gives in the second filial generation (not in the first) four varieties, viz., agouti, chocolate, black and cinnamon. We could only have shaken our heads and looked wise (or skeptical).

Then we had no explanation to offer for such occurrences other than the "instability of color characters under domestication," the "effects of inbreeding," "maternal impressions." Serious consideration would have been given to the proximity of cages containing both black and cinnamon-agouti mice.

Now we have a simple, rational explanation, which any one can put to the test. We are able to predict the production of new varieties, and to produce them.

We must not, of course, in our exuberance, conclude that the powers of the hybridizer know no limits. The result under consideration consists, after all, only in the making of new combinations of unit characters, but it is much to know that these units exist and that all conceivable combinations of them are ordinarily capable of production. This valuable knowledge we owe to the discoverer and to the rediscoverers of Mendel's law.

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July 15, 1908

THE ORIGIN OF VARIETIES IN DOMESTICATED SPECIES

The great diversity of varietal forms, or races, amongst domesticated animals and plants, as compared with the corresponding wild species has always been a subject of remark, and it has generally been assumed that domestication, involving as it does radical changes in environment, induces variation. The considerations mentioned below indicate that we may have given too much prominence to the effect of domestication in inducing variation. It will be seen that, at least in many cases, domestication merely gives opportunity for the segregation and development of variations which may have existed practically unnoticed in the wild species.

The writer has previously shown that the poll character in cattle is a dominant Mendelian character, the dominance being somewhat variable, but the heterozygotes always being distinguishable from the extracted recessives. Let us suppose that a number of polled and horned cattle be allowed to interbreed freely. Let the number of the original polled cattle be a, and the horned cattle i, both types being equally divided between the sexes. The total number of cattle is $a+i$. The chance that in any mating the male shall be polled is $a/a+i$, the chance that it is horned is $i/a+i$. The chance that the female is of a particular type is the same. The following table (table I.) shows the probability of each of the various types of matings, and the corresponding probability of progeny of each type. Since the denominators of all the probability fractions in this table are the same, and since we are concerned only with the ratios between the types, only the numerators of the fractions are used.

TABLE I.

Ratios of Types of Progeny descended from polled (a) and horned (i) cattle, under conditions of random mating. (A = polled character, a its absence.)

Generation F_0.				
Type numbers		I	II	III
Type formulæ		AA	Aa	aa
Ratios of types		a	—	i
Generation F_1.				
Matings *M.* *F.*	Probability of mating	Probability of progeny of each type		
I × I	$a \times a$	a^2		
I × III	$a \times i$		ai	
III × I	$i \times a$		ai	
III × III	$i \times i$			i^2
		a^2	$2ai$	i^2
Generation F_2.				
I × I	$a^2 \times a^2$	a^4		
I × II	$a^2 \times 2ai$	a^3i	a^3i	
I × III	$a^2 \times i^2$		a^2i^2	
II × I	$2ai \times a^2$	a^3i	a^3i	
II × II	$2ai \times 2ai$	a^2i^2	$2a^2i^2$	a^2i^2
II × III	$2ai \times i^2$		$a i^3$	$a i^3$
III × I	$i^2 \times a^2$		a^2i^2	
III × II	$i^2 \times 2ai$		$a i^3$	$a i^3$
III × III	$i^2 \times i^2$			i^4
		$a^2(a+i)^2$	$2ai(a+i)^2$	$i^2(a+i)^2$
	or	a^2	$2a i$	i^2

From which it is seen that after generation F_1 there is no tendency for the ratios of the three possible types to change, any such change being purely a matter of chance. It is assumed that there is no selective mating and that each type of mating is equally fruitful. This point has already been brought out by Hardy in SCIENCE, July 10, 1908, p. 49.

Hybrids of Higher Order

By a process similar to the above it may be shown that when the two types differ in respect of two Mendelian characters, or a single character consisting of two factors, the population tends to assume the following ratios for the various types:

TABLE II.

Type formulæ, " ratios:	*AABB*,	*AABb*,	*AAbb*,	*AaBB*,	*AaBb*,	*Aabb*,	*aaBB*,	*auBb*,	*aabb*,
Generation F_0,	a	.	.	.	.	.	.	.	i
" F_1,	a^2	.	.	.	$2ai$	.	.	.	i^2
" F_2,	$(a^2+\frac{1}{2}ai)^2$	$a^2i(a+\frac{1}{2}i)$	$\frac{1}{4}a^2i^2$	$a^2i(a+\frac{1}{2}i)$	$a^3i+3a^2i^2+ai^3$	$ai^2(i+\frac{1}{2}a)$	$\frac{1}{4}a^2i^2$	$ai^2(i+\frac{1}{2}a)$	$(i^2+\frac{1}{2}ai)^2$
" F_3,	$(a^2+\frac{1}{4}ai)^2$	$\frac{3}{2}a^3i+\frac{3}{8}a^2i^2$	$\frac{9}{16}a^2i^2$	$\frac{3}{2}a^3i+\frac{3}{8}a^2i^2$	$\frac{1}{2}a^3i+3\frac{1}{4}a^2i^2+\frac{1}{2}ai^3$	$\frac{3}{2}ai^3+\frac{3}{8}a^2i^2$	$\frac{9}{16}a^2i^2$	$\frac{3}{2}ai^3+\frac{3}{8}a^2i^2$	$(i^2+\frac{1}{4}ai)^2$
" F_n,	a^4	$2a^3i$	a^2i^2	$2a^3i$	$4a^2i^2$	$2ai^3$	a^2i^2	$2ai^3$	i^4

That is, the proportions of the various types tend to assume the relative numbers shown in the last line of the above table, and thereafter there is no tendency for these ratios to change. It is interesting to note that the terms of the last line of table II. may be obtained from those of the last line of table I. by multiplying by $a^2+2ai+i^2$ (= the square of $a+i$); thus, multiplying a^2 the first term in the last line of table I., by $a^2+2ai+i^2$, gives the first three terms of the last line of table II.

If the original population consists of two types which differ in respect of three Mendelian characters, the ratios of the twenty-seven resulting types in the final population may be obtained from the last line of table II., as that was from the last line of table I.

The fact that in such a mixed population, with no selectional mating, and with equal fruitfulness of the various matings, there is no tendency for the relative numbers of the various zygotic types to change, offers a rational explanation of the rapid development of races having strikingly different characteristics, when a species is first brought under domestication. Let us consider for a moment the condition of the wild species. Amongst our wild gray squirrels are occasionally seen black specimens; also albinos. These varietal characters have originated presumably by the loss, either gradually or in any other manner, of a character formerly possessed. This change may have occurred at any time in the history of the species, or even before the species existed in its present form. There is no tendency, with random mating, for the new characters to spread through the species. In fact, there is probably a tendency toward their elimination by natural selection. Such a tendency, however, would operate very slowly in the case of a recessive character, which is transmitted unseen in far more individuals than those showing it (under the conditions assumed). It is entirely possible that all the varietal variations which are possible to this species actually exist in the wild species, each in exceedingly small proportions, because it has originated in a very small fraction of the species, and does not tend to spread over the species unless favored by natural selection. Should the species be domesticated, the art of the breeder, who would naturally be attracted by new types that crop out (which occurs when heterozygotes are mated) would seize these forms and establish races from them.

It is a fact noted by many investigators, and especially insisted on by de Vries, that most races of domesticated species are derived from the wild form by the loss of one or more hereditary characters. That these race peculiarities are, generally speaking, recessive to the wild form is well established, and the reason therefore is apparently clear. But that these peculiarities may have originated ages ago in the wild form, and been transmitted almost unnoticed, has not hitherto been suggested. We have seen above that such may be the case. Furthermore, peculiarities that may have had indefinite time in which to develop are not greatly in need of a theory of "saltatory change" to explain their abundant development in domesticated species.

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE SECTION B—PHYSICS

The summer meeting of the American Association for the Advancement of Science, Section B, was held in the Wilder Laboratory of Dartmouth College, Hanover, N. H., June 30, 1908. This was a joint meeting with the American Physical Society. There were two sessions, one in the forenoon and one in the afternoon. The attendance at each was about seventy. Professor Edward L. Nichols, president of the American Physical Society and president last year of the American Association for the Advancement of Science, was the presiding officer.

The titles and abstracts of the sixteen papers presented are given below:

Light Pressure on Black Surfaces and on Thin Plates of Glass (with experimental demonstration): G. F. Hull, Dartmouth College.

Some years ago E. F. Nichols and Hull proved the existence experimentally of a pressure due to light upon a silvered glass surface. Maxwell had proved theoretically that such a pressure exists. By Larmor's theory, however, the pressure on a glass surface should be zero. Professor Hull showed experiments which do not justify Larmor's conclusion. He exhibited an apparatus in action which showed the comparative effects obtained by allowing radiation of the same intensity to fall successively upon four kinds of surface. The results of such a comparison show the pressures to be as follows:

	Deflection
1 glass vane	1.0
2 glass vanes	1.7
Enclosed black vane	5.6
Silvered vane	11.5

These results indicate that Larmor's conclusion is incorrect. Maxwell's formula gives results quantitatively agreeing with the above measurements. For example, the values indicated for the above four cases by applying Maxwell's formula are 1.0, 1.83, 5.86 and 11.2, respectively.

(At the conclusion of the paper the president of the Physical Society, who was presiding, congratulated the section that all its members had been able to see for themselves an effect due to a force so small that the possibility of showing its actual existence had not been hoped for by eminent physicists until a very few years ago.)

Changes in Density of the Ether, and Some Optical Effects produced by it: Charles F. Brush, Cleveland.

This paper described two series of careful experiments, conducted on different lines, the results of which afford strong evidence in support of the following hypotheses:

1. The ether passes slowly, and *not* freely, through glass and presumably through other bodies.

2. The ether is susceptible of change in density. It may be dilated and presumably compressed in a glass vessel, the phenomenon lasting long enough to be observed with ease.

3. While dilation of the ether does not alter materially, if at all, the velocity of the light waves in it, it does reduce the amplitude or energy-carrying capacity of both long and short waves, *i. e.*, of low heat and actinic radiation.

The apparatus and experiments were fully described by means of a fine set of lantern slides, many of which showed photographic effects obtained during the experiments themselves.

On Oscillations in the Metallic Arc: W. G. Cady, Wesleyan University.

Two types of oscillations occurring in an electric arc light were considered. The first are produced in the iron arc in free air, with a frequency of about 1,500 per second. These seem to be mechanical and were dismissed with brief comment. The second type was considered more at length. They are of much higher frequency and occur with electrodes of various substances,