PROS AND CONS OF INBREEDING

Inbreeding is the mating together of closely related cats, for example mother/son, father/daughter, sibling/sibling matings and half-sibling/half-sibling. It is the pairing of animals which are more closely related than the average population. For breeders, it is a useful way of fixing traits in a breed - the pedigrees of some exhibition cats show that many of their forebears are closely related. For example, the name of Fan Tee Cee (shown in the 1960s and 1970s) appeared in more and more Siamese pedigrees, sometimes several times in a single pedigree, as breeders were anxious to make their lines more typey. Superb specimens are always much sought after for stud services or offspring (unless they have already been neutered; cloning may solve that problem in the future) having won the approval of show judges.

To produce cats which closely meet the breed standard, breeders commonly mate together animals which are related and which share desirable characteristics. Over time, sometimes only one or two generations, those characteristics will become homozygous (genetically uniform) and all offspring of the inbred animal will inherit the genes for those characteristics (breed true). Breeders can predict how the offspring will look. "Line-breeding" is not a term used by geneticists, but comes from livestock husbandry. It indicates milder forms of inbreeding. Line-breeding is still a form of inbreeding i.e. breeding within a family line and includes cousin/cousin, aunt/nephew, niece/uncle and grandparent/grandchild. The difference between line-breeding and inbreeding may be defined differently for different species of animals and even for different breeds within the same species. It is complicated by the fact that a cat's half-brother might also be her father!

However, inbreeding holds potential problems. The limited gene-pool caused by continued inbreeding means that deleterious genes become widespread and the breed loses vigour. Laboratory animal suppliers depend on this to create uniform strains of animal which are immuno-depressed or breed true for a particular disorder e.g. epilepsy. Such animals are so inbred as to be genetically identical (clones!), a situation normally only seen in identical twins. Similarly, a controlled amount of inbreeding can be used to fix desirable traits in farm livestock e.g. milk yield, lean/fat ratios, rate of growth etc. In human terms, inbreeding is considered incest; cats do not have incest taboos.

Outcrossing is when the two parents are totally unrelated. In pedigree animals, this often means where a common ancestor does not occur behind either parent within a four or five generation pedigree. In animals with a small foundation gene pool, this condition is difficult to meet.

First I will define some terms used by animal breeders. In general I've avoided specialist terms, but you will meet these terms outside of this article.

Homozygous means having inherited the same "gene" for a particular trait from both parent e.g. for fur length. Barring random mutation, 100% of the offspring of a homozygous individual will inherit that gene. Inbreeding increases homozygosity by "fixing" a particular trait. Purebred animals display a high degree of homozygosity compared to mixed breeds and random-bred animals. The idea of purebred animals is that they should "breed true". When one purebred is mated with another of the same breed, the offspring will have uniform characteristics and will resemble the parents.

Heterozygous means having inherited a different gene for a particular trait from each parent. For example one gene of long fur (recessive) and one gene for short fur (dominant). 50% of a heterozygous individual's offspring will inherit one form and 50% will inherit the other. Carefully controlled "out-crossing" increases heterozygosity for selected traits by introducing new genes into the hybrid offspring.

Heterosis is the scientific term for hybrid vigour. It is possible that there are "bad" genes which produce less vigourous individuals when in the homozygous state because good genes have been bred out along with the undesirable characteristics; theoretically the bad genes could be bred out, but in practice this doesn't seem to happen. The other theory is simply that you simply need to have a mixture of two different genes to get the desired effect as they somehow complement each other; highly inbred animals lack this diversity and have poorer immune systems.

Sex-linked refers to a trait which is passed on, or determined by, a particular gender. In Abyssinian cats there are several versions of the red colour. One is sex-linked i.e. a male cat only needs one copy of the gene, but a female needs two copies of the gene to produce the red colour.

Degree of homozygosity means the number of genes an animal is homozygous for. If most of its genes are matched pairs it has a high degree of homozygosity; if most of its genes are mismatched pairs it has a low degree of homozygosity. An animal can be homozygous for some traits, but heterozygous for others.

NATURAL OCCURRANCE OF INBREEDING

This is not to say that inbreeding does not occur naturally. A feral colony which is isolated from other cats, by geographical or other factors, can become very inbred especially if a dominant male mates with his sisters, then with his daughters and grand-daughters. When he is deposed it will most likely be by his own son or grandson which therefore continues the inbreeding. The effect of any deleterious genes becomes noticeable in later generations as the majority of the offspring inherit these genes. Scientists have discovered that cheetahs, even if living in different

areas, are genetically very similar. Possibly disease or disaster drastically reduced cheetah numbers in the past creating a genetic bottleneck. All modern day cheetahs may be descended from a single surviving family unit hence their genetic uniformity.

In the Cheetah, the lack of genetic diversity makes them susceptible to disease since they lack the ability to resist certain viruses. Extreme inbreeding affects their reproductive success with small litter sizes and high mortality rates. Some scientists hope that the appearance of the "King Cheetah", characterised by its blotched markings, means that the Cheetah can develop a healthier gene-pool through mutation (provided man doesn't wipe them out in the meantime). Mankind has contributed to the loss of diversity by sport-hunting cheetahs and reducing the number of available mates. Hunters preferred to shoot unusual specimens (i.e. genetically diverse ones) for the trophy room and this previously included long-haired "woolly cheetahs" and grey/blue cheetahs indicating much greater genetic diversity in the past.

Despite the hopes of scientists, some cheetah populations are showing further signs of inbreeding. Confined to ever-smaller areas such as wildlife reserves, the populations have become genetically isolated from each other. In one population there is an increasing frequency of misaligned jaws and kinked tails. Continued inbreeding will reinforce, or fix, these traits. Ultimately, they could reduce the cheetah's hunting effectiveness - the kinked tail will reduce its agility and cornering ability and the misaligned jaws may not be able to hold onto prey.

The wolf was once widespread throughout North American, but many of the remaining packs are isolated and have become inbred. The isolation/inbreeding problem has become so acute that conservationists have taken wolves from one area and introduced them into a another area to revitalise the gene pool. In some areas, the choice of mates is so reduced that wolves have resorted to mating with domestic dogs - an extreme form of outcrossing called hybridization. A similar situation in Scotland where the Scottish Wildcat mates with domestic cats is threatening to wipe out the wildcat as domestic cat genes become more widespread. These are two cases where outcrossing (following, and followed by, inbreeding) may lead to extinction of a species (analogous to loss of type in domestic breeds).

Another animal suffering from the effects of inbreeding is the Giant Panda. As with the Cheetah, this has led to poor fertility among Pandas and high infant mortality rates. As Panda populations become more isolated from one another (due to humans blocking the routes which Pandas once used to move from one area to another), Pandas have greater difficulty in finding a mate with a different mix of genes and breed less successfully. It is almost inevitable that the Giant Panda will become extinct even if cloning techniques become available since the gene pool is now probably too impoverished for the species' long term viability. It may, therefore, be considered that all purebred animals will ultimately become unviable through inbreeding and that breeders must work carefully to maintain type while slowing down the detrimental effects of selective breeding.

There have been numerous studies into inbreeding and viability. Mandarte Island, off Vancouver, Canada is so tiny that every single song sparrow can be ringed, monitored and matings recorded. Researchers know exactly how inbred each individual is. When severe winter storms wiped out over 90% of the birds, Lukas Keller of Zurich University, Switzerland found that all inbred individuals were killed. He defined "inbred" as matings between first cousins or closer. Loeske Kruuk, Edinburgh University, Scotland found that collared flycatchers born from brother-sister matings were more than 90% less likely to survive to maturity than offspring of non-incestuous matings. Ilkka Hanski of Helsinki University, Finland found that 50% of male offspring of brother-sister matings in a certain species of African butterfly were sterile.

Natural isolation and inbreeding have given rise to domestic cat breeds such as the Manx which developed on an island so that the gene for taillessness became widespread despite the problems associated with it. Apart from the odd cat jumping ship on the Isle of Man, there was little outcrossing and the effect of inbreeding is reflected in smaller-than-average litter sizes (geneticists believe that more Manx kittens than previously thought are reabsorbed due to genetic abnormality), stillbirths and spinal abnormalities which diligent breeders have worked so hard to eliminate.

As mentioned, some feral colonies become highly inbred due to being isolated from other cats (e.g. on a remote farm) or because other potential mates in the area have been neutered, removing them from the gene pool. Most cat workers dealing with ferals have encountered some of the effects of inbreeding. Within such colonies there may be a higher than average occurrence of certain traits. Some are not serious e.g. a predominance of calico pattern cats. Other inherited traits which can be found in greater than average numbers in inbred colonies include polydactyly (the most extreme case reported so far being an American cat with 9 toes on each foot), dwarfism (although dwarf female cats can have problems when try to deliver kittens due to the kittens' head size), other structural deformities or a predisposition to certain inheritable conditions.

The ultimate result of continued inbreeding is terminal lack of vigour and probable extinction as the gene pool contracts, fertility decreases, abnormalities increase and mortality rates rise. On the other hand, too much outcrossing will cause loss of type and therefore the loss of a distinct breed.

SELECTIVE BREEDING

Artificial isolation (selective breeding) produces a similar effect. When creating a new breed from an attractive mutation, the gene pool is initially necessarily small with frequent matings between related cats. Some breeds which resulted from spontaneous mutation have been fraught with problems such as spasticity (cerebellar hypoplasia) in Devon Rexes, skeletal problems in Scottish Folds and the effects of a semi-lethal gene (aka deferred lethal gene) in Manxes and the lethal gene in Ojos Azules. Problems such as hip dysplasia and patella luxation are more common in certain breeds and breeding lines than in others, suggesting that past inbreeding has distributed the faulty genes. Selecting suitable outcrosses can reintroduce healthy genes, which might otherwise be lost, without adversely affecting type.

Just as Fan Tee Cee changed the shape of the Siamese, a cat called Good Fortune Fortunatus in the 1970s changed the shape of Burmese cats in the United States and gave rise to the "Contemporary" look now fashionable in that country. American Burmese changed from being moderate, foreign-type cats into short-nosed, round-headed, barrel-chested cats which some have described as "pug-like". Unfortunately, the "Burmese head fault", a lethal condition that requires euthanasia, came hand-in-hand with the "Contemporary" look. As more people wanted the new look in their breeding lines, so the lethal defect spread. Burmese cats in Europe, Australia and New Zealand were not influenced by the Fortunatus lookand are free of the hereditary fault; in addition, occasional outcrossing to introduce new colours has ensured that European lines do not become so inbred.

Another example of a lethal gene which determines a breed trait is the blue-eyed Ojos Azules. The gene is lethal in the homozygous form causing stillbirth, cranial deformities, white fur and a small curled tail. In the heterozygous form, the Ojos Azules are blue eyed non-white cats. Breeders must therefore breed blue-eyed cats (heterozygous) to non-blue-eyed cats (lacking the gene for the eye colour, but having the conformation) in order to get a roughly 50/50 split of blue-eyed and non-blue-eyed kittens while avoiding deformed dead kittens.

The more that inbreeding is used to get rid of undesirable traits or to fix a desirable trait, the more likely it is that individuals will also inherit the same set of genes for the immune system from both parents, and be born with less vigourous immune systems. The immune system problem is compounded over successive generations as the animals become genetically more uniform (like the cheetah). According to one theory, immunodeficiency may be caused by a simple lack of heterozygosity in the genes that control the immune system. This is why random-bred cats are generally so robust.

Breeder and author Phyllis Lauder wrote in 1981: "Favoured varieties of today have been bred sire to daughter and cousin to cousin until their breeds are ruined [...] man's insistence on upon breeding in order to perpetuate features approved in the show ring has produced animals of weak constitution, prone to such conditions as skin troubles, lacking in intelligence, no longer mentally alert, eventually stupid; and at last breeding with difficulty: a state of affairs leading in the end to the sterility and death of the breed."

Zoos engaged in captive breeding programs are aware of this need to outcross their own stock to animals from other collections. Captive populations are at risk from inbreeding since relatively few mates are available to the animals, hence zoos must borrow animals from each other in order to maintain the genetic diversity of offspring. In sheep, centuries of selective breeding to improve the quality of wool has caused an important trait to be lost. Ancestral sheep could breed more than once per year. Modern sheep breed once per year. Only recently has the importance of the lost gene been realised (i.e. to increase meat yield), but to reintroduce it from primitive sheep would reduce other qualities selectively bred for over centuries.

Most laboratory mice are becoming so highly inbred that they would probably not survive outside of a sterile laboratory due to poor immune systems (they are generally killed before this becomes a problem in the laboratory situation) and some strains become extinct due to reproductive failure. Many are selectively bred to exhibit defects which will kill them.

Inbreeding holds problems for anyone involved in animal husbandry - from canary fanciers to farmers. Early Turkish Vans were reported to be temperamental, a problem apparently rectified by the importation of new stock. Attempts to change the appearance of Burmese cats in America to produce a cat with a rounder head resulted in cats with congenital problems. Siamese cats have become progressively finer-boned as breeders strive to emphasise the foreign look, resulting in frailer cats in some breeding lines.

In the dog world, a number of breeds now exhibit hereditary faults due to the over-use of a particularly "typey" stud which was later found to carry a gene detrimental to health. By the time the problems came to light they had already become widespread as the stud had been extensively used to "improve" the breed. In the past some breeds were crossed with dogs from different breeds in order to improve type, but nowadays the emphasis is on preserving breed purity and avoiding mongrels.

Those involved with minority breeds (rare breeds) of livestock face a dilemma as they try to balance purity against the risk of genetic conformity. Enthusiasts preserve minority breeds because their genes may prove useful to farmers in the future, but at the same time the low numbers of the breed involved means that it runs the risk of becoming unhealthily inbred. When trying to bring a breed back from the point of extinction, the introduction of "new blood" through crossing with an unrelated breed is usually a last resort because it can change the very character of the breed being preserved (as noted by cat fanciers when Russian Blues were crossed to Blue Point Siamese after World

War II). In livestock, successive generations of progeny must be bred back to a purebred ancestor for 6 - 8 generations before the offspring can be considered purebred themselves.

In the cat fancy, breed purity is equally desirable, but can be taken to ridiculous lengths. Some fancies will not recognise "hybrid" breeds such as the Tonkinese because it produces variants (yet Manxes are recognised and also produce variants). Breeds which cannot produce some degree of variability among their offspring risk finding themselves in the same predicament as Cheetahs and Giant Pandas. Such fancies have lost sight of the fact that they are registering "pedigree" cats, not "pure-bred" cats, especially since they may recognise breeds which require occasional outcrossing to maintain type!

The breed purity debate goes along these lines: should a breed be based on genotype (what genes it inherited) or phenotype (appearance, despite an out-cross four generations ago) A Tabby-point Siamese is phenotypically Siamese, but because the tabby pattern was introduced from non-Siamese cats, genotype-followers consider it "not Siamese" and are worried it will pollute their purebred breeding lines. In some registries, Exotic Longhairs are identical to Persians, but may not be bred with Persians. Likewise, some registries do not allow chocolate or lilac Persians to be classed as Persians because the colours were introduced from Siamese cats (via the Himalayan breed) umpteen generations ago and are therefore "tainted". Those "tainted" genes may be bundled with whole lot of healthy genes; by not outcrossing "purebreds" to "tainted" cats, the opportunity to increase the heterozygosity of the immune system is lost (there is a footnote on phenotype/genotype/purebred/pedigree philosophies).

One formula to reduce inbreeding and slow down the loss of vigour is to line-breed for 2-3 generation and then out-cross to an unrelated line (or occasionally another breed) to get back hybrid vigour and genetic diversity. However with the emphasis on breeding for type and competitiveness on the showbench (and when making a sale), the typey studs get used more and more often and there is less and less chance of finding a truly unrelated line.

See The Pros and Cons of Cloning for further discussion on inbreeding hazards should cloning of typey animals become permissible.

EFFECT OF SELECTIVE BREEDING ON GENETIC DIVERSITY

In their study comparing the genetics of several breeds (Lipinski MJ, et al., The ascent of cat breeds: genetic evaluations of breeds and worldwide random-bred populations, Genomics (2007), researchers found artificial selection had reduced genetic diversity within single breeds. The study confirmed that cat breeds are less genetically diverse than random-bred cats. Lipinski et al, found that loss of diversity did not correlate with breed popularity or age, but did correlate with the number of foundation animals from which a breed was established (and the degree of permitted outcrossing). The Burmese, Havana Brown, Singapura, and Sokoke were least genetically diverse.

The Burmese and Singapura breeds were the least genetically diverse of the breeds sampled, reflectting the most intense inbreeding . The Burmese was descended from a Tonkinese-type female called Wong Mau. The Singapura is largely a derivative of the Burmese in spite of a fanciful mythology about it being an indigenous Singaporean cat (in Holland there are cats identical to the Singapura that have been bred from wholly Burmese lines). The Sokoke is a recent breed being developed from a small pool of distinctive looking cats found in the Sokoke forest region of Kenya. Outside of the USA, the Havana brown is a colour variant of Oriental cats.

The Siberian was the most genetically diverse and comparable to the genetic diversity in random-bred cats due to having a broad foundation stock. The Norwegian Forest Cat, Persian (and related Exotic) and British Shorthair were also genetically diverse, reflecting multiple lineages (the Persian was developed in the 19th century from a mix of Turkish, Russian and British longhairs and other genes have crept in along the way during the development of other breeds; including Siamese genes and even rex genes).

IMPLICATIONS OF INBREEDING FOR THE CAT BREEDER

Most cat breeders are well aware of potential pitfalls associated with inbreeding although it is tempting for a novice to continue to use one or two closely related lines in order to preserve or improve type. Breeding to an unrelated line of the same breed (where possible) or outcrossing to another breed (where permissible) can ensure vigour. Despite the risk of importing a few undesirable traits which may take a while to breed out, outcrossing can prevent a breed from stagnating by introducing fresh genes into the gene pool. It is important to outcross to a variety of different cats, considered to be genetically "sound" (do any of their previous offspring exhibit undesirable traits?) and preferably not closely related to each other. Outcrossing is made difficult by the amount of inbreeding in previous generations - it becomes hard to find cats which are not related, sometimes several times over.

How can you tell if a breed or line is becoming too closely inbred? One sign is that of reduced fertility in either males or females. Male Cheetahs are known to have a low fertility rate. Failure to conceive, small litter sizes and high kitten mortality on a regular basis indicates that the cats may be becoming too closely related. The loss of a large proportion of cats to one disease (e.g. enteritis) indicates that the cats are losing/have lost immune system diversity. If 50% of individuals in a breeding program die of a simple infection, there is cause for concern.

Highly inbred cats also display abnormalities on a regular basis as "bad" genes become more widespread. These abnormalities can be simple undesirable characteristics such as misaligned jaws (poor bite) or more serious

deformities. Sometimes a fault can be traced to a single stud or queen which should be removed from the breeding program even if it does exhibit exceptional type. If its previous progeny are already breeding it's tempting to think "Pandora's Box is already open and the damage done so I'll turn a blind eye". Ignoring the fault and continuing to breed from the cat will cause the faulty genes to become even more widespread in the breed, causing problems later on if its descendants are bred together.

One breed which was almost lost because of inbreeding is the American Bobtail. Inexperienced breeders tried to produce a colourpoint bobtailed cat with white boots and white blaze and which bred true for type and colour, but only succeeded in producing unhealthy inbred cats with poor temperaments. A later breeder had to outcross the small fine-boned cats she took on, at the same time abandoning the rules governing colour and pattern, in order to reproduce the large, robust cats required by the standard and get the breed on a sound genetic footing.

	PROS	**CONS**
INBREEDING (Mating of closely related individuals)	Produces uniform or predictable offspring. Hidden (recessive) genes show up and can be eliminated. Individuals will "breed true" and are "pure." Doubles up good genes. Eliminates unwanted traits.	Doubles up on faults and weaknesses. Progressive loss of vigor and immune response. Increased reproductive failures, fewer offspring. Emphasis on appearance means accidental loss of "good" genes for other attributes. Genetically impoverished individuals.
LINE-BREEDING (Mating of less closely related individuals)	Avoid inbreeding of very closely-related cats, but cats are still "pure". Produces uniform or predictable offspring. Slows genetic impoverishment.	Require excellent individuals. Does not halt genetic impoverishment, only slows it down.
OUTCROSSING (Mating of unrelated individuals within the same breed)	Brings in new qualities or reintroduces lost qualities. Increases vigor. Cats are still "pure".	Less consistency and predictability of offspring. May have to breed out unwanted genes accidentally introduced at same time. May be hard to find individuals which are true outcrosses.
HYBRIDIZATION (Mating of unrelated individuals of different breeds)	Brings in new qualities or reintroduces lost qualities. Increases vigor, may improve immune system and reproductive capacity. Introduces totally new traits e.g. color. Fur type. May result in new breeds. The offspring are considered "impure" for many generations.	Unpredictable - new traits may not all be desirable. Must choose outcross breed whose qualities complement or match own breed. May take years to eliminate unwanted traits/loss of type. May take years to get consistent offspring. Produces many variants not suitable for use in breeding program.

GENOMICS

As well as recording matings and tracing pedigrees, modern biologists can look for genetic evidence of inbreeding in an individual's genome (genomics). Zoologist Bill Amos at Cambridge University, England analyses genetic markers to assess how closely related an individual's parents are. This allows them to look at the effect of inbreeding in wild populaitons, something previously difficult or impossible as it was not possible to trace pedigrees. Although not foolproof, blood testing and genetic analysis can indicate how closely animals are related.

As well as inheriting copies of genes from each parent, animals inherit sections of non-coding ("junk") DNA which can be used as genetic markers and are known as microsatellites. As well as being homozygous or heterozygous for genes, animals can be homozygous or heterozygous for these microsatellites. Even without inbreeding, some markers are naturally more widespread in a population than others. Looking at several markers at a time gives a better measure of relatedness (the more markers which can be tracked, the better the results). Some of those markers may be next door to beneficial or harmful genes (or, because many genes work in association with other genes, next door to genes which are influenced by other "good" or "bad" genes elsewhere in the genome) - in the absence of artificial selection by breeders, markers next to "good" genes will be more widespread than those next to "bad" genes because the "bad" genes make the animal less likely to survive.

The technique is not foolproof, but if Amos's currently controversial calculations do turn out to be correct, inbreeding is more damaging than previously realised and even cousin-cousin matings may result in inbreeding depression. His

studies suggest inbreeding is more important than environmental challenges in determining an individual's chances of survival. The "degree of microsatellite homozygosity" (what Amos calls "internal relatedness") means the number of identical markers. Animals with high microsatellite homozygosity fare worse than highly heterozygous individuals. In island-living wild Soay sheep, those with higher homozygosity also had more parasitic worms and were more likely to be sick.

Amos suggests that the disadvantages of inbreeding are more pervasive than previous suspected. In the past, inbreeding was considered relatively unimportant compared to environmental challenges such as finding food, finding mates or avoiding predators. Amos suggests that animals with higher internal relatedness produce fewer young and suffer more from disease, parasites or cancer. In nature, inbred individuals tend not to survive; this removes harmful mutations from the population. Inbreeding depression is known to affect the immune system. Artificial selection by breeders means genetically weak individuals, which would normally be weeded out by natural selection, get a chance to pass on their mutations to another generation and, being more prone to disease, will need more medical care during their lifetimes than less inbred individuals.

As well as selecting animals for physical traits, it is important to select them for health traits as the prevalence of Polycystic Kidney Disease in Persians and Exotics demonstrates. Registries may have to permit more outcrossing between breeds to ensure the vigour of any single breed. Currently, many gene pools are closed (no more outcrossing) when the desired traits are fixed and a certain population level is reached.

CONCLUSION

Inbreeding is a two-edged sword. On the one hand a certain amount of inbreeding can fix and improve type to produce excellent quality animals. On the other hand, excessive inbreeding can limit the gene pool so that the breed loses vigour. Breeds in the early stages of development are most vulnerable as numbers are small and the cats may be closely related to one another. It is up to the responsible breeder to balance inbreeding against crossings with unrelated cats in order to maintain the overall health of the line or breed concerned.

FOOTNOTE: THE CHEETAH

In January 2003, India announced plans to clone cheetahs to help restore the Indian sub-continent's now extinct cheetah population. India plan to clone cheetahs from Iran where about 50 Asiatic Cheetahs remain.

Cloning creates genetically identical individuals. However, cheetahs are already so highly inbred that individuals are already almost genetically identical so the impact of clones on the population will be to increase numbers rather than further decease genetic variation. If it uses the leopard's own egg cells it would introduce the leopard's mitochondrial DNA (the DNA found in an egg cell) into the cheetah population.

FOOTNOTE: PUREBRED VS PEDIGREE; PHENOTYPE VS GENOTYPE

There is a long-running and often bitter in several cat registries about recognising and perpetuating breeds based on phenotype or on genotype. Phenotype means "what it looks like" while genotype means "its genetic make-up". The latter requires a cat's pedigree to be known over several generations and for the pedigree to contain only cats of the same breed.

The debate has been a long-running one among breeders of Persian and Siamese cats; this is hardly surprising as recognition of these two breeds dates back to the dawn of the cat fancy in the 1870s and 1880s. Should the "new" colours of Siamese (red points, tortie points etc) be recognised as Siamese or should they be kept separate e.g. as Javanese, because their bloodlines are not pure; the same applies to self chocolate and self lilac in Persians since these colours came from the Siamese via the colourpoint Persian (Himalayan). Among rare breed livestock breeders, the 7th generation offspring of an outcross is considered purebred if each generation of offpring have been backcrossed to a pure bred animal following the initial outcross. In cat breeding, the only remaining trait from the outcross might be the new colour, but among extremely pro-genotype cat breeders, that bloodline is considered forever tainted by the outcross and will never produce "purebred" cats. Some pro-genotype breeders admit to wanting cat fancying to remain an elite hobby, with only "purebred" cats tracing back to original stock being accepted for breeding.

Among pro-phenotype breeders, the situation is somewhat different. If it looks like a Siamese in all respects, apart from the new colour, then it is accepted as a Siamese regardless of mixed ancestry several generations back. They accuse the pro-genotype breeders of unnecessary snobbery and point out the dangers of inbreeding. The separation of the new colours of Siamese and Persians is considered artificial since the cats' conformation is unchanged.

As mentioned earlier, pro-genotype cat fanciers lose sight of the fact that they are registering *pedigree* cats - pedigree does not mean the same as purebred! *All* breeds began based on phenotype i.e. what they looked like. For example, naturally occurring cats with a particular "look" might gathered together and called a breed e.g. the British Shorthair or Maine Coon. These are considered natural breeds. Even where the foundation cats are pedigree members of different breeds, the new breed is selected for, and refined, according to its appearance. In the early days of a breed it sometimes becomes necessary to accept cats of unknown ancestry but appropriate appearance into the breed to expand the bloodlines and prevent a dangerous level of inbreeding. All breeds have to start somewhere - and that somewhere has a phenotypic basis.

One danger, pointed out by pro-genotype breeders is that accepting "lookalike" cats into a breed with a known genotype can introduce unwelcome unknown genes which could become widespread and result in undesirable traits later on. If the two faction, pro-genotype and pro-phenotype, diverge any further, it will result in different variants of breeds being recognised - not just a split along tradition vs classic vs contemporary lines, but a split along the lines of "Phenotypic Siamese" and "Genotypic Siamese" with the two strains no longer being interbred for fear of taining the genotypically "pure" variety. Isolating a strain to keep its genotype pure means it will inevitably become inbred.

There needs to be a sensible balance. When enough generations have elapsed, a descendant far removed from the original outcross is, to all intents and purposes, purebred. The variation in its genes from the outcross is probably no greater than the variation due to natural mutation. Breeds in their infancy may need to pursue phenotypic breeding programs until the gene pool is wide enough to support breeding along genotypic lines. To revisit the example of Siamese cats - the early imports may have been seal and the earliest colours seal, blue, chocolate and lilac, but in their homeland, as I have witnessed on the streets of Malaysia and Thailand, colourpoint cats occur in all colours! It is only a quirk of cat fancy history that has led to those first four colours being declared true Siamese colours and the others being considered "introduced" colours.