# Everything you need to know about Genetics...

## *You can learn from your Cat!*

### PART ONE

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DOMESTIC CATS -
We see them every day, in our households, on the farm, and in the streets. Their various colors and patterns are fascinating, the perfect camouflage. And yes, if we pay a little more attention – we can learn everything we need to know about genetics, from our cats!

Cats have been at the forefront of genetics since the rediscover of Mendelians Laws of Inheritance in the 1890's. This recurring column will work our way through the history and science of cat genetics. We will discuss the early discoveries of inheritance patterns and cat mutation population data, reveal some of the early highlights of gene mapping, discuss the current state of genetic testing for cats for their diseases and traits and bring ourselves forward to the era of genomics and Precision Medicine for cats in the 21st century.

Gregor Mendel, the father of the science of genetics, was an Augustinian Monk who studied seven different traits in pea plants (plant height, pod shape and color, seed shape and color, and flower position and color) and established many of the rules of heredity, primarily dominant, recessive and co-dominant inheritance patterns and the rules of segregation and independent assortment, known as Mendel's Laws of Inheritance. Mendel conducted his research between 1856 to 1863 and published his findings in 1866, which then went unnoticed for the next three decades.

Meanwhile, Charles Darwin, an English geologist and naturalist, gathered compelling evidence for his theories of evolution and natural selection during his voyage on the *HMS Beagle* from 1831 – 1836. However, Darwin did not publish his research until 1859, in his book *"On the Origin of the Species"*. Darwin continued gathering data that supported his theories, including field trips to the first cat shows in the 1870's in the UK.

In the early 20th century, Mendel's Laws were rediscovered and the role of natural and artificial selection in various species, including cats, began to be deciphered. As several of Mendel's traits had dominant inheritance, scientists were scanning species for similarly performance of visible characteristics in other animals. The Reverend William M. Hind (1815 – 1894) noticed the taillessness of the Manx cats could be a candidate for dominant inheritance[1].

Thomas Hunt Morgan (1866 – 1945) is credited with the discovery of sex linkage using fruit flies, along with Leonard Doncaster (1877 – 1970), who realized the orange coloration of the tortoiseshell female and orange males was also sex linked[2]. Thus, the *Orange* locus in cats was one of the first traits, for any species, to be localized to a specific chromosome!

**Figure 1. Everything you need to know about genetics, you can learn from you cat!**
The calico cat can teach us about many aspects of genetics, including, dominant and recessive inheritance, variable expression, plieotrophic effects, co-dominance, sex-linkage, Lyonization (X-inactivation and epigenetics). Photo (Sadie) courtesy L. Solecki.

EDITOR:

This is the first

in a series

of articles

based on

feline genetics

by Dr Leslie Lyons

that will be

published in

FELIS HISTORICA

in the ensuing months

Charles B. Davenport (1866 – 1944) was one of the first American geneticists, supporting the rediscovery of Mendel's laws. He recognized cats had many visible traits demonstrating different inheritance patterns, such as, white coat, long fur, tailless, polydactyla, yellow (Orange) and maltese (blue dilution) and he documented his early observations[3].

Dr. Davenport later became one of the leaders of the American eugenics movement, as did Clarence C. Little (1888 – 1971), who made significant contributions to color genetics in the domestic mouse and examined the cat *Orange* locus[4]. Cat chromosomes were visualized as early as 1909[5], however, the correct number of autosomes (18) and the X-Y sex chromosomes were finally demonstrated in 1928 by Osamu Minouchi[6]. Once the chromosomes of cats were depicted using karyotypes, many investigators showed tortoiseshell male cats were chromosomally abnormal as either being XXY or XX/XY chimerism.

By examining just calico cats (Figure 1), we will discover the Mendelian Law's of dominant and recessive inheritance, begin to understand what causes variable expression, plieotrophic effects, co-dominance, sex-linkage, Lyonization and why Cc, the first cloned cat, does not like her nuclei donor, a calico cat named Rainbow!

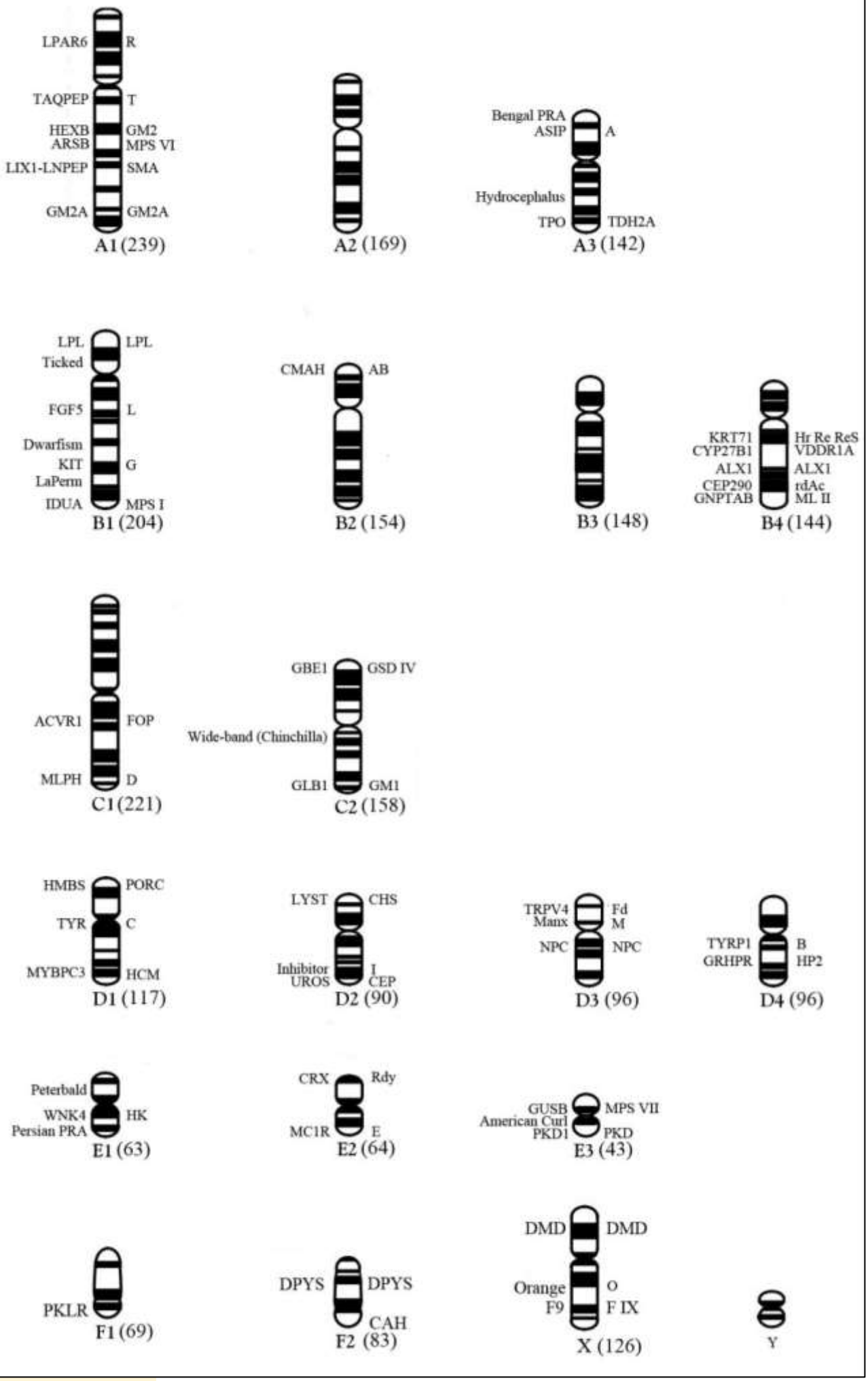
LPAR6
R
TAQPEP
T
HEXB
GM2
ARSB
MPS VI
LIX1-LNPEP
SMA
GM2A
GM2A
A1 (239)
A2 (169)
Bengal PRA
ASIP
A
Hydrocephalus
TPO
TDH2A
A3 (142)
LPL
LPL
Ticked
FGF5
L
Dwarfism
KIT
G
LaPerm
IDUA
MPS I
B1 (204)
CMAH
AB
B2 (154)
B3 (148)
KRT71
Hr Re ReS
CYP27B1
VDDR1A
ALX1
ALX1
CEP290
rdAc
GNPTAB
ML II
B4 (144)
ACVR1
FOP
MLPH
D
C1 (221)
GBE1
GSD IV
Wide-band (Chinchilla)
GLB1
GM1
C2 (158)
HMBS
PORC
TYR
C
MYBPC3
HCM
D1 (117)
LYST
CHS
Inhibitor
I
UROS
CEP
D2 (90)
TRPV4
Fd
Manx
M
NPC
NPC
D3 (96)
TYRP1
B
GRHPR
HP2
D4 (96)
Peterbald
WNK4
HK
Persian PRA
E1 (63)
CRX
Rdy
MC1R
E
E2 (64)
GUSB
MPS VII
American Curl
PKD1
PKD
E3 (43)
PKLR
F1 (69)
DPYS
DPYS
CAH
F2 (83)
DMD
DMD
Orange
O
F9
F IX
X (126)
Y

**Figure 2. Genetic anatomy of the cat.** The ideogram represents the 18 autosomes and the X and Y chromosomes of the domestic cat. The nomenclature and the size in megabases are depicted under each chromosome.

Left of each chromosome is the gene name and on the right is the locus name for traits to be discussed in future issues.

We will use what we learn about basic genetics, to understand the different patterns, colors, fur types, body structures and diseases that make our domestic cats and their fancy breeds fascinating and unique.

As my own adventure in cat genetics began at the National Cancer Institute in 1992, Roy Robinson published his last compilation of cat genetics in 1991, expanding on the first works of RC Bamber[8] and then AC Jude[9]. Over 75 traits and diseases are now of common concern for cat breeders (Figure 2).

This column will update these bibles of cat genetics and traits and bring our knowledge forward to cat Precision Medicine of the 21st Century.

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