it remains incomprehensible why this decision of the method of making up a deficiency, which can be made only by the individual teacher in the individual case, should determine a difference of grade. The grade to be recorded on the books of the institution should signify the student's rank and nothing else.

We now have before us this entirely practical question: If an institution adopts a system of grading like the one proposed, in which 3 per cent. are called excellent, 22 per cent. superior, 50 per cent. medium, 22 per cent. inferior and 3 per cent. failure, how can the individual teacher, who is perhaps in charge of a class of only five or eight students, comply with the system? There is only one answer to this question: He must work out his method of grading for himself on the basis of his individual experience with the students. But he should be given one kind of aid by the institution which he serves. The institution should publish annually a statistical table showing how each teacher has graded all his students the last year and the last five years, so that each teacher can inform himself easily as to whether he has graded his students in accordance with the system adopted by the institution or has unconsciously applied an arbitrary standard of his own and thus introduced confusion into the system. There can be little doubt that this would soon result in a great uniformity of grading, and inequalities of the size described would be impossible, to the satisfaction of both faculty and students.

One problem is still left. How should the ability of the five groups of students be represented in order to compute the claims of various students for honors which are to be given to those having the highest rank of a whole student body. The University of Missouri prescribes for this purpose that the first grade be represented by 95, the second by 85, the third by 75 and the fourth by 65. These values are so arbitrarily chosen that any one can see that no scientific influence has been effective grading on the probability curve, as we have tried to do, we are able to give a reasonable answer to the present question. In Fig. 2 the ability of the average medium student is found at the point where the abscissa is 0. The ability of the average superior student is found near +1, that of the inferior student near —1. The ability of the average excellent student is found near +2, that of the average failure student near —2. All these differences of ability are represented by steps which are about equal. To avoid negative values, it would, therefore, be the simplest method to represent the different grades agreed on by the numerical values 5, 4, 3, 2 and 1, and to multiply these values by the number of hours of work for which each grade has been received. The students whose totals are highest—making allowance for the probable error, which is about .04, if the total number of grades recorded during the college course is about 40—have then the best claims for the honor as far as scholarship is concerned.

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A NEW COLOR VARIETY OF THE GUINEA-PIG[1]

EXPERIMENTAL studies made in recent years show that color inheritance in mammals is a matter of considerable complexity, but not beyond the possibility of analysis. The more carefully the matter is studied, the clearer does the fact become that color inheritance, in all its phases, conforms with Mendel's law of heredity. The seemingly complicated results are due to multiplicity of factors concerned in the production of those results. If we confine our attention to one factor at a time, we find that its behavior is strictly and simply Mendelian. Each factor is either present or absent and in general the presence of a factor is dominant over its absence. It is only when two or more independent factors are simultaneously concerned that complications arise. Thus two simple factors acting simultaneously may produce a result different from that of either factor by itself.

In the issues of SCIENCE for January 25, 1907, and for August 30, 1907, I have advocated the view (first advanced concerning mice

[1] Published by permission of the Carnegie Institution of Washington.

by Bateson[2]) that in the pigmentation of guinea-pigs, three different kinds of pigment are produced, viz., black, brown and yellow. In wild guinea-pigs (Cavidæ) these pigments are so placed on the individual hair as to give it a banded appearance, and the banding is inherited as a factor independent of the colors present. In tame guinea-pigs this pattern factor may be wanting, together with one or more of the fundamental color factors, and this loss of color factors gives rise to a long series of color variations. But any mating which will bring together in one individual all of the four color factors will result in a return (reversion) to the coat condition of the wild Cavidæ.

In the issue of Science for August 30, 1907, I showed that, if the hypothesis of an independent color pattern (barring of the hair) is correct, it should be possible to produce a color variety of guinea-pig at that time unknown, one similar to the cinnamon-agouti variety of mice. In confirmation of the hypothesis, I may now say that this variety has recently been produced, and in the following way: Agouti-colored individuals were crossed with chocolates. The young were all agouti-colored. But when mated with each other these agouti young produced offspring of four sorts, agouti, black, cinnamon-agouti and chocolate. The cinnamon agoutis are a sharply defined and unmistakable new variety, differing from the wild (agouti) type in the total absence of black pigment from the eye, the skin of the extremities, and from the hair. The black young obtained from this cross, in generation F_2, were an unpredicted result which serves further to confirm the hypothesis of independent factors.

Let us now apply the hypothesis to the facts observed. The original agouti parents by hypothesis carry the four factors: (1) black, (2) brown and (3) yellow pigments, and (4) the barring pattern (agouti), and have completely the wild type of pigmentation. The chocolates, however, have hair entirely devoid of black pigment and unbarred. They lack, therefore, the factors black and agouti (barring).

In crosses of chocolate with agouti individuals, agoutis only are obtained, as already stated, the presence of the factors black and agouti dominating their absence. Using symbols, B for black, Br for brown, Y for yellow and A for agouti, the parental contributions in this cross are: by the agouti parent, $B\,Br\,Y\,A$; by the chocolate parent, $Br\,Y$. The young, therefore, are heterozygotes of the formula, $B\,Br\,Y\,A \cdot Br\,Y$. Such individuals should, in accordance with Mendelian principles, produce ripe germ cells of four sorts: viz., (1) $B\,Br\,Y\,A$, (2) $B\,Br\,Y$, (3) $Br\,Y\,A$ and (4) $Br\,Y$. These four sorts should, on the theory of probabilities, be equally numerous. Each sort, if united with a germ cell having the same constitution as itself, should produce a different color variety, these four varieties being, respectively, (1) agouti, (2) black, (3) cinnamon-agouti and (4) chocolate.

The result should be visibly the same if a gamete united with one of another sort containing fewer factors than itself, but none of them different from its own factors. Thus the first sort of gamete should produce an agouti individual if united to either of the other three sorts. Allowing for such unions in their chance frequencies, we should expect the second generation offspring to consist of four visibly different sorts of individuals, on the average, in the following proportions; agouti, 9; black, 3; cinnamon-agouti, 3; chocolate, 1. Up to the present time there have been obtained, of agouti, 8; black, 4; cinnamon-agouti, 2; chocolate, 2. This is a perfectly normal Mendelian result, both qualitative and quantitative, and confirms in the most complete manner the hypothesis of an independent pattern factor. For, can a more severe test of the hypothesis be conceived than that by its application one should produce a wholly unknown variety?

A moment's consideration of this case shows what a really great advance in the theory and practise of breeding has been obtained through the discovery of Mendel's law. What a puzzle this case would have presented to the biologist ten years ago! Agouti crossed with chocolate

[2] *Proc. Zool. Soc. Lond.*, 1903.

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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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.

	I	II	III
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.

Matings M. F.	Probability of mating	Probability of progeny of each type		
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	$2ai \times i^2$		ai^3	ai^3
III × I	$i^2 \times a^2$		a^2i^2	
III × II	$i^2 \times 2ai$		ai^3	ai^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	$2ai$	i^2