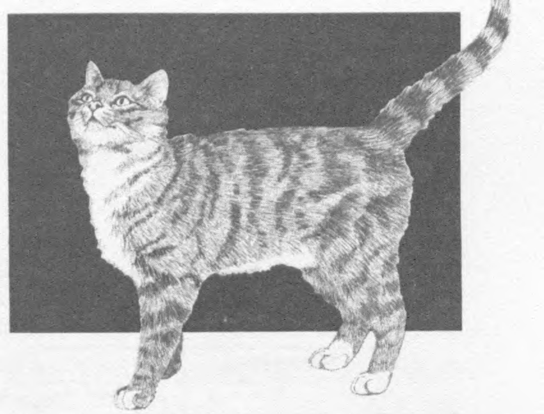
Perspectives On Cats

A Newsletter for Cat Fanciers From The Cornell Feline Health Center



Fall 1991

Coats of Many Colors

The varying coat colors and patterns displayed by cats fascinate us. But equally fascinating is learning how coat color is determined. The information which controls inherited traits, such as coat color, is encoded in genes. Genes are composed of the chemical substance called deoxyribonucleic acid (DNA). This genetic material makes up the *chromosomes*. Each chromosome contains hundreds or even thousands of different genes. However, there are only 38 chromosomes present in each cell. These 38 chromosomes consist of 18 pairs of *autosomes* and one pair of *sex chromosomes*. In the case of a normal male cat, the pair of sex chromosomes consists of one X-chromosome and one Y-chromosome. In a female cat, the pair of sex chromosomes consists of two X-chromosomes.

The genetic endowment is transmitted from a parent to its offspring via the chromosomes of the gametes (egg and sperm). Each gamete has 19 chromosomes (18 autosomes and one sex chromosome). Each gene controls a function, such as the pattern of tabby striping. And each gene may have several alternative forms, which are known as *alleles*. (See table 1 for a list of the major color alleles.) If a cat has two identical alleles, e.g. *TT*, it is said to be *homozygous*. If a cat has two different alleles, e.g. Tt^b, it is said to be *heterozygous*. A heterozygous cat with the genetic information or *genotype* Tt^b has two conflicting sets of information—*T* is to produce mackerel stripes and t^b is to produce blotched stripes. In this heterozygote, only one of the messages is expressed, namely mackerel stripes. The trait that is expressed in the heterozygote is said to be *dominant*; the trait that is hidden in the heterozygote is said to be *recessive*. From this example, it can be seen that if a cat displays a mackerel pattern, its genotype may be either homozygous *TT* or heterozygous Tt^b. However, if one of the parents of a mackerel tabby was known to be blotched, then the genotype of the mackerel offspring could be assigned with certainty as Tt^b.

When gametes are formed by meiosis, only one of each pair of chromosomes passes to a particular gamete. In consequence, for each gene, only one of each pair of alleles is found in a particular gamete. A cat that is homozygous for a given gene (e.g., *TT*), will produce gametes of one kind only with regard to the trait under consideration—*T*. A cat that is heterozygous (e.g., Tt^b) can produce two kinds of gametes

Inside this issue ...

Table 1. Major Color Alleles of Cats

Dominant		Recessive	
Symbol	Phenotype	Symbol	Phenotype
A	Agouti (banded hair color)	a	Nonagouti (solid hair color)
B	Solid black color	b	Dark brown
		b^1	Light brown
C	Complete color	c	White with pink eyes
		c^a	White with blue eyes
		c^b	Burmese
		c^s	Siamese
D	Intense color	d	Dilute color
I	Pigment inhibitor	i	Normal pigmentation
O	Orange (sex-linked)	o	Nonorange
S	White spotting	s	No spotting
T	Striped tabby	t^b	Blotched tabby
T^a	Abyssinian tabby		
W	Dominant white	w	Colored

with respect to that gene—*T* and t^b. Each type of gamete is equally likely to be formed.

The genotype of a cat cannot be directly observed. However, it is possible to observe, measure or detect the expression of that genotype in the visible appearance or *phenotype* of a cat. So we cannot see the genotype of the two $t^b t^b$ alleles in the chromosome of a blotched tabby cat, but we can observe its blotched tabby pattern. From the observed phenotype, we can infer or deduce possible genotype(s).

Where color appears, how intensely it is expressed, and whether it appears alone or in combination with other colors depend on other genetic information carried by the cat.

A cat which displays a dominant trait, e.g. black, may also be carrying the allele which determines the recessive trait, e.g. brown. This allele can be hidden for several generations. Test crossing helps to determine the status of carrier or noncarrier of a recessive trait. Carrier status is identified with certainty if even one kitten showing the recessive trait is produced. Carrier status can be rendered less likely if only kittens showing the dominant trait are produced; there is a probability of error which decreases as the number of kittens produced increases. This testing may also involve the crossing of a suspected carrier with a known carrier for the recessive trait.

Perspectives On Cats

A Newsletter for Cat Fanciers From The Cornell Feline Health Center

The ultimate purpose of the Cornell Feline Health Center is to improve the health of cats everywhere, by developing methods to prevent or cure feline diseases, and by providing continuing education to veterinarians and cat owners. All contributions are tax-deductible.

Director: **Fred W. Scott, D.V.M., Ph.D**
Assistant Director: **James R. Richards, D.V.M.**
Editor: **June E. Tuttle**
Secretaries: **Sheryl A. Thomas, Gwen Frost, Julie Elzer**

This publication is made possible, in part, by a grant from **9-Lives Cat Foods**. We gratefully acknowledge this interest and support in the furthering of feline health. This acknowledgement of our gratitude is not an endorsement of any particular company or product.

X-linked Color

The color of a cat's coat is basically due to the presence or absence of two pigments—eumelanin and phaeomelanin. Eumelanin is a dark pigment found in black or brown areas of the coat. Phaeomelanin is a yellow-red pigment found in orange areas. If neither pigment is present the coat will be white.

There is a gene which controls the production of orange pigment. The gene is carried on the X-chromosome, and is said to be *X-linked*. This gene has the alternative alleles—O^O (orange) and O^+ (non-orange). A female cat may be one of three possible genotypes (O^OO^O, O^OO^+,O^+O^+). A normal male cat has one *X*-chromosome only and may be one of two possible genotypes (O^O *and* O^+).

The tortoiseshell phenotype cannot occur in a normal male cat. The rare male tortoiseshell cats which are occasionally observed are found to have a chromosomal anomaly. Most commonly, the males are found to have a total of 39 chromosomes per cell including an extra X-chromosome. These XXY tortie males are as a rule sterile.

The asymmetric mosaic distribution of orange and non-orange patches seen in the tortie female is caused by the process of X-chromosome inactivation. It results in the switching-off of the genetic information carried on one of the two X-chromosomes present in each somatic cell.

Color Density

Another gene in cats controls the density of color. This gene has the alternative alleles—*D* (non-dilute) and *d* (dilute). In cats of genotype *dd*, the color is diluted; nondiluted occurs in cats of genotype *DD* or *Dd*.

There are many examples of the action of the *d* allele in both pedigreed and unpedigreed cats. For example, a potentially black cat, genotype *BB*, which is also carrying the genetic information *dd* will be blue. In summary then *dd* dilutes black to blue (e.g. Russian blue, Korat); orange dilutes to cream; and brown dilutes to lilac or lavender. In Siamese cats, the *dd* genotype acts as follows—sealpoint dilutes to blue point; chocolate point dilutes to lilac point; red point dilutes to cream point; seal red tortie point dilutes to blue cream tortie point; and chocolate red tortie point dilutes to lavender.

The *D/d* gene illustrates the general rule that genes do not act in isolation, but act in conjunction with other genes in the genetic makeup of a cat. The *D/d* gene is strictly not a color gene, but it acts on the expression of pigment produced by other genes.

A Fading Gene

The first Siamese cats arrived in England from Bangkok in 1880. This introduced the c^s allele into breeding stocks in England. The first Tonkinese cat was brought from Burma to the United States in 1930 and this introduced the c^b allele into breeding populations here. The Siamese and Burmese alleles are alternative forms of a gene which affects coloring. The complete series of alleles for this gene are—C, c^b, c^s, c^a, *and* c. The cat with at least one copy of the *C* allele has normal or full intensity of coloring. The genotype of such a cat may be represented *C*_. (The line denotes any allelic form of that particular gene.)

The c^sc^s genotype, which is the essential genetic basis of the Siamese breed, reduces pigmentation over the body such that coloring is largely confined to the points (i.e., mask, ears, legs and tail). The extent of pigmentation in Siamese cats is temperature-dependent, with color development being restricted to the relatively cooler areas of the body. Siamese kittens have light fur at birth; color first appears on the fur overlying the coolest area of the body—the ear margins. The temperature-sensitivity also means that fur regrowing on a shaved area of the trunk of a Siamese cat will be pigmented.

Other genes govern the actual color of the points. Genotypes of female Siamese cats are shown in table 2, along with their corresponding phenotypes.

Table 2. Genotypes and Phenotypes of Female Siamese Cats	
Genotype	Phenotype
$B\_D\_c^sc^sO^+O^+$	Seal point
$bbD\_c^sc^sO^+O^+$	Chocolate point
$\_\_D\_c^sc^sO^oO^o$	Red point
$B\_D\_c^sc^sO^+O^o$	Seal-red tortie point
$bbD\_c^sc^sO^+O^o$	Chocolate-red tortie point
$B\_ddc^sc^sO^+O^+$	Blue point
$bbddc^sc^sO^+O^+$	Lilac point

Cats carrying c^a or c alleles have been reported only very rarely. The cat of genotype c^c is a true oculocutaneuous albino with no pigment in either the fur or in the iris of the eye. The cat genotype c^ac^a is a white cat with blue eyes.

The Gene that Hides Everything

A white cat is a cat in disguise. Beneath that white coat there may lurk a chocolate point Siamese or a black mackerel tabby, or anything. It is only by careful analysis of the pedigree of a white cat that one might obtain some information as to what lies beneath that white exterior. In genetic terms, then, it may be said that the *W_* genotype masks the phenotypic expression of all other genes for color and pattern.

The all-white coat condition, particularly in combination with unilateral or bilateral blue eye color, is associated with deafness. Studies indicate that this deafness is related to a failure of nerve cells to migrate to the inner ear.

Predicting Genotypes

Matings of cats produce litters of small size. Mendelian expectations and Punnett squares are often used to predict the outcomes of matings (see table 3) and the relative proportions of each type of offspring. Within the context of matings which produce large numbers of offspring, predictions based on Mendelian ratios provide a reliable guide and there is a good agreement between the actual and the predicted outcomes. However, litter sizes in the cat are small, and even the cumulative total of offspring from repeat matings involving the same pair of parents is generally low.

The classic Mendelian ratios and Punnett squares are useful to cat breeders to (1) identify what kinds of kittens are possible from a particular mating and (2) to estimate the chance of occurrence of each type. For example, consider the outcome of the mating of a heterozygous black cat, *Bb*, with a homozygous brown cat, *bb*. The classic expectation is 1 black:1 brown. However, this should *not* be interpreted as meaning that half of the kittens in the litter will be black and half will be brown. This expectation should be interpreted by the breeder as indicating that: black kittens are possible; brown kittens are possible; the chance of a black kitten is 1/2; the chance of a brown kitten is 1/2.

Table 3. Basic Punnett Square

Dam: bb \ *Sire: Bb*	B	b
b	Bb (black)	bb (brown)
b	Bb (black)	bb (brown)

Deducing Genotype

It is possible to deduce a cat's color genotype by noting its appearance. You can make an educated guess as to a cat's genotype by referring to table 1 to determine the alleles that express the cat's color and pattern. If a phenotype results only from a recessive genotype, the cat's alleles at that locus are both known (e.g., a blotched tabby is t^bt^b). If the color is from a dominant allele, half the genotype is known (e.g., an orange cat is *O_*). Tabbies must be *A_*, unless the orange allele is present. White cats can be white for several genetic reasons, so many possible genotypes are probable. ■

This article has been adapted from "Feline Genetics" by Dr. Judith Kinnear in Felis Domesticus: A Manual of Feline Health, published by the Cornell Feline Health Center (1983).

Mail Bag

Q. I am concerned about the amount of alcohol in Nolvadent which I use weekly on my cat's teeth. Is 6 percent alcohol toxic for my cat? (I use very little of the solution on a gauze pad.) What is the best type of home care for the cat's teeth?—J.H., New Jersey

A. The alcohol content in Nolvadent is insignificant and would not constitute a risk for the cat. The best home care is daily brushing of the teeth with a tooth paste that has been specifically formulated for the cat and a special tooth brush. These are available from veterinarians. Rinses such as Nolvadent can be used weekly or daily depending on the amount of plaque and the ease of brushing the cat's teeth.

Q. Since fluoride has been added to most human toothpaste, why is a fluoridated toothpaste not available for home use on cats?—J.G., Michigan

A. A 0.4% stannous fluoride gel has been recommended by veterinary dentists for weekly application to feline teeth to help decrease plaque accumulation and possibly reduce the development of feline cervical line erosions. Fluoride has the added effect of possibly reducing pain associated with sensitive teeth particularly associated with gingival recession and root exposure.

The reason fluoride is not available for daily use is that the toxic levels of daily administered fluoride have not yet been identified for the cat. When safe levels of fluoride are established for the cat, and if they will allow daily application, a dentifrice containing fluoride will probably be marketed. In the mean time, your veterinarian can supply you with a fluoride gel that is safe for weekly use.

If you would like to have a question on cat health answered in this column, please write to:

Cornell Feline Health Center
POC/Mail Bag
College of Veterinary Medicine
Ithaca, NY 14853-6401

✂ *Clip and Save*

First Aid Kit for Cats

"Be prepared" is the cardinal rule in emergency first aid. Having a well stocked, easily accessible first aid kit will enable you to react immediately in an emergency, and may even save your cat's life. A first aid kit should contain:

Materials

- gauze bandages (1" and 2" widths)
- gauze pads (2" and 3")
- adhesive tape
- triangular bandage
- cotton swabs and balls
- tweezers
- rectal thermometer
- roll of cotton

Medications

- 3% hydrogen peroxide
- milk of magnesia tablets
- activated charcoal tablets
- kaolin mixture
- antibacterial ointments for eyes and skin

Honor Roll

We extend a special "thank you" to the following people, foundations and cat clubs who contributed $100 or more to support the programs of the Center during the last three months. We also wish to thank those who are not listed on the honor roll, but made a contribution.

Donor(s)	**Gift Description**
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The International Cat Association
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Dr. Mew Recommends

Special Gifts for you and your friends—

Tee-shirts ($12)

These shirts are a 50/50 blend of polyester and cotton. The shirt is red with the logo in white. Available for adults in one-size-fits-all (XL).

The Cornell Book of Cats ($30)

This comprehensive reference on cat health care is a must for every cat owner's library. By ordering directly from the Center you will receive an autographed copy by the director, Dr. Fred Scott.

Gift Memberships ($12)

Order gift memberships for your friends for birthdays, anniversaries, and other special occasions. Your friends will also receive a special letter acknowledging your thoughtful gift.

Honor Certificates ($25)

If you're looking for a special way to say "thank you" to your veterinarian, consider a special personalized 8x10 parchment certificate. Your veterinarian will also receive a personalized letter with the certificate.

Gifts to the Center

There are only three months left before the end-of-the-year. Now is a good time to review your year-end contributions to various organizations. The following gifts can provide tax advantages for you, *and* assist the Center in sustaining and expanding its programs on feline health—

Cash Gift—The actual out-of-pocket cost of a cash gift is less than the dollar amount of the gift because of the income-tax charitable deduction.

Appreciated Property—A gift of long-term appreciated property, i.e. stock, can result in substantially greater tax benefits because the tax on the unrealized appreciation is avoided.

Bequests—An estate-tax charitable deduction is allowed for the full value of the gift.

Life Insurance—Depending on the arrangement of your gift, life insurance can create a number of favorable tax consequences.

Additional information is available by contacting Thomas S. Foulkes, Director of Planned Giving, 55 Brown Rd., Ithaca, NY 14850.

Order Form

Use this form to order the special gifts listed above. Make checks payable to the Cornell Feline Health Center. Send this form, the names and addresses for any gift or honor certificates*, and your remittance to: Orders, Cornell Feline Health Center, 618 VRT, Ithaca, NY 14853-6401.

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Book	$30.00	________	____
Gift Membership*	$12.00	________	____
Honor Certificate*	$25.00	________	____
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Center Announces Staff Changes

The Cornell Feline Health Center is pleased to announce the appointment of **Dr. James R. Richards** to the position of assistant director of the Center and feline extension veterinarian for the Dr. Louis J. Camuti Memorial Feline Consultation and Diagnostic Service. He will also have additional responsibilities in the veterinary college's community service practice program.

Dr. Richards is a 1979 graduate of the College of Veterinary Medicine at The Ohio State University. During the past 12 years he has worked in Ohio as a small animal veterinarian. He is a member of the American Animal Hospital Association and the Cleveland Academy of Veterinary Medicine.

Dr. John E. Saidla, who joined the staff in 1988 as feline extension veterinarian, has a new position in the College of Veterinary Medicine. He is the director of continuing education, as well as having responsibilities in pet dentistry and primary care medicine.

Feline Advisory Council Welcomes New Members

This year three people have been appointed by Dean Phemister to the Cornell Feline Health Center Advisory Council. We are happy to welcome:

Wilson Greatbatch—President, Wilson Greatbatch Prosthetics, Ltd., New York

Roy V.H. Pollock, D.V.M., Ph.D.—Director of Technical Services, SmithKline Beecham Animal Health, Pennsylvannia

Alison Steele—Owner of "Just Cats" store, New York

Other members of the council are: *Dr. George W. Abbott*, retired veterinarian, Rhode Island; *Dr. Jane Bicks,* Fauna Foods, New York; *Joan Blackburn*, Blackburn Drives & Controls, Texas; *George Cook*, Ralston-Purina, Missouri; *Hazel Lindstrand*, CFA judge and breeder, Illinois; *Dr. Mark L. Morris, Jr.*, Morris Animal Foundation, Kansas; *Barbara Royer*, Carnation Co., California; *Ellen Sawyer*, TreeHouse Animal Foundation, Illinois; *Mordecai Siegal*, author, New York; *Dr. Barbara S. Stein*, Chicago Cat Clinic, Illinois; and *Joan Wastlhuber*, Winn Foundation and CFA judge, California.

Each member serves a term of three years. The council meets yearly to assist the Feline Health Center in developing long-range goals, publicity and public relations plans, and fund-raising ideas. Representing the interests of cat owners, cat breeders, animal shelters, the veterinary profession, scientific community, and pet-related industry, the Council provides a balanced outlook and valuable suggestions. The Feline Health Center is privileged to have these dedicated people contributing their skills and talents to improve the health and welfare of cats. ■

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