der Vogelfänger

by Joseph G. Griffith

A GENETIC OVERVIEW

A discussion of genetics is likely to begin with a biography of Gregor Mendel and how he made his discoveries. The story is too well known to repeat here. Mendel discovered that genes operate in pairs; one from each parent, that genes may be dominant or recessive, that one of a pair may be dominant and the other recessive (heterozygous = split = carrier) or that both may be either dominant or recessive (homozygous = pure), that some dominant genes are weak (incomplete dominance).

Plotting a single characteristic in genetics is easy if the 13, 14, 23, 24 method is used. The numbers 1 and 2 are assigned to the male genes and 3 and 4 to the female ones. A single characteristic split is as follows:

12	X	34
(Aa	X	AA)

13	14	23	24
(AA	AA	aA	aA)

Sex linked recessives can be worked out in the same way using Y to replace one of the genes in the female parent.

12	X	34
(Aa	X	aY)

13	14	23	24
(AaA	AY	aa	aY)

Birds are the opposite of mammals i.e. the female is the sex determiner (XY).

The same pattern can be used for more than one characteristic but it is more involved. For example;

12	12	12	12	X	34	34	34	34
Ss	Aa	EE	bb		Ss	Aa	EE	Bb

The EE's can be dropped since they are the same for each parent and would remain constant. The result begins like this:

1. 13 13 13
   (SS AA bB)
2. 14 13 13
   (Ss AA bB)
3. 13 14 13
   (SS Aa bB) etc.

The Mathematical formula for the number of possible combinations is, $2^{2n}=64$.

2=the number of each kind of gene from each parent.

$\underline{2}$=the number of possible combinations of each.

$\underline{n}$=the number of characteristics being worked with. In this case 3.

Thus $\underline{n}=\underline{3}$

Multiply $2(X)^{2(X)n} = 2(X)^{2(X)3} = 2(X)^6 = 64$. The power^6 means that 2 is multiplied by itself 6 times.

Dominance is really quite simple when for example black is dominant to white, in which case the animal is split for white (a white carrier). Using the same example for incomplete dominance would give grey. The black in this case would not be strong enough to completely obscure the white.

Mendelian genetics is fairly straightforward. More recently, many new discoveries have been made that both complicate and fascinate. The electron microscope and molecular biology (biophysics and/or bio-chemistry) are making dramatic changes in our knowledge of heredity and its many facets.

Genes are not as independent as Mendel thought. A gene responsible for one characteristic may act as a modifier of a gene for a different one. Some "modifier" genes don't seem to have any other function; at least none is known. Many animals have genes for spotting; where black and brown are removed from certain areas leaving white, yellow or red. In canaries, cockatiels and lovebirds the simplest form of spotting is fowl; a dark bird with some white tail feathers. Heavy variegates have light feathers in tail, wings, rump and belly. The most pronounced forms are ticked; almost clear with a small dark spot usually on the head with no other dark plumage.

Each major degree of variegation would be easy to define except that the changes are so gradual. To account for this there would have to be a large number of genes acting in concert or a few variations of one gene with a modifier(s). Economy would favor the latter.

Relative or series dominance is another facet of the picture. When a gene changes, mutates, the variant form continues to operate at the same location and may be dominant or recessive to the original form. The majority of such changes are recessive, so chances are that the first form will be dominant. Altered genes are called alleles. An allele of black might give rise to grey. A subsequent change in grey might further dilute it to silver. Black would be dominant to both grey and silver. Grey would be dominant to silver only.

Mutations are permanent changes in gene structure. During the life of almost every animal or plant, many hundreds of mutations occur as the result of cosmic radiation and other factors. To begin with, most of these mutations occur in body cells, and what's more, they rarely interrupt the normal function of the cells where they occur. To have hereditary significance, mutation must occur in the gametes (ova or sperm) or in the cells that give rise to them. This happens infrequently. Mutations are also very random.

Probably the easiest mutations to detect are those governing color. Size and shape changes are rarely as dramatic. Generally there are six colors in four categories.

I. MELANINS
   a. Black
   b. Brown

II. LIPOCHROMES
   c. Yellow
   d. Red

III. STRUCTURAL
   e. Blue

IV. DIFFUSE REFLECTION
   f. White

It is remarkable how conservative nature has been in using these basics throughout the animal and plant kingdoms. The exceptions are truly notable. In birds, there are two that largely defy the rules. Touracoes have normal melanins, but all other colors are different from other birds. Hummingbirds also have melanins, but all other colors are due to special cells that reflect light of selected wavelengths. The thickness of the cells determines the color that is reflected. For this reason the gorgets of hummingbirds appear black except when the viewer, the bird and the angle of the light are in a particular relationship.

Black is the darkest of the melanins and discussion has arisen whether or not it is really very intense brown or a separate color. Since it dilutes to grey (not brown) and is often subject to different genes, the question seems superfluous. When not too intense, black may combine with other colors: black + yellow = olive green, black + white = grey.

Brown is normally recessive to black but may combine with it to form sable. As with black, when not too intense, brown may combine with other colors. Brown + yellow = cinnamon, brown + white = fawn, brown + red = copper.

Melanins are manufactured by special cells called melanosomes. They are located in the inner skin layers.

Unlike melanins, lipochromes come to most animals from plants in the form of large molecules called carotenoids. Some birds are capable of synthesizing them from smaller molecules; others must make minor alterations in existing carotenoids. In any case, they usually fall into the category of "waste products". Put another way, they are available through synthesis or otherwise in such quantity that they are in excess to the metabolic needs of the animal and are passed into the hair, scales or feathers as coloring agents.

Yellow carotenoids are xanthophyls, red ones are carotenes. Since they are so closely allied, it is not surprising that in many birds they are subject to the same genetic influence. In some species, where the use of these colors are very stabilized, they have genetically differentiated. Yellow, red and white are often referred to as "ground" colors when combined with black and/or brown.

Blue is reflected from hollow, prism-like cells in the feathers. In a "pure"

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form, the cells usually overlay black or brown and if the blue feathers are soaked in water in such a way as to fill them, the underlying color becomes visible. Blue + yellow = green, blue + red = purple or violet.

White has more than one genetic cause. Where a bird is basically or totally white, the suprression of nomal melinins is called leuco-melanism. Its most dramatic form is albinism, or total suppression, including eye pigment. Another kind, as well as a different gene series, is pied or variegated. Here the various parts of the body are effected, even to the whole body, but not eye color which remains normal. In yellow ground birds, the same mechanisms apply giving lutino and pied respectively. Oddly enough, these same genes suppress or greatly reduce blue along with melanins.

Yellow and red ground birds have other genes for white. These genes suppress lipochromes but not melanins. A gene that suppresses yellow usually suppresses red and vice versa. Often there are two genes that act in this way, one dominant, the other recessive. The dominant form is usually lethal when homozygous. The use of carotenoids is evidently interrupted at a stage that is critical to the cellular metabolism and the embryo dies. The recessive form, though weakening, is rarely lethal.

Leuco-melanistic white (sic), including lutino, interrupts the manufacture of melanins at one stage. Another form prevents perfectly normal melanin from entering skin, hair, feathers, or scales.

What is fascinating is that these genes have recently shown how genes can and do effect more than one characteristic. The eyes of animals are connected to opposite lobes of the brain; the right eye to the left lobe and the left to the right. In animals with binocular vision (most predators), the nerves divide and while most of the right eye nerves go to the left lobe, some of them connect to the right lobe. Dr. Carl J. Witkop, Jr., in his study of albinism has shown that these unilateral connections are impaired in various albino forms. His studies suggest that the greater the suppression of melanins (dilute to albino), the greater the degree of impairment. It is interesting to note that both of these mechanisms are more or less light responsive.

Carotenes, although responsible for the oranges and reds in most animals and plants, have another common denominator in light-responsive mechanisms. Certain carotenes in plants act as precursor or base molecules for the formation of chlorophyll which is activated by light. In animals, the same molecules are precursors of vitamin A, which is responsible, in part, for night vision; the ability to see in dim light.

Nature is extremely conservative and once a workable compound arises, it is made to serve again and again in a whole series of variations.

Heredity and learning, or better, heredity and environment, are often so closely linked as to be difficult to separate. In a large number of cases, genes merely supply potential, and the use of it is determined by the poverty or richness of the environment.

Among humans, a child deprived of all language from birth to the age of 13 will lose the ability to use any language. Puppies denied social intercourse at certain periods lose their normal social development and may become psychotic.

Imprinting is a genetically based species trait. It provides a strong preference for members of ones own species. In the normal course of events, young animals are cared for by their own parents and they become imprinted upon them. At maturity, they seek those of similar type, color or voice. Imprinting occurs early in some, late in others. Likewise it is strong in some, weaker in others.

A frequent puzzle to novices occurs when matings fail to produce the predicted result. It should be understood that predictions are statistical and represent averages of fairly large sample. Traditionally, an animal receives half its genes from each parent and one fourth from each grandparent. When dealing with homozygous parents, there is no problem since no hidden characteristics can be passed on. Heterozygotes are another story.

Occassionally, one gene seems to be favored over another for reasons that are unknown. Canary breeders have had experiences where a dominant white bird (carrying yellow) will have either all white or all yellow offspring regardless of how many different mates it may have. In spite of this, the statistical average remains 50% white and 50% yellow.

A dominant over which there is some confusion is corona (crested). Corona is a better term since the feathers radiate from a central point rather than being a series of elongated feathers such as in cardinals. There are no graduations in coronas; if the bird has the gene it's a corona. Conversely, if a bird is plainheaded it cannot "carry" the gene for crest. Much has been said of crest-bred.

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There is no genetic difference in a plainhead derived from a corona mating and any other plainhead. In canaries specifically bred for crests (Gloster Fancies), the size and shape of the consort's (plainhead's) head has an influence on the quality of the coronas bred from it. Head of good type should be sought for "crest" breedings. Length of feather is the second factor influencing corona quality; fine long feathers giving the best type.

One mechanism that partially accounts for the inheritance of more, or less than 1/4 of a grandparent's genes is crossover. Frequently, chromosome pairs (the giant chains of genes) are entwined just prior to cell division, Fig. 1a. When the signal for separation is given, the sections on either side of a mid-line merely move off and the chromosomes have a new arrangement. Thus, an animal may derive less than 1/4 of its genes from one grandparent, Fig. 1b.

The indications are that genes tend to crossover (migrate) in blocks (linkage). On the other hand, recent evidence that some genes have more than one effect may modify this view.

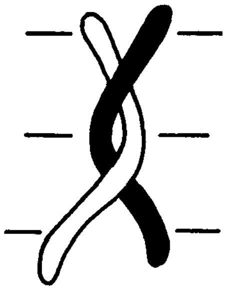

Fig. 1a

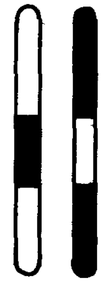

Fig. 1b

A gene is not a single entity as formerly thought. Each gene is a double chain of four nucleotides in the form of a helix. Genes for a given character are rarely singular. Each gene for a given characteristic or function is composed of several identical minor units of a given number and the units are made up of fixed numbers of nucleotides. Further, they occupy fixed positions on the chromosomes. The gene for grey in cockatiels might look something like this on the chromosome:

As the gene units for grey are all the same size, so the size of the spacers is also the same in each species, although not the same as the genes. Little is known of the reason for, or function of, the spacers.

All of the metabolic functions of every living thing are genetically governed. There is no surprise inherent in that statement. What is surprising is the remarkable uniformity of some of them. A study of the genes that code for RNA (ribonucleic acid) in two African Clawed Toads *(Zenopus laevis* and *X. mulleri)* showed that the genes controlling the production of one nucleic protein contained the same number of nucleotides in both species. The sequence is: DNA (gene) RNA nucleic protein. This is a conservative gene since it governs a basic cellular function. The study further showed that over 50 species, including mammals, invertebrates, higher plants, fungi and yeasts all had at least some nucleotide sequences in common. Another study dealing with a different nucleic protein composed of 120 nucleotides has tested several animals from marsupials to man (including the clawed toads) and discovered that they all have 120 nucleotides for the same gene. These are just two of the many results that are coming to light that clearly illustrate the kinship of all living things.

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The maximum area of red is always presented to the intruder. If the intruder is below the displaying resident the latter extends his head and lowers the red breast, thereby exposing the maximum amount of red. If the intruder is above the owner of the territory, the resident bird throws its head back and puffs the feathers of the breast. The function of display is to intimidate the intruder and thereby not necessitate fighting,which is detrimental to the species if the individuals are injured or killed.

Using stuffed specimens, Mr. Lack experimented with the responses to the red breast area. A live bird will sing, display and finally attack if a stuffed specimen is placed in its territory. One living male attacked the specimen so hard that it knocked the head off of the stuffed bird. This did not cause the attack to be lessened. Mr. Lack removed the tail from the specimen. The owner of the territory continued to attack. The wings were taken off and still the living bird attacked. Finally the only thing that was left was a bundle of red feathers with some white below. 50% of the living Robins to which these remains were presented attacked it.

When a complete specimen had the red of the breast colored brown, no living bird would attack it, but the same birds would attack a bundle of red feathers lacking head, tail, wings and legs!

Stuffed specimens stimulated different responses depending upon the physiological state of the living birds. If a stuffed bird is placed and left near a nest during the period of nest building,the specimen is attacked,but since it does not leave the nest it is eventually deserted. If the specimen is placed near a nest during incubation,the female of the live pair will come to the eggs but the male stays away. If young are in the nest,the stuffed bird is violently and continuously attacked.

When song and display fail to intimidate an invading bird,the owner of a territory is forced to fight. Usually in the wild state no real damage is done,but occasionally one bird will be injured and Lack records a few instances in which one bird killed his opponent. However, this is decidedly unusual in the wild state.

The invincibility of males in their own territory is illustrated by the following. A male English Robin entered a trap in his own territory. An adjacent male entered the trapped bird's territory and the resident bird sang from his prison, at which time the free intruder promptly left. The trap containing the bird was then moved over into the intruder's territory and the latter, now on his home ground, came to the trap, displayed and sang. The bird in the trap made no attempt to sing or display aggressive actions.

Perhaps more than any other subject, that of animal behavior points up the danger of error when we interpret the reason for the actions of animals in terms of human emotions.

As an example of the fallacies that could result from explaining animal behavior based on a human viewpoint, consider the following:

1. A man sings because he is happy.
2. Therefore when a bird sings it is happy. (This may be the case with canaries.)

If this is true, it follows from what has been described in the English Robin that whereas male Robins are happy most of the year, the females are happy only in the fall; that males are happier before than after obtaining their mates; and that they are happiest of all when they are fighting!

The truth seems to be that a human parallel to a singing bird would be a man standing in his own yard loudly threatening his neighbor with physical violence if the neighbor should so much as set foot over the property line.

I will be most appreciative if our readers will forward to me written statements of authentic observations of birds in the wild state exhibiting territorial behavior. Even though these birds are protected and not kept in our local aviaries, they may appear in aviaries in other countries. This information may then be used for articles in later issues to better help us understand the actions of our birds and thereby help us make them more comfortable.

This should also go a long way toward improving our aviary breeding results■

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Variations in genetic makeup (rate of mutation) were formerly thought to be fixed in all populations; so much variation per so many individuals. New light has been shed on this subject and it has been found that living organisms in a stable environment have greater genetic variation than those in harsher climates. Thus, animals in the tropical forest and coral reefs are more varied than those in temperate and arctic habitats.

The rate of mutation in captive animals seems to increase more than would be accounted for by the fact that when they occur, man tends to nurture them. This latter discovery helps to explain what has happened to the canary, cockatiel, budgie, zebra finch, and peach faced lovebird. Although captive birds may be kept outdoors where the weather is unstable, all of the other factors in the environment are usually very stable. Food, protection from predators, shelter, and nesting sites are all fixed parts of the environment. Given this stability, it is logical to assume that the factors that work in tropical habitats are allowed to assert themselves and the rate of variation increases.

Although knowledge of the mechanisms of inheritance and gene operation is expanding daily, the basic rules of inheritance remain the same. Every breeding program must be based on genetics to produce the best quality with the greatest predictability■