Chapter Seven

Heredity and Mutations

During the last few years, the breeding of color mutations in cockatiels has attracted a great deal of attention. It would be a shortcoming not to cover this exciting new branch of the hobby, especially as interest in mutations is rapidly increasing.

While it will not be possible to delve deeply into the subject of genetics, I will try to explain the essential principles as simply and practically as possible. Note well, however, that some time and patience will be required of anyone who has not previously studied the subject.

Colors

Three factors produce all of the color variants seen in psittacines: changes in the pigment melanin; changes in the pigment carotenoid; changes in the structure color blue.

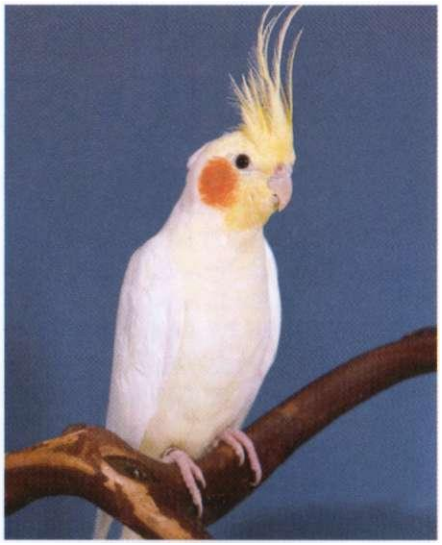
Melanin: the dark pigments of the feathers, eyes, beak, feet, and nails—in other words, the colors black, gray, and brown.

Carotenoid: the bright pigments, which can occur in feathers and beak—specifically the colors yellow, orange, and red.

Structure Color: blue (and violet). The words *structure color* indicate that the color is related to the *structure* of the feather. In other words, blue plumage is not the result of a distinctive pigment; rather, it is a physical effect produced by the structural arrangement of molecules on the feather's surface.

***This is one of the later mutations*—a white, not an albino, female cockatiel with black instead of red eyes (as in albinos); this mutation is autosomal recessive.**

The breeding of color mutations in cockatiels has become a major part of aviculture. It obviously all started with the domesticated wild-colored or normal gray birds—after they were being bred in captivity some 100 years after they were first introduced to Europe!



A lutino mutation. Some lutino birds have a visible bald patch at the back of the head. This is a genetic fault that has so far not been bred out.

Right a pied, left a pearl pied cockatiel.

A champion heavy pied cockatiel, bred and owned by the author.

You will have noticed that the color green has not been mentioned. This is because green, which is not a primary color, results from a combination of the carotenoid pigment color yellow and the structure color blue. If the yellow fails in a green bird, the result is a blue bird; if the blue fails, the result is a yellow one.

Mutations

Mutations in the psittacine species are generally caused by changes in the melanin and the carotenoid, and only occasionally in the structure color. We can therefore concern ourselves mainly with the changes in melanin and carotenoid. The following are the most usual forms. (Note that not all of these color mutations have been observed in cockatiels, though it remains theoretically possible that they may occur in the future.)

Pastel: In this mutation, the quantity of melanin is reduced. The colors of the wild form are retained in lighter, diluted form—frequently as light, grass green. The yellow turquoisine parakeet is an example of this mutation.

Lutino, Albino, Yellow: In these mutations, melanin is completely or almost completely lacking. In lutinos and albinos, melanin is absent from all parts of the body—feathers, eyes, beak, feet, and nails. In yellows, melanin is absent only from the plumage. Lutinos and albinos are therefore easily recognizable by their red eyes; normal yellows have dark eyes. Lutinos and albinos differ from each other in that the former still has its carotenoid and, therefore, will show some yellow, orange, and/or red, while the latter has lost these colors as well as the melanin colors, leaving a pure white bird with red eyes.

A male lutino pied cockatiel.

In cockatiels, lutino males are whitish with buttercup yellow suffusion, especially under the wings and tail, red-orange cheek patches, dark red eyes, pinkish feet and legs, and horn-gray beak and yellow crest. The females are like the cocks. Barring on the undersurfaces of the tail and underwing feathers appear to be yellow against a white background, due to the lack of melanin. The young are like the females, but

the eyes are lighter with some yellow. This mutation originated in 1958 in Florida from two normal-looking cockatiels, in the aviaries of Mr. C. Barringer. It was, however, the late Mrs. E. L. Moon who saw to it that this mutation was firmly established. In the lutino cockatiel the melanin has been lost completely, although the red cheek patches are retained.

Since albino cockatiels are void of all carotenoid, both sexes are pure white with ruby or red eyes; even the orange-red ear patches are white. Primaries and flight feathers have sometimes an off shade of white. The albino mutation occurred in the Netherlands in the early 1980s.

Pied, Opaline: Here, the melanin is absent from parts of the plumage. The pied mutation usually has a patchy, irregular color pattern, with white or yellow patches where the melanin is absent. There is a great variety of pied patterns, ranging from a few affected feathers to large areas of the plumage.

In cockatiels, pied males are like normal gray cocks, but with irregular white patches—which may be small, large, or between these extremes. Ideal pied mutations are clear (meaning: without melanin). Eyes brown, feet and legs grayish, beak gray. Females are like normal gray hens, but with the plumage broken by white patches. The tail is usually clear without bars. The warbling whistle of the male may be the best—and often only—indication of the bird's sex. The young have shorter tails and often some pink around the cere. This mutation originated in the United States in 1949. Different strains were developed in the aviaries of Mr. D. Putman and Mrs. R. Kersh. Birds of the latter were used to found European strains. Females can be split to pied as the mutation is recessive; split birds often have white or yellow flecked feathers on the back of the neck.

This mutation must not be confused with the results of an inadequate diet. A deficiency of the amino acid lysine in the diet, for example, can result in an inadequate formation of melanin. Thus, some green feathers can become yellow, while black ones can become very pale gray to whitish. An improvement in the diet will result in normalization of the plumage after the following molt.

The second mutation in this category is the opaline. Here, the carotenoid becomes more intense. Light yellow becomes deep yellow, medium yellow becomes near orange, and pink becomes near red. The opaline mutation is difficult to recognize, as its outward appearance varies from species to species. I will, therefore, provide short descriptions of three "typical" opalines: the red rosella, the rose Bourke's, and the pearled cockatiel.

In the red rosella, virtually the whole underside and tail are red; red can also be seen in the back markings.

The rose Bourke's is also a brilliant example of the opaline mutation. The normal yellowish color is

replaced by a pure pink, and the melanin is lost in the mantel, back, secondary flight feathers, and head. This arrangement is similar to that of the budgerigar, in which the mantel has no markings; in the Bourke's this also applies to part of the wings.

The pearled (or opaline) cockatiel shows a totally different variation. Melanin is absent from the center of the feather, so that each affected feather is white or yellow with a dark edge. This gives a checkered effect, seen most often on the wings. The yellow of the pearled is lighter than that of a normal gray cockatiel. Birds with a deep yellow color are known as golden pearls. Cockatiels with heavy pearl markings with an elongated effect right down from the back of the neck are known as Laced or Lacewings.

Young cockatiel males are like normal gray cocks. The back of the neck, mantle, and wings are covered with white or yellow pearly markings. After approximately 6-12 months, the males molt into their adult plumage, being normal gray. The hens, however, keep their beautiful pearling. Eyes, beak, feet, and legs are as in normal gray. This mutation was first seen in 1967 in West Germany and the next year in Belgium. The pearled mutation has been used for breeding and establishing the so-called double and combined mutations (Cinnamon-Pearl, Pearl Pied, Lutino Pearl, Lutino Pearl Pied, and so on).

Cinnamon, Fallow: In these mutations, the color of the melanin is changed: black is replaced by brown. In cinnamons (usually called Isabelles in Europe), brown predominates; fallows show a gray-brown that is particularly obvious on the primary wing feathers.

These mutations give varying outward appearances, depending on the bird species. The effects are more obvious in a cockatiel than in a Bourke's or a kakariki. Green becomes lighter in color and more yellowish; gray becomes more brown-gray.

Male cockatiels are like normal gray cocks, but with a warm tannish (brownish) tone; after the first molt cocks acquire dark rather than barred

A beautiful cinnamon pearl male cockatiel.

Left, a male and right, a female pearl cockatiel.

A pearl female cockatiel. Males scarcely reveal any pearl design.

undertail coverts. The yellow colors are soft, the orange-red cheek patches bright and clear. In this mutation the melanin is brown, not black. Sometimes birds have splotches of color on wings and back; some even have markings that are scalloped, and show shading. Those birds are often called marbled cinnamons. The females are like normal gray hens, but the dark areas have a brownish tone. In general, the female is somewhat lighter than the male. The young are like the parents, although young males are often paler. The mutation, first bred in Belgium in the early 1960s, is sex-linked.

An interesting difference between the cinnamon and the fallow is that, although the young of both are hatched with red eyes, the cinnamon gets dark eyes within a week and the fallow retains the red eyes. There can, therefore, be no confusion with yellow mutations, which are hatched with dark eyes. The origin of this mutation in the cockatiel has not been precisely documented. It occurred in the United States as well as in Europe in the early 1970s.

Silver (recessive): Male cockatiels are like normal gray cocks, but the gray color is replaced with metallic silver. Both sexes have red eyes.

Females are like the males, with characteristic differences seen in normal gray hens. The young resemble the normal gray cockatiel, but the basic coloration is metallic silver. This mutation was first developed in the late 1950s in Belgium, and was noted for its poor eyesight and fertility. The mutation is now well established, and is less afflicted with blindness.

A second strain of silver is the Dominant or Dilute Silver. The cockatiel is silvery-pastel with bright cheek patches; the eyes are black, the legs and feet are gray. Youngsters look like normals (wild color), although the yellow color is much stronger and the gray is darker, especially on the head (skull cap) and neck. After the first molt, the males become silver gray, although the depth of the color may differ from very light to normal (wild color), but with a yellowish wash. The skull cap (dark gray) remains.

A third strain is the Double Factor. A Dominant (Dilute) Silver cockatiel has genes that produce two visual effects in either a single or double quantity, defined as single or double factor. The latter is responsible for a further dilution with, as a result, a yellowish-white head and wings and a grayish wash. The eyes are black, the feet and legs are gray.

The mutation was first bred by Mr. T. Cole of Swindon, England in 1986. It is still rather rare in aviculture.

Seagreen: In this mutation, the carotenoid is diminished. The plumage, therefore, shows less yellow, orange, and/or red. In a good seagreen mutation, the carotenoid is reduced by half. There are variations. Less carotenoid produces a more bluish bird; more carotenoid gives a greener one. An example is the seagreen splendid parakeet.

This is a beautiful bird with an even pearl design.

Blue: A pure blue bird has melanin and, of course, the structure color blue. Since carotenoid is absent, yellow, orange, and red tints are totally missing.

The white face or charcoal cockatiel is also included in this group. Here, too, the yellow and red are missing, but since the wild color is not green, the mutation produces white rather than a blue plumage. In other respects, these cockatiel

males and females are like normal grays. The mask area of the cock will be pure white after the first molt. This mutation first appeared in a Dutch collection in 1964, and again in 1978 in Frankfurt, West Germany. The mutation, which is recessive, is now well established, often being combined with other mutations in order to create new strains. Well-known, for example, is the triple split to Cinnamon-Pearl and Pied.

Principles of Heredity

We will now consider the means by which the mutations are inherited. This, in turn, determines what the offspring of various combinations will look like.

Dominant: If one of the parent birds is pure-bred (see Recessive below) for the dominant color, all of the young will take on that color. In other words, the pure-bred dominant suppresses all other colors, even though the offspring carry other colors in their genetic material (or *genes).* Colors hidden in the genes can emerge later in particular pairings. In general, the wild color is dominant. (If two birds are pure-bred for the dominant color, all of the offspring will also be pure-bred for the dominant color.)

Recessive: If two recessive-colored birds are bred, the offspring will also be of the recessive color. However, if a dominant bird is paired with a recessive bird, all of the young will take on the color of the dominant bird. The recessive color is thus hidden.

Pure-bred (homozygous): A pure-bred bird possesses only the genes for the revealed color. All recessive-colored birds must be pure-bred. Dominant-colored birds, however, may carry a masked gene for a recessive color.

Split (heterozygous): This means a bird of the dominant color has a hidden color mutation, which can be passed on to its offspring. For example, a green bird with a hidden blue mutation in its genetic makeup is called "split for blue" or "green/blue."

Sex-linked: This means that the inheritance of a particular factor is dependent on sex. For example, hemophilia in humans is carried by females, but is revealed only in males. It is thus important to know which cockatiel parent has the appropriate colors that, with the sex, will be passed on to the young.

Sex-linked recessive means that the recessive gene for a particular factor is associated with the group of genes (or *chromosomes)* that determines the sex of the offspring.

Autosomal: This refers to inheritance that is not sex-linked.

Autosomal recessive means that the gene for the factor in question is not carried on a sex chromosome.

In most cases, the same mutations are inherited by the same means, although there are occasional exceptions to the rules. One

example is the lutinos: most inherit sex-linked recessive, but there are also some lutino forms that inherit autosomal recessive (the lutino Princess of Wales parakeet and the lutino elegant parakeet, for example).

Formulas

Most color mutations in cockatiels may be dealt with either in the autosomal recessive or in the sex-linked recessive form.

Autosomal recessive inheritance:
See tables 1, 2, 3, 4

Sex-linked recessive inheritance:
See tables 5, 6, 7, 8

A white face white cockatiel mutation—a rather rare mutation—and easily distinguished from a white cockatiel (see page 141).

Pied (Harlequin or Variegated)

Table 1: **The pied mutation is autosomal recessive.**

Parents			*Young*	
Male		*Female*	*Males*	*Females*
gray	x	pied	50% gray/pied	50% gray/pied
pied	x	gray	50% gray/pied	50% gray/pied
gray/pied	x	gray	25% gray/pied; 25% gray	25% gray/pied; 25% gray
gray	x	gray/pied	25% gray/pied; 25% gray	25% gray/pied; 25% gray
gray/pied	x	pied	25% gray/pied; 25% pied	25% gray/pied; 25% pied
pied	x	gray/pied	25% gray pied; 25% pied	25% gray/pied; 25% pied
gray/pied	x	gray/pied	25% gray/pied; 12'/$_2$% gray; 12. 1/$_2$% pied	25% gray/pied; 12.1/2% gray; 12.1/2% pied
pied	x	pied	50% pied	50% pied

Silver

Table 2: **The silver mutation is autosomal recessive.**

Parents			*Young*	
Male		*Female*	*Males*	*Females*
gray	x	silver	50% gray/silver	50% gray/silver
silver	x	gray	50% gray/silver	50% gray/silver
gray/silver	x	gray	25% gray/silver; 25% gray	25% gray/silver; 25% gray
gray	x	gray/silver	25% gray/silver; 25% gray	25% gray/silver; 25% gray
gray/silver	x	silver	25% gray/silver; 25% silver	25% gray/silver; 25% silver
gray	x	gray/silver	25% gray/silver; 12.1/2% silver, 12.1/2% gray	25% gray/silver; 12.1/2% silver, 12.1/2% gray
gray/silver	x	gray/silver	25% gray/silver; 121/2% gray; 12.1/2% silver	25% gray/silver; 12.1/2% gray; 12.1/2% silver
silver	x	silver	50% silver	50% silver

(left) A white face pied cockatiel.

(right) The white face cockatiel is an autosomal recessive mutation. In the U.S. this fascinating mutation was originally called "charcoal" because of the sooty appearance.

White Face (Charcoal)

Table 3: **The white face mutation is autosomal recessive.**

Parents			*Young*	
Male		*Female*	*Males*	*Females*
gray	x	white face	50% gray/white face	50% gray/white face
white face	x	gray	50% gray/white face	50% gray/white face
gray/white face	x	gray	25% gray/white face; 25% gray	25% gray/white face; 25% gray
gray	x	gray/white face	25% gray/white face; 25% gray	25% gray/white face; 25% gray
gray/white face	x	white face	25% gray/white face; 25% white face	25% gray/white face; 25% white face
white face	x	gray/white face	25% gray/white face; 25% white face	25% gray/white face; 25% white face
gray/white face	x	gray/white face	25% gray/white face; 12.1/2% gray; 12.1/2% white face	25% gray/white face; 12.1/2% gray; 12.1/2% white face
white face	x	white face	50% white face	50% white face

White face pearl cockatiel (front and back). Look at the even design on "both sides" of the back. No wonder this cockatiel mutation became a champion at various national and international bird shows!

Fallow

Table 4: **The fallow mutation, which is autosomal recessive, is very similar to the sex-linked cinnamon. The main difference is that adult fallows have red eyes.**

Parents			*Young*	
Male		*Female*	*Males*	*Females*
gray	x	fallow	50% gray/fallow	50% gray/fallow
fallow	x	gray	50% gray/fallow	50% gray/fallow
gray/fallow	x	gray	25% gray/fallow; 25% gray	25% gray/fallow; 25% gray
gray	x	gray/fallow	25% gray/fallow; 25% gray	25% gray/fallow; 25% gray
gray/fallow	x	fallow	25% gray/fallow; 25% fallow	25% gray/fallow; 25% fallow
fallow	x	gray/fallow	25% gray/fallow; 25% fallow	25% gray/fallow; 25% fallow
gray/fallow	x	gray/fallow	25% gray/fallow; 12.1/2% gray; 12.1/2% fallow	25% gray/fallow; 12.1/2% gray; 12.1/2% fallow
fallow	x	fallow	50% fallow	50% fallow

(left) A wonderfully colored and marked white face pearl fawn cockatiel—again, many times a top winner at bird shows!

(right) A pied white face cockatiel.

Pearl (Laced or Opaline)

Table 5: **The pearl mutation is sex-linked recessive. After 6 to 12 months the males molt into normal gray adult plumage. The females retain their pearl markings.**

Parents			*Young*	
Male		*Female*	*Males*	*Females*
gray	x	pearl	50% gray/pearl	50% gray
pearl	x	gray	50% gray/pearl	50% pearl
gray/pearl	x	gray	25% gray/pearl; 25% gray	25% gray; 25% pearl
gray/pearl	x	pearl	25% gray/pearl; 25% pearl	25% gray; 25% pearl
pearl	x	pearl	50% pearl	50% pearl

(left) One of the author's beautiful mutations: a pearl cockatiel. The pearl mutation, first bred in the 1960s in Europe, may have either relatively dark or pale yellow areas in their pearled plumage. Male birds revert to normal gray after their first molt.

(right) A yellow cheek fawn cockatiel; a very special and rather rare bird!

Cinnamon (Fawn or Isabelle)

Table 6: **The cinnamon mutation is sex-linked recessive. Cinnamons, like the autosomal recessive fallows, are born with red eyes. However, the cinnamons get dark eyes within a week, whereas the fallows retain their red eyes.**

Parents			*Young*	
Male		*Female*	*Males*	*Females*
gray	x	cinnamon	50% gray/cinnamon	50% gray
cinnamon	x	gray	50% gray/cinnamon	50% cinnamon
gray/cinnamon	x	gray	25% gray/cinnamon; 25% gray	25% gray; 25% cinnamon
gray/cinnamon	x	cinnamon	25% gray/cinnamon; 25% cinnamon	25% gray; 25% cinnamon
cinnamon	x	cinnamon	50% cinnamon	50% cinnamon

(left) A yellow cheek cockatiel, far from common.

(right) A pied female cockatiel with quite some yellow in her plumage. Nature is full of surprises!

Lutino

Table 7: **The lutino mutation is sex-linked recessive.**

Parents			*Young*	
Male		*Female*	*Males*	*Females*
gray	x	lutino	50% gray/lutino	50% gray
lutino	x	gray	50% gray/lutino	50% lutino
gray/lutino	x	gray	25% gray/lutino; 25% gray	25% gray; 25% lutino
gray/lutino	x	lutino	25% gray/lutino; 25% lutino	25% gray; 25% lutino
lutino	x	lutino	50% lutino	50% lutino

Table 8: **The albino mutation is sex-linked recessive.**

Parents			*Young*	
Male		*Female*	*Males*	*Females*
gray	x	albino	50% gray/albino	50% gray
albino	x	gray	50% gray/albino	50% albino
gray/albino	x	gray	25% gray/albino; 25% gray	25% gray; 25% albino
gray/albino	x	albino	25% gray/albino; 25% albino	25% gray; 25% albino
albino	x	albino	50% albino	50% albino

The perfect pair!

Table 9: **The four possible mutation x mutation crossing combinations**

Male		*Female*
sex-linked recessive	x	sex-linked recessive
sex-linked recessive	x	autosomal recessive
autosomal recessive	x	sex-linked recessive
autosomal recessive	x	autosomal recessive

Crossing Mutations: Some Interesting Combinations

Table 10: **For crossings not shown above, simply substitute for a corresponding mutation. For example, to determine the result of cinnamon x albino, replace lutino female (in the second line of the Table) with albino. The young males will be 50% gray cinnamon/albino, the young females, 50% cinnamon.**

Parents			*Young*	
Male		*Female*	*Males*	*Females*
sex-linked recessive	x	*sex-linked recessive*		
lutino	x	pearl	50% gray/lutino/pearl	50% lutino
cinnamon	x	lutino	50% gray/cinnamon/lutino	50% cinnamon
lutino	x	cinnamon	50% gray/lutino/cinnamon	50% lutino
cinnamon	x	pearl	50% gray/cinnamon/pearl	50% cinnamon
sex-linked recessive	x	*autosomal recessive*		
lutino	x	pied	50% gray/lutino/pied	50% lutino/pied
pearl	x	pied	50% gray/pearl/pied	50% pearl/pied
cinnamon	x	silver	50% gray/cinnamon/silver	50% cinnamon/silver
pearl	x	fallow	50% gray/pearl/fallow	50% pearl/fallow
autosomal recessive	x	*sex-linked recessive*		
pied	x	pearl	50% gray/pied/pearl	50% gray/pied
silver	x	lutino	50% gray/lutino/silver	50% gray/silver
white face	x	lutino	50% gray/lutino/white face	50% gray/white face
silver	x	pearl	50% gray/pearl/silver	50% gray/silver
autosomal recessive	x	*autosomal recessive*		
silver	x	pied	50% gray/silver/pied	50% gray/silver/pied
pied	x	silver	50% gray/silver/pied	50% gray/silver/pied
white face	x	pied	50% gray/white face/pied	50% gray/white face/pied

Crossing Mutations

The crossing of mutations is a little more complicated, but even here we have a few simple formulas. To do this, we must bring the autosomal recessive and the sex-linked recessive forms together. There are four possibilities, as shown in Table 9. Examples of each of these combinations are given on page 156. To determine what you can obtain from a certain pairing, use the formula or check Table 10.

Additional Considerations

There are two important points that apply to everything discussed in this chapter. The first is that all of the percentages given for results are *averages:* Do not expect to find the young to be 50 percent cocks and 50 percent hens in every nest. The second point is that the results of these formulas will be correct only if you know precisely the genetic makeup of the parents and how the colors are passed on. If different results should arise from those given in the formulas, then you have an unknown hidden color factor in one (or both) of the parents.

There are certain color forms that are not connected with inheritance. Frequently, this happens when birds with slight differences are bred selectively over a long period of time. Consider, for example, the red-bellied turquoisine parakeet and the red-bellied splendid parakeet. These are produced by breeding birds that have a lot of red in their plumage.

(top) A pet white face white cockatiel.

(bottom) A female yellow cheek fawn cockatiel. Once you have established a certain mutation you can start "playing" with various options as the previous pictures have shown us.