streptomycin also causes misreading of the genetic message (*12, 13*). Therefore, the structure of the ribosomal site which responds to Sm should be important in influencing the specificity of the interaction between the codon in messenger RNA and the anticodon in transfer RNA. Our work shows that a protein in the CP30 protein fraction is an essential component of this structure.

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7 March 1968

Selection for Higher Fitness in Populations of *Drosophila pseudoobscura*

Abstract. *Four laboratory populations, each consisting of flies homozygous for a wild second chromosome, were maintained in population cages. Three of them were initially characterized by low fecundity of the females; the fourth was a control. After 15 months, in all three populations with low fecundity this character was much improved; two of them have reached the control level. The changes observed were presumably due to mutation and selection under highly competitive conditions.*

Natural populations of *Drosophila* carry concealed recessive genes which, when homozygous, decrease the fecundity of the flies. Females of *D. pseudoobscura* homozygous for wild second chromosomes lay approximately 19 percent fewer eggs ($\bar{X} = 26.0 \pm 0.7$ per day per female) than females heterozygous for the same chromosomes ($\bar{X} = 32.2 \pm 0.8$ per day per female) (*1*). If the survival from egg to adult is taken into account, the difference between the homozygotes and the heterozygotes becomes even greater, reaching a value of about 48 percent (*2*).

Among 211 wild second chromosomes analyzed for the fecundity of the homozygous females in spring 1966 (*1*), three conferring to their carriers the lowest egg-laying capacity and one conferring a high capacity (used as a control) have been chosen. Four experimental populations, each homozygous for one of these wild second chromosomes were maintained at 25°C in laboratory population cages, with an initial number of founders between 800 and 1000. For all four populations, chromosomes other than the second came from a laboratory tester stock carrying the markers Delta/Bare.

Over a period of 15 months, five samples of eggs were taken in the cages. The survival from egg to adult and the fecundity were measured simultaneously in the four populations. The eggs collected in the cages were distributed in ten groups of about 50 each, and each group was allowed to develop in a separate culture under uncrowded conditions. The percentage of emerging adults was the measure of survival from egg to adult. From these emerging adults, 30 impregnated females were distributed in ten vials with three females per vial. Fecundity was measured by counting daily the eggs laid in each vial from the 6th to the 15th day after emergence. Ten replications were thus available per sample for each measure. The determinations of the two parameters made in May 1966 were, however, made with three replications. The mean average number of eggs laid per female per day, the percentage of survival from egg to adult, and the standard errors for both measures are given in Table 1.

The fecundity of the control females fluctuated throughout the experimental period, owing to uncontrolled environmental variations in the cultures. With the performance of the control population taken as a standard, the fecundity of the experimental populations increased gradually and rather dramatically. The initial fecundity of the females in the three homozygous strains (Pinon 9, Borrego 71, and Borrego 41) was 3.2 and 8.6 times lower than that in the control strain (Borrego 3). During the period of 15 months (corresponding to about 15 generations under the experimental conditions), the fecundity increased in two populations to the degree found in the control population. The difference between the third population, Borrego 41, and the control diminished to about 15 percent. The survival from egg to adult was also improved in the populations in which it was low (Borrego 3, 41, and 71) and remained approximately constant in the Pinon 9 population where it was initially high. At the end of the experiment, the four populations were very much alike and approached the means obtained for random heterozygous com-

Table 1. Average number of eggs deposited per female per day, and percentage of survival from egg to adult, with their standard errors, in the experimental populations.

Date	Measurement	Borrego 3	Pinon 9	Borrego 71	Borrego 41
May 1966	Fecundity	43.0	13.5	5.0	12.9
May 1966	Survival	17.0	71.7	37.3	52.8
August 1966	Fecundity	31.9 ± 0.7	16.5 ± 1.3	16.9 ± 1.5	13.6 ± 3.7
August 1966	Survival	47.0 ± 3.5	74.0 ± 4.2	59.1 ± 3.8	46.1 ± 3.6
January 1967	Fecundity	39.4 ± 2.1	32.2 ± 2.1	24.2 ± 2.6	30.1 ± 2.2
January 1967	Survival	68.0 ± 4.7	77.0 ± 3.9	77.1 ± 3.5	67.1 ± 4.4
April 1967	Fecundity	41.1 ± 3.3	30.1 ± 1.7	33.9 ± 3.3	30.7 ± 1.8
April 1967	Survival	64.2 ± 5.4	63.9 ± 5.9	68.0 ± 4.9	81.5 ± 3.1
July 1967	Fecundity	27.2 ± 2.5	27.1 ± 2.6	30.8 ± 3.0	23.4 ± 2.0
July 1967	Survival	68.9 ± 3.6	74.3 ± 4.3	82.8 ± 4.1	83.7 ± 3.2
August 1967	Fecundity	33.5 ± 2.0	35.2 ± 3.1	33.6 ± 3.4	28.1 ± 3.5
August 1967	Survival	76.6 ± 5.0	76.3 ± 8.9	79.4 ± 4.8	66.3 ± 6.5

binations of wild second chromosomes from natural populations. The mean number of eggs laid by heterozygous females was 30.3 ± 1.3 per day (number of females = 52), and the survival from egg to adult was 69.9 ± 1.8 percent. Both means are very similar to those obtained in the four experimental populations at the last testing in August 1967.

Dobzhansky and Spassky (*3*) have found improvements in the viability and in the rates of the development in strains of *D. pseudoobscura* homozygous for second and fourth chromosomes. The strains were kept in mass cultures for 50 generations. It seems, however, that the changes obtained were less uniform compared to the changes in the fecundity and in the egg-to-adult survival found in my experiment. With Zelikman's (*4*) "intensity of reproduction" used as a parameter of the betterment of fitness (the mean number of progeny per female per interval of time), it appears that in Borrego 71 populations, the fitness was improved by a factor of more than 14.

The genetic raw materials which were utilized by the natural selection to increase the fitness of the experimental populations arose probably by spontaneous mutations. According to Mukai (*5*), the rate of spontaneous mutations causing minor changes in the viability is very high, about 20 times greater than the rate of mutation to recessive lethals. Although the mutation process generates raw materials from which adaptive changes are constructed by selection, it also brings forth a multitude of poorly adapted variants. Since in the experimental populations the percentage of the eggs surviving to give adult flies is very small, the opportunity for the selection to operate must have been considerable.

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Exercise: Effects on Hexokinase Activity in Red and White Skeletal Muscle

Abstract. *Single bouts of exercise increase hexokinase activity in red and white skeletal muscle of guinea pigs. Multiple bouts of exercise cause twofold increases. In contrast to other enzymes associated with glycolysis, hexokinase activity is higher in red than in white skeletal muscle.*

Strenuous exercise can result in adaptations in the activities of certain enzyme systems providing the energy for muscle contraction. However, little is known about the amount of exercise required to produce such adaptations, the time course for their appearance, or how long they persist. Likewise, no comparisons of the effects of exercise on red and white skeletal muscle have been reported although red and white skeletal muscle have different metabolic characteristics, showing a reciprocal relationship of glycolytic and mitochondrial enzymes (*1*). Type I, or red muscle fibers, have a high capacity for oxidative metabolism with strong activities of Krebs cycle and electron transport enzymes, whereas type II, or white muscle fibers, have high rates of glycolysis with high activities of glycolytic enzymes and phosphorylase. We have measured hexokinase activity in both red and white skeletal muscle and compared effects of single and repeated bouts of exercise.

Three groups of male guinea pigs (mixed strains) weighing, on the average, 600 g were studied for 3 weeks. The sedentary group was not exercised; the exercised group ran once for 30 minutes and was killed 48 hours later; and the trained group ran for 30 minutes every other day for 21 days and was killed 48 hours after the last training session. All exercise was performed on a treadmill driven at 1.9 km/hour in a room maintained at 21°C. When the animals were killed a superficial quadriceps muscle, corresponding to the vastus lateralis of rats, was removed and frozen at −80°C. This muscle possesses distinguishable red and white segments which were shown histochemically to be composed mainly of type I and type II fibers, respectively.

Frozen muscles were later thawed and homogenized in a cold (1° to 4°C) medium containing in final concentration 50 m*M* tris(hydroxymethyl)aminomethane buffer, 1 m*M* ethylenediaminetetraacetate, 15 m*M* K_2SO_4, 6 m*M* $MgCl_2$, and 10 m*M* mercaptoethanol at *p*H 7.8. The homogenates were centrifuged for 45 minutes at 105,000*g*, and the resulting supernatants were used directly for enzyme assay.

Enzyme activity was determined spectrophotometrically, by a modification of the method used by Sharma *et al.* (*2*), by measuring the rate of formation of reduced nicotinamide-adenine dinucleotide phosphate (reduced NADP) at 340 nm. The reaction was started by the addition of a small volume of supernatant to a cuvette containing in final concentration 50 m*M* tris buffer, 0.75 m*M* NADP, 3.0 m*M* adenosine-5′-triphosphate, 8.0 m*M* $MgCl_2$, 1 m*M* glucose, and excess glucose-6-phosphate dehydrogenase and 6-phosphogluconate dehydrogenase at *p*H 7.5. The rate of increase of optical density was halved to correct to micromoles of glucose-6-phosphate formed, and a molar absorbancy index for reduced NADP of 6.22×10^6 cm²/mole was used. Reduced NADP formed during the assay was stable. The concentration of soluble protein in the respective supernatants was determined by the biuret method (*3*).

The 3-week training program resulted in approximately twofold increases in total hexokinase activity of both red and white skeletal muscle (Table 1). Differences were also manifest in the

Table 1. Hexokinase activities in red and white skeletal muscle from sedentary, exercised, and trained guinea pigs. Results are given as nanomoles of glucose-6-phosphate formed at 37°C per minute per gram of tissue or per milligram of soluble protein in the 105,000*g* supernatants. Values represent group means and standard errors with the numbers of animals in parentheses.

Group	Red muscle		White muscle	
	Unit/g muscle	Unit/mg protein	Unit/g muscle	Unit/mg protein
Sedentary (9)	188 ± 16*	5.08 ± .58*	135 ± 12*	4.64 ± .40*
Exercised (9)	281 ± 15	8.12 ± .55	211 ± 13	6.96 ± .46
Trained (10)	341 ± 24*	9.22 ± .80*	290 ± 29*	8.90 ± .75*

* Differences between sedentary and trained significant at $P = .05$.

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3 January 1968