three absorptions was carried out at 10°C for 15 minutes in order to minimize hemolysis. The final absorption was at room temperature for 30 minutes. After the last absorption, each serum reagent was further diluted 1/4 in saline for lytic tests.

Each test consisted of 0.2 ml of serum reagent and 0.1 ml of 2-percent red-blood-cell suspension; after shaking, 0.1 ml of guinea-pig complement at 1/4 dilution was added. Appropriate serum, complement, and saline controls were also run. In all four of the absorption analyses, the red cells of the fish that were tested completely removed antibodies for each other but left in hemolysins for the cells of the donor used in immunization. Thus, only one antigen could be distinguished among the fish tested. The reciprocal removal of antibodies for red cells other than those of the donor was not a consequence of overabsorption, be-

cause, whenever fewer cells (or tubes) were used, the absorptions proved incomplete for the absorbing cells.

The extent of absorption also proved to be critical when agglutinating, rather than lytic, tests were performed with this same rabbit antiserum. After three absorptions performed at room temperature, only one antigenic factor could be distinguished. When sufficient blood was obtained from each fish for four absorptions, the antibodies directed against the individual antigen(s) previously detected were completely removed. The ease with which antibodies specific for individual differences were completely absorbed indicates that closely related antigens were involved in these antibody reactions. This finding is analogous to the well-known A_1 and A_2 specificities of human erythrocytes. Despite the difficulty of working with smaller species, it is probable that future investigations will show that inherited individual differences in erythrocyte antigens are widespread among fishes and other lower vertebrates.

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Visual Contour and Movement Perception

The means by which the visual system forms and maintains a contour is a central problem in vision, and one not well understood. By contour we mean the sharp boundary that separates two adjacent areas of the visual field. Specific studies of contour perception are few in number. Investigations of static and dynamic visual acuity, form perception, and visual-contrast phenomena all bear directly upon the subject of contour, but they all assume the operation of a contour-formation process without inquiring into the fundamental nature of the process itself. These allied phenomena in vision will be understood only when the essential facts of contour formation are known.

This report presents some preliminary observations on the subject of contour perception in relation to moving stimuli, a problem that has received little attention from those who have studied visual processes. The observations presented here stem from a phenomenon originally observed by Albert Michotte of the psychological laboratory at Louvain University in Belgium.

A stimulus (A) is observed moving horizontally through distance (D), from left to right. Its velocity (V) is increased until the contours of A cannot be seen clearly. At this velocity, if A is exposed for a brief interval in a fixed position prior to movement (this interval we shall call t_1) and then for another interval in a fixed position after movement (we shall call this interval t_2), A now is seen moving from left to right with sharp contours. This effect has been systematically explored by investigation of the quantitative relationship between the exposure durations of the stimulus in the fixed positions and the velocity of movement.

With an apparatus similar to the one employed by Michotte (*2*), a large white disk whose surface is perpendicular to the line of sight is rotated behind an aperture 6 in. long and 0.5 in. high. A concentric band on the disk is observed as a stationary square when the disk rotates. A band falling toward the center of the disk is translated into horizontal movement. By varying the speed of rotation of the disk and the length of the concentric bands, the necessary control over velocity of movement and exposure duration of the stimulus in the fixed positions is achieved. Figure 1 depicts the appearance of the black stimulus before, during, and after movement. The angular size of the stimulus object was 0.5°. The field of movement (D) was 5°.

For five subjects, the value of V at which contour was lost was determined with t_1 and $t_2 = 0$. At this velocity, t_1 and t_2 were increased by equal amounts in steps of 10 to 20 msec to some value (T) at which contour was regained. This procedure was continued until either the subject's limit of discrimination or the limitation of the apparatus was reached. The latter limitation concerned the exposure duration of t_1 and t_2. These values could not exceed 350 msec.

When the values of V are plotted against the values of T for each subject and these individual functions are combined, we get the relationship between V and T shown in Fig. 2. Because of the procedure employed, points were not always in common at different values of T for all subjects. Consequently, appropriate values of V were interpolated from the individual functions at 50-msec intervals of T. These values were averaged to give the points plotted in Fig. 2. Each point represents a mean of five values. This figure also includes data for vertical movement. The displacement of this function to the right is believed to be the result of a practice effect, a characteristic effect found in these kinds of observations. The data for vertical movement were gathered after the observations of horizontal movement.

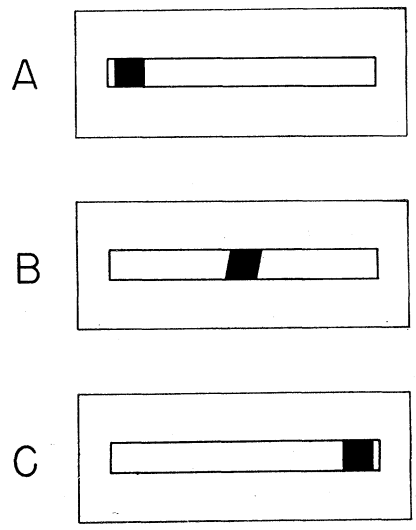

Fig. 1. Schematic illustration of the appearance of the stimulus as seen by the subject before movement (A), during movement (B), and after movement (C).

The linear functions in Fig. 2 may be thought of as *contour-contours*. All combinations of velocities and time values falling to the right of these lines will not produce contour, whereas all combinations to the left will. Figure 2 shows clearly that the contour of moving stimuli can be maintained as velocity increases, as long as the stimulus is exposed for a longer and longer time, both before and after movement. At some velocity this relationship breaks down, and the function becomes asymptotic to the ordinate. We cannot specify this critical velocity now because of apparatus limitations. The

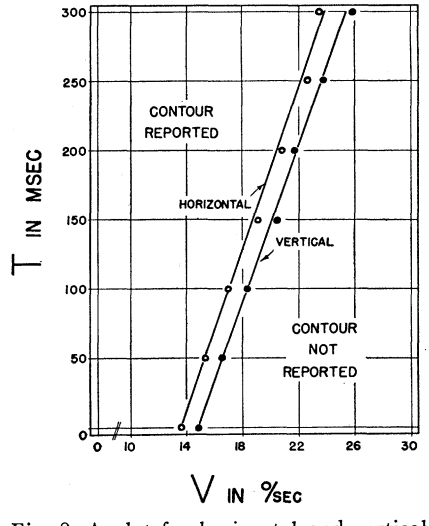

Fig. 2. A plot for horizontal and vertical movement showing the relationship between the velocity of the stimulus (V) and T, where T is the exposure duration of the stimulus before (t_1) and after (t_2) movement. In all instances $t_1 = t_2$.