



# **A Review of Coat Varieties & Genetics in the Domestic Rat**

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**By: Alan diGangi**

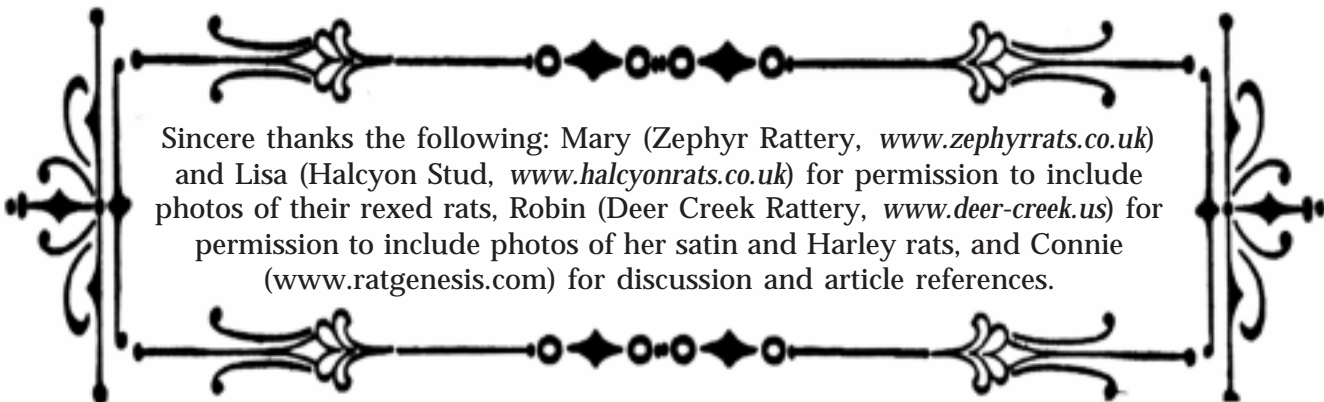


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Sincere thanks the following: Mary (Zephyr Rattery, [www.zephyrrats.co.uk](http://www.zephyrrats.co.uk)) and Lisa (Halcyon Stud, [www.halcyonrats.co.uk](http://www.halcyonrats.co.uk)) for permission to include photos of their rexed rats, Robin (Deer Creek Rattery, [www.deer-creek.us](http://www.deer-creek.us)) for permission to include photos of her satin and Harley rats, and Connie ([www.ratgenesis.com](http://www.ratgenesis.com)) for discussion and article references.



Many mutations affect the rat's coat. Some have won the appreciation of fanciers, while others are scorned. Due to considerable overlap in appearance, many of the coat mutations can be difficult to tell apart.

This booklet reviews the biology of the rat's coat, what different coat varieties look like, their history when known and some of the many genetic mutations. Some of the varieties discussed in this booklet are controversial because some feel that research proves these rats are disabled or unhealthy; others disagree, pointing out how healthy and able-bodied their pet rats are. Because we cannot experience life as a rat, nor can we ask our rats how they feel, we must rely on observations and research to form our opinions. It is best to respect, rather than vilify, those whose opinion differs from ours. There are some mutations described in this booklet that are, without question, deleterious (eg: Rowett nude and masked). They are included for completeness, not as support for perpetuating these mutations in the fancy.

Feedback is welcomed, and as new information becomes available, updated versions of this booklet will be made available on [RodentFancy.com](http://RodentFancy.com)

## The Development of the Rat's Coat

A rat's coat begins to develop when it has been in the womb for 17 days, but the hair does not break through the skin until the second day after birth. By the twelfth day, the rat is fully covered in fine fur.

The adult coat begins to replace the juvenile coat when the rat is about a month old. It takes about twenty days for this moult to be completed. During this time, it is common to see a wavy boundary between the two coats, which have notably different textures. Often the coat colour may appear to be a different shade. People new to rats sometimes mistake this for a rat with two different fur colours (three, if white spotting is present). Rats continue to moult for the rest of their lives, but it is usually not as noticeable as the first moult.

The hair follicles are clustered in groups of three. One is a guard hair which is coarser and longer; the other two are fine and significantly shorter than the guard hair. The guard hairs come in different lengths, the longest of which are called *monotrichs*; medium and shorter guard hairs are called *awls* and *auchenes* respectively. The guard hairs, which collectively make up the *overcoat*, have several functions. They protect the undercoat, and

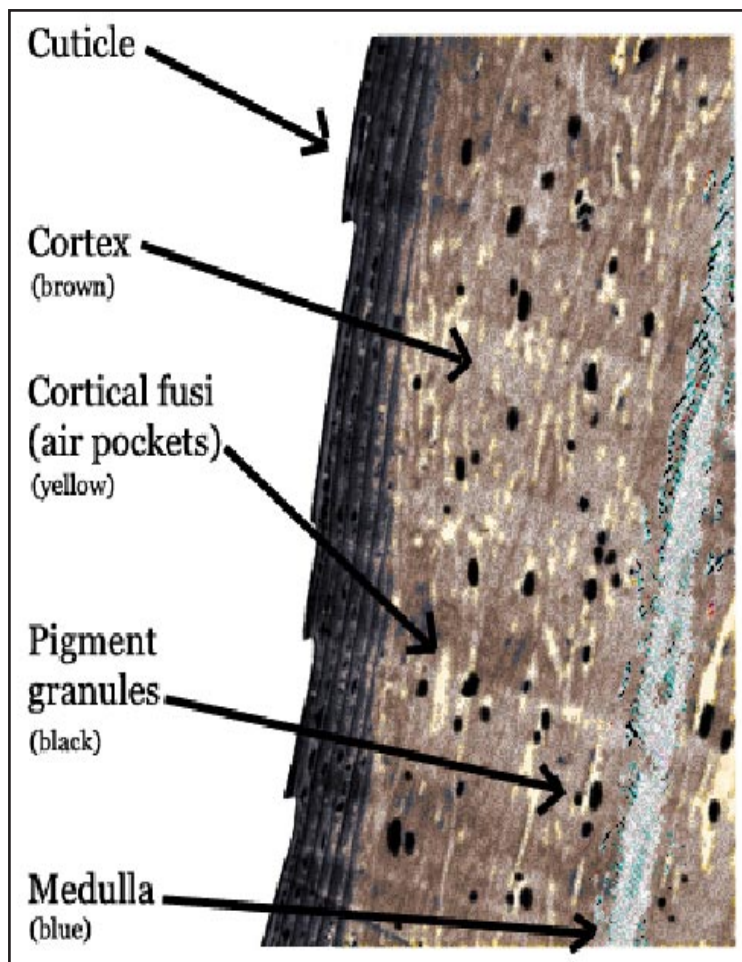
have some waterproofing function. The longest guard hairs may also provide the rat with some sensory information about the physical surroundings. The short fur is usually referred to as the *undercoat*, and the individual hairs are sometimes called *zigzags* in literature. The undercoat is dense, and helps the rat stay warm.

There is very fine hair on the ears, the tops of the feet, and the tip of the scrotum; the tail has short bristles. *Vibrissae* (whiskers) are arranged in rows of five or six; there are between five to ten of these rows on each side of the whisker bed. Very fine vibrissae can be found elsewhere, a few over each eye, two at the corner of the mouth, and a few on the chin. Rats use their whiskers to feel their surroundings and to compensate for poor eye sight. Eyelashes (also called *cilia*) help keep the eyes free of debris.

## Biology of the Rat's Hair

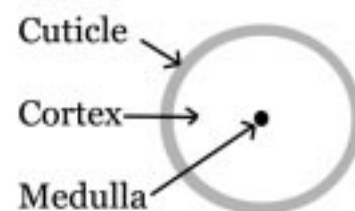
The hair shaft is made up of columns of dead cells that are pushed out of a *follicle* in the skin. This column of cells has three distinct layers with different functions. The outer layer, or *cuticle*, is made up of tightly packed, transparent, overlapping scales which point upwards, and hold the hair firmly in the follicle. It also protects the softer inner layers from damage.

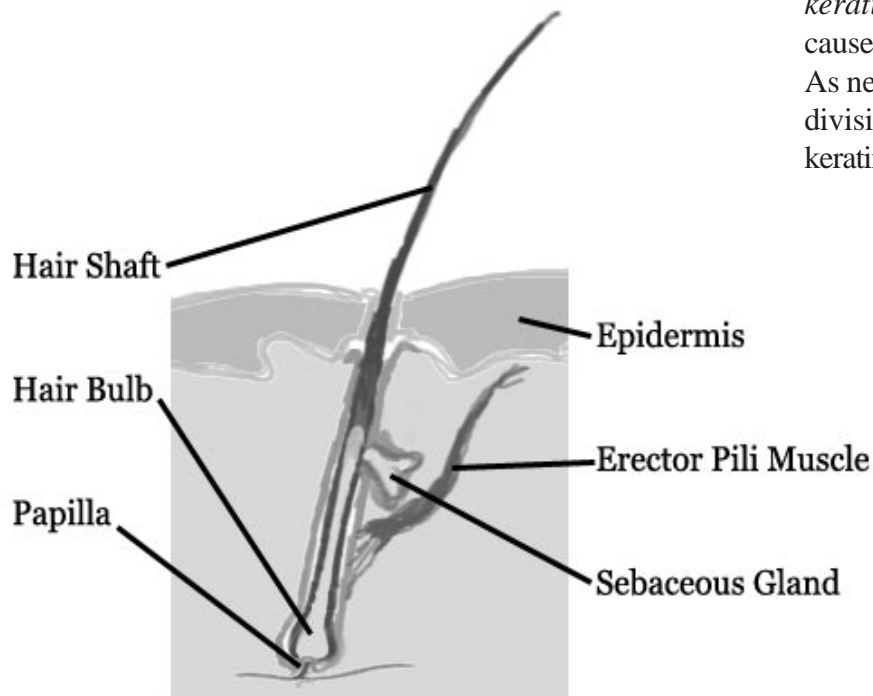
The cortex is the next, and thickest layer. It is made up of cells that contain the protein, keratin. Pigment granules, which give the rat its colour, are also found in the cortex.



At the very centre of the hair is the *medulla*, although this innermost layer does not tend to occur in finer hairs. It also may be absent in some light coloured hairs. The *medulla* is made up of round cells, two to five rows across.

The *follicle* is a pocket-like structure in the skin. At the base of the follicle is a small projection called the *papilla*, which contains capillaries (tiny blood vessels) to feed the hair bulb. The hair bulb is the only living part of the hair. The cells in the bulb divide faster than any other cells in the body. Some become





*keratinised* (filled with keratin), which causes them to stop functioning and die. As new cells are produced through cell division in the hair bulb, they push these keratinised cells up, and out of the follicle.

There are also sensory nerves at the base of the hair bulb. This is what allows you to feel when your hair is tugged or brushed. This is also true in rats; the guard hairs, and the whiskers in particular, are sensitive touch receptors that help the rat to “see” the environment.

The follicle is surrounded by two sheaths to protect and mould the growing hair.

Further up is the *sebaceous (oil) gland*, and sometimes the *apocrine (scent) gland*. The sebaceous gland provides natural conditioner for the hair. Production tapers off with age, which is why older animals tend to have dull looking coats.

The *erector pili muscle* attaches below the gland to a fibrous layer around the sheath. Contraction of this muscle causes the hair to stand up. This may be done to make the animal appear larger when it feels threatened, as well as to help regulate body temperature. This is also what causes “goose bumps” when humans are scared (threatened) or cold.

## Hair Follicle Growth Cycle

Follicles go through repeated cycles of growth and rest. *Anagen* is the phase in which there is hair growth. Hair produced in this phase has thicker shafts and more pigment. The rate of growth during this phase may vary. For example, guard hairs have a faster rate of growth than the hairs that make up the undercoat, which is why guard hairs are longer. Mutations can also affect the length of time that the anagen phase lasts, and the growth rate during this phase. Many *rexoid* (curly coated) mutations have shortened guard hairs and whiskers, which is usually caused by a slowed growth rate. In species that have the angora, or longhaired, mutation, the growth rate remains normal, but the anagen phase is lengthened.

The anagen phase is metabolically very demanding. Animals that are poorly fed, or have health disorders preventing them from making full use of the nutrients in food, have characteristically short, sparse coats. The anagen phase is also sensitive to *thyroid hormone*, which influences cellular metabolism throughout the body.

If the levels of this hormone are too low, follicles may prematurely rest, cutting the anagen phase short and leading to hair loss. Some hairless mutations in humans and mice are known to be caused by a disruption of the thyroid hormone, but this cause of hairlessness has yet to be found in rats.

Next comes the *catagen* phase in which the follicle begins to shut down. Cell division stops, the palilla condenses, and the sheath shrinks. Once this is complete, the follicle enters the *telogen* phase, a resting period during which the loosened hair falls out.

Follicles cycle through the phases at different times, and this tends to be determined by the overall moult cycle. These moult cycles start on the muzzle, and work their way back over the body. This is why, when some rats moult, you can see patterns between the old, and new coats. It is most obvious on the head and rump, and easiest to see on juvenile rats moulting from their first coat into their adult coats.

## The Different Rat Coats in the Fancy

### Standard

The wild rat's default coat is made of short, straight hairs. These rats have no mutations affecting the coat. This may be called 'smooth' by the common pet fancier, but all clubs refer to it as *Standard*. All clubs recognise the standard coat. When shown, rats must have the guard hairs, the undercoat, the whiskers (including those over the eyes), eyelashes, and the fine fur on the feet, ears and tail. Additionally, clubs specify that the coat must be







This rat, with an unknown Rexoid coat mutation, was photographed in a Chicagoland PetsMart store.

smooth and glossy, which is a reflection of good health and diet. It is not uncommon for male rats' fur to be coarser than females'; this is usually allowed for when judging.

## **Rexoids**

Many mutations have been scientifically described as causing curled or kinked hairs (a "rexoid" appearance). These include: wavy, rex, ragged, curly-1, curly-2, kinky, shaggy, tremor, and zitter. Some of these (curly-1, curly-2, kinky, and shaggy) appear to be extinct in the scientific community, while others (tremor, zitter) cause serious health defects that the fancy would reject.

The frequency of these different mutations in pet rats is unknown. There may also be additional rexoid mutations in the fancy and the general pet trade, which have not yet been described or studied.



Thank you Lisa ( Halcyon Stud, [www.halcyonrats.co.uk](http://www.halcyonrats.co.uk) ) and Mary (Zephyr Rattery, [www.zephyrrats.co.uk](http://www.zephyrrats.co.uk) ) for granting permission to include photos of their rexed rats in this article.

## Rex

In 1974, the first rex rats were found in a random-bred albino Sprague-Dawley line. Shortly thereafter, Roy Robinson worked out the genetics of the new coat type and introduced it to the English fancy, where it was quickly standardised. Rex is dominant and the symbol used for it is *Re*.

Rex rats were exported to the United States in November of 1983; however, AFRMA records the variety being shown earlier than this. In AFRMA's 1999 feature article on the variety, these early American rexed rats are described as having a "soft plush coat," which contrasts with Robinson's description of the coat being "rough" and "harsh". This suggests that the earliest rexes in the United States were based on one of the many other genes that add texture to the coat.

Today, most rat clubs recognise the rex coat, which is to have dense curls for show. The whiskers are short and bent. Although soft when young, adult rexes tend toward coarser coats, but clubs prefer them not to be overly harsh. Standards usually describe the rex as having few to no guard hairs; this is not entirely accurate. The growth of the hair is somewhat retarded, so that the guard hairs do not grow much longer than the



undercoat. Because of the effect on the guard hairs, ticked colours may not show as well when rexed, although some clubs will make allowances for this when judging.

Rex is not standardised in a few clubs. In some cases, the mutation has not reached that part of the world. Other clubs feel strongly against the mutation. Rats use their whiskers to feel their surroundings, and to compensate for poor eye sight; the short, curled whiskers of a rex are thus considered to be a disability.

Because rex is semi-dominant, it is easy to reproduce. A rex bred to a standard-coated rat will generally produce a litter that is half standard, and half rex. A rex bred to another rex produces a litter that is approximately one quarter standard, one half rex, and one quarter 'double-rex'. These double-rex rats, which have inherited two copies of the rex mutation, begin to lose their fur around six weeks of age. They never become completely hairless, but instead have very short fur with bald patches. Sometimes the bald patches will cover the entire torso. These rats are usually known as double-rex, mock-hairless, or patchwork-hairless. A double rex rat bred to a standard rat will produce only rexed rats.

Although easy to reproduce, breeding a quality rex is difficult. Many rexes lose their curl by adulthood, ending up with lightly wavy fur. Those that manage to hold their curl are usually males. Because it is difficult to judge the quality of the rexing until the adult coat comes in and the curls *stay* in, a breeder must usually keep several of the best males in the litter to evaluate until they are as much as six months of age. By a year and a half, many have thinning fur, and sometimes even small bald spots. Even before this, they may go through periods of moult when they are not showable. Because of these factors, it is recommended that a breeder have some experience before getting involved with rexes, as well as a lot of patience and space!

### Teddy and Velveteen

In 1997, I found two female rats in the feeder tank of a Glen Ellyn, Illinois pet shop. Elignore was a black Berkshire with a wavy coat, and Prudence was a mismarked hooded American lilac with the same coat texture. The coat proved so popular with local fanciers that the rex variety was lost in the area. Teddy was preferred because it was usually described as feeling like goose down- significantly softer than the rex. It also differed from the rex in that the guard



hairs were of normal length; this caused no interference with the way ticked colours were expected to look. Teddies were also seen as easier to breed, because although they, like the rex, lost their texture when moulting into their adult coat, the quality of their coat could be judged soon after it came back in. Also, the females are usually showable.

Like rex, teddy is semi-dominant. A rat with two teddy genes will appear double-rexed (many fanciers still call these double-rex (instead of double-teddy)). These rats can vary from appearing almost hairless (and may also be called a mock-hairless), to having a short, sparse coat, which may be given non-standardised names such as “fuzz” or “velour”. It is not known if teddy is an allele of rex, a rex that has additional (or missing) modifiers, or a totally separate gene. Many fanciers use *Cu* for the symbol, but this is not likely correct, as the curly mutations have reduced guard hairs.

These rats were first shown in the Great Lakes RMCA, and later the Midwest RMCA. When RMCA stopped holding shows, RMFE took over and standardised teddy. Most of the officers and judges were the same people, despite the change in which clubs were active in the area, so the work that was done in one club was carried over to the next. The standard was based on the breeding and judging of rats that traced directly back to Elignore, and had never been crossed with any other rex-like rats.

Around the country, fanciers had been calling rats with wavy coats by different names: wavy, teddy, or velveteen. It is not known how many, if any of these, are the same mutation, or an allele thereof. When I sent teddy rats to breeders in Washington, they were re-labelled as velveteen. I don't have much experience with velveteen rats, but it is not unlikely that teddy and velveteen are two names for the same mutation. Like teddy, velveteen is not widely recognised. RatPacNW, in the Pacific Northwest (USA), is one club that has it standardised; they describe it as a soft and wavy coat with lightly curled whiskers. As with all varieties, standardising is dependent on the trait being reproducible and the fanciers active in the club seeing the variety as significantly unique from other standardised varieties.



Above: 6H Tristan was a Teddy who traced back to Elignore. Right: Elignore shortly after purchase. Her poor coat in the photo was due to poor diet and crowded, dirty conditions at the pet store.

Teddy descendants of Elignore still exist in some ratteries, but they are no longer as common due in part to the popularity of newer varieties. Another factor that worked against their establishment in the fancy was that some fanciers believed



teddies to be ‘poor rexes’. The variety may have been dismissed in some cases because inexperienced fanciers were, in fact, presenting poor rexes as teddies. It is important not to claim that a rat represents a variety if this is not verifiable; doing so can work against standardisation, or complicate the work being done on new varieties.

When placed side by side, it is simple enough to see that a teddy and a rex are only superficially alike:

<u>Rex</u>	<u>Teddy</u>
Few to no guard hairs; guard hairs very short	All guard hairs of normal length
Short, kinked or curled whiskers	Long whiskers slightly curved forward
Rough coat	Downy-soft coat
Usually only males are showable	Both sexes are usually showable
May need to wait months to judge quality	Quality can be judged after first moult
Wide range of texture-quality in offspring	Quality of texture in offspring more uniform



### **Fuzzy and Velour**

Fuzzy, fuzz, or fuzzy-hairless, and less commonly, velour, are terms given to hairless-like rats that have too much fur on them to meet the standard for hairless. These could be rats with the recessive hairless mutations that just aren’t up to standard, as well as various genetic types of mock-hairless or double-rexes. (Note: do not confuse “fuzzy” as a descriptive name for a rat’s appearance with the “fuzzy”/“frizzy” mutation described in the section on hairless)

### **Patchwork**

This term is sometimes used for double-rex rats, whose bald spots and patches of hair happen to form patterns. This usually takes the form of stripes over the body, following the natural moult pattern. As the rat moults, the stripes will appear to move over the body. The specific genetics have not been identified, however, there are two likely possibilities. One is the original *naked* mutation described by Castle and King. There is also a similar mutation in mice called *Travelling Wave*. The mutant mouse has a defect in splicing of the *Foxn1* (Whn or Rowlett Nude) gene, which terminates hair follicle development just after pigment begins to accumulate in

the follicle. The immature follicles are rapidly discharged, and a new hair cycle resumes. Eventually, the skin colour of the mouse appears to oscillate, forming travelling, evenly spaced stripes. It is possible that the Patchwork Rat is, as in mice, due to the Travelling Wave allele of the Rowlett Nude mutation (*rnu(tw)*, or more properly, *foxn1(tw)*).

As far as I am aware, no club currently recognises the variety for show, however, clubs that do not have a ban on hairless rats have usually allowed patchworks to be shown in the pet class, such as for “most unusual appearance”. Because it is not known what mutation the patchwork rat is based on, it is best to act cautiously, treating it as if it is an allele of the Rowlett Nude mutation; this means that such rats should not be taken to shows, even if a club would allow them to be shown, and that extra care must be taken when obtaining new rats. More information on the effects on the rat’s immune system, and what it means for fanciers, can be read in the Hairless section, under Rowlett Nude.

## **Het-Rex and Homo-Rex**

When I got my first down-under rat, I was told that he was a “homo-rex”, for lack of a fancier name. Indeed, when he was bred, every one of his offspring had wavy fur, somewhat less curled than their father’s. Only a few breeders have this mutation at the moment. No one has suggested a name as far as I am aware. As they are not very unique, it is not likely that they will be standardised.

The heterozygous form is slightly coarse, and has curled whiskers. The homozygous form is much softer, and tends towards reduced guard hairs; unexpectedly, the homozygote’s whiskers are only lightly curled, almost straight. Unlike other rexed rats, these rats tend to keep plush coats well into adulthood. This mutation tends to create a coat less wavy than that of the Teddy or Velveteen rat.

## **Other Varieties**

### **Velvet**

Sometimes, new fanciers will confuse “Velvet” and “Velveteen”, but usually Velvet describes a coat that is short, lacking in long guard hairs, with a plush feel to it. The coat is very dense so that it is difficult to part the fur to see the skin. This is sometimes also called a “double coat”. There maybe other definitions that people have given this term. If you find it in a pedigree or discussion, ask to have it defined by the person using it.

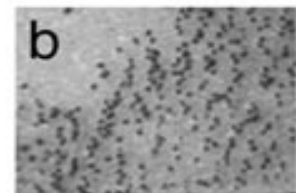
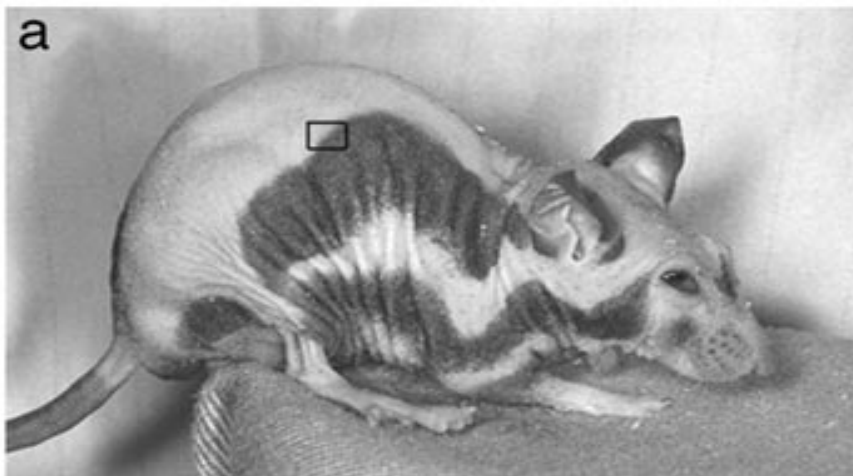
Some fanciers have described Russian-blue rats (or colours created with Russian-blue) as having velvet fur. Most of the time, this is simply due to the effect of the colour mutation that a fancier with a keen sense of touch may notice. However, Russian blue and velvet have been related in the past. In AFRMA’s newsletter, it was reported that their Russian blues all traced back to Karla Barber’s velvet rats. In an article about Russian blue rats, Nichole Royer wrote that these rats had a short, plush coat but that “this difference is not distinctive enough to consider it a unique coat type, and it is unknown whether it is caused by the color itself, by the Russian blue’s velvet background, or by some other unknown cause.” Nonetheless, I’ve seen it shown unstandardised at two shows; uniqueness may in part be selection for the trait’s expression combined with what is in the eye of the beholder. The genetics are unclear, but I’ve heard that it involves multiple recessive mutations, so that it may take a few generations to get it back after an outcross.



**ADULT NAKED RAT**

Castle, W.E., Dempster, E.R., Shurrager, H.C.:

Three new mutations of the rat. Shaker, cowlick, and naked, *Journal of Heredity* 46:9-14, 1955.



Panel A. An 120 day old Foxn1tw/Foxn1tw mouse. These mice have a continually changing color variation that occurs at the same rate of speed in juvenile mice. As the mice age, the color variation results in evenly spaced bands travelling across the body. Panel B. Close-up of the pigmented region.

Suzuki N, Proc Natl Acad Sci U S A 2003 Aug 19;100(17):9680-5



**Siblings, Het-Rex Champagne and Homo-Rex Beige**

## **Harley**

In September of 2002, D. Needham of Oddfellows Rattery was in a pet shop, and spotted a light colour-point coloured rat with a coat that reminded her of a teddy bear hamster. The rat, which she named Harley, was purchased pregnant, likely by a brother. Of the first five babies born, none had the same coat texture, but four did have Velveteen coats. A son, OFR Curly, was bred back to Harley, and the mother's coat type was seen in the resulting litter, demonstrating that this was a recessive mutation at work.

Needham described the coat as being “soft and wispy like a teddy bear hamster... The whiskers curl around the nose slightly.” While considered a long haired variety, the length of each hair is rarely over an inch in length. Currently, RatsPacNW is the only club I know of that has the Harley coat standardised, and they recognise it in both straight, and curly variations (the curly variation would be combined with one of the many rexing gene).

## **Satin**

Satin rats have long been desired in the fancy, and as is not uncommon in such a situation, inexperienced fanciers often think they see the trait when it's not really there. Black, Russian blue, and other dark coloured animals are often mistaken for being satin when they simply have excellent coat condition (healthy coats should have a natural gloss).

The first satins are generally attributed to a litter of three, two of which were satin. They were born on the 2<sup>nd</sup> of February, 1990 to Karen Robbins (litter #E1208), the products of a female Pearl Rex, bred to her Cinnamon Pearl English Irish brother. These rats were of pure English descent. The first generations were heavily culled



due to poor respiratory health, before being placed to other breeders.

Robbins attributes the satin rat's shine to the same cause as in the satin mouse- a mutation that, among other things, creates finer hair with a more transparent shell. This increases the hair's ability to reflect light, as well as making the colour pigment more vibrant.

Some clubs have satin standardised while others have it in provisional, or guide standard status. All clubs look for a lustrous, satiny sheen, and note that colour is intensified which must be taken into consideration when judging; this includes a slight yellowing of white coats. American clubs tend to specify that the hairs are slightly longer and thinner; The NFRS does not, but does include a note in their standard: "[due to an] unrecognised recessive gene Sa\*. Probably at least 2".

It is quite likely that two mutations are at work. The photo example at the NFRS's website has a sleek coat, and neither in their standards, nor in the article by Karen Robbins, is there any mention of unusual whiskers. However, some fanciers in the United States are breeding satin rats that have lightly crimped whiskers, and a somewhat greasy, dishevelled look.

As a long time breeder of satin mice, I can see the similarity between the first recessive mutation and the satin mutation in mice, which fanciers genetically describe as sa/sa. There is another mutation that has been scientifically described in mice called lustrous (recessive, genetically described as lt/lt). This mutation has a coat that is oily in appearance with an unkempt look. The appearance is due to the normally air-filled parts of the hair shaft being replaced with fatty fluid. The whiskers of these mice start out curled and short, and straighten somewhat with age, but always remain irregular. Lustrous in mice, rather than satin, might prove to have more in common with the second type of satin mutation in rats.





**Satin and Standard Coat Comparison**  
**SFR Desperado X SFR Tequila Sunrise**  
**D.o.B. 4/14/06**  
**© Deer Creek Rattery 5/1/06**



**DCR SFR Astronomy Domine**  
**Russian Silver Blazed Berkshire Satin Doe**  
**© Deer Creek Rattery 5/9/06**

**Hairless Rat.**—I have recently had in my possession a stuffed specimen of a hairless Rat (*Mus rattus*, male). It was kindly lent to me for inspection by Mr. Ernest Lowe, the Curator of the Plymouth Museum and Art Gallery.\*



The Rat was caught alive in October, 1898, in the victualling yard of the Ordnance Store Department at Stonehouse, Devonport. At the time of its capture it was in possession of a few long woolly hairs, besides the whiskers. When the animal was at rest the skin appeared all creased and wrinkled, but in active movements the folds disappeared. The Rat measured 7 in. from the muzzle to the root of the tail, taken along the contour. The tail, which was not perfect, measured  $6\frac{3}{4}$  in. in length. The ambit, behind the scapulars,  $5\frac{3}{4}$  in. Skin granulated, dirty brown. Hind feet webbed to half length of first phalanx. Tail hairless; scutellæ cycloid, encircling, but somewhat widely separated, and attached all round. Ears also quite nude. The loss of hair is attributable to disease.—T. EDWARD BELCHER (24, Clapham Road).

[For another record of a hairless Rat (*M. decumanus*), cf. 'Zoologist' (1908), p. 454.—ED.]

\* Mr. Lowe tells me that the transverse folds of skin across the shoulders are the work of the taxidermist; there were folds, but they were further back, and not transverse.

Newman, Edward and James Edmund Harting. *Zoologist: A Monthly Journal of Natural History* Published by J. Van Voorst, No. 752 February 15th, 1904. Page 64

Dr. Bree has recorded (*Field*, Oct. 5th, 1872, p. 328) the capture of two hairless Rats at Thorpe-le-Soken. They were entirely without hair, except for their whiskers. He forwarded the specimens to the Museum of the Royal College of Surgeons.

Laver, Henry. *The Mammals, Reptiles, and Fishes of Essex: A Contribution to the Natural History of the County.* Published by E. Durrant, 1898. (Page 64.)

## **Silky**

In Australia, breeders are working with varieties called “Silky” and “Carasilk”. Although I asked a number of fanciers, feedback conflicted on whether or not these are two different mutations, or two names for the same things. It is also not known if this is a re-mutation, or allelic variation, to other coat mutations elsewhere in the world (eg: Harley or Satin). It has been suggested that the mutation is likely dominant or semi-dominant.

The coat is described as being composed of very fine hair that looks wispy as well as having a satin gleam to it. Some rats, particularly adult males, have slightly waved or ruffled appearance. As with satin rats, colours appear more intense, and white appears to be ivory.

## **Cowlicked**

The recessive cowlicked mutation (symbol *cw*) is described by Roy Robinson as creating of a whorl of hair on the forehead or back, along the dorsal line. I’ve only seen what appeared to be a cowlicked rat once, and there were no offspring to see if it was inheritable. The whorl is most obvious when on the back.

# **Hairless**

As early as the Victorian era, hairless rats have been reported, but only a few have been given significant attention. It is likely that many of the hairless rats seen over the past century are re-mutations or alleles of other hairless mutations. It is also likely that some have become extinct, and that others may exist that have yet to be scientifically identified. Most fanciers’ articles state that there are only three known hairless mutations in rats: Shorn, Fuzzy, and Rowett Nude. While these may be the best known in scientific literature, there are other scientifically described hairless mutations. It is also likely that there are mutations in the fancy that have not been identified in the laboratory. I’ll describe a few below, to illustrate how numerous these mutations may be, and how they tend to compare.

## **Hairless and Fuzzy**

The first hairless rats to be studied in detail were said to owe their appearance to a recessive mutation denoted as *hr* for hairless. Some of these rats were used to found hairless lines maintained by labs to the present day. Not long ago, researchers discovered that the mutation they were calling hairless was actually an allele to the mutation in another line which was called Fuzzy. Not only that, but the biological mechanism that caused the hairlessness in these rats was different from that which causes hairlessness, and given the genetic symbol (*hr*), in mice and other species. It was found to actually be an orthologue of the frizzy gene in mice (if it had been an orthologue of hairless, it would have been on chromosome #15; instead it is found on chromosome #1 and is linked with albinism). To further complicate things, mice also have a gene called fuzzy, but it isn’t related to fuzzy in the rat!

What a complicated history for just one hairless mutation. Basically, if you look back at old articles, simply keep in mind that most rats identified as *hr/hr* hairless are actually *fz/fz* fuzzy rats (as usual, there may be an exception (likely extinct), but to avoid confusion, it is discussed only in the mutation list at the end of this booklet, under ‘hairless’).

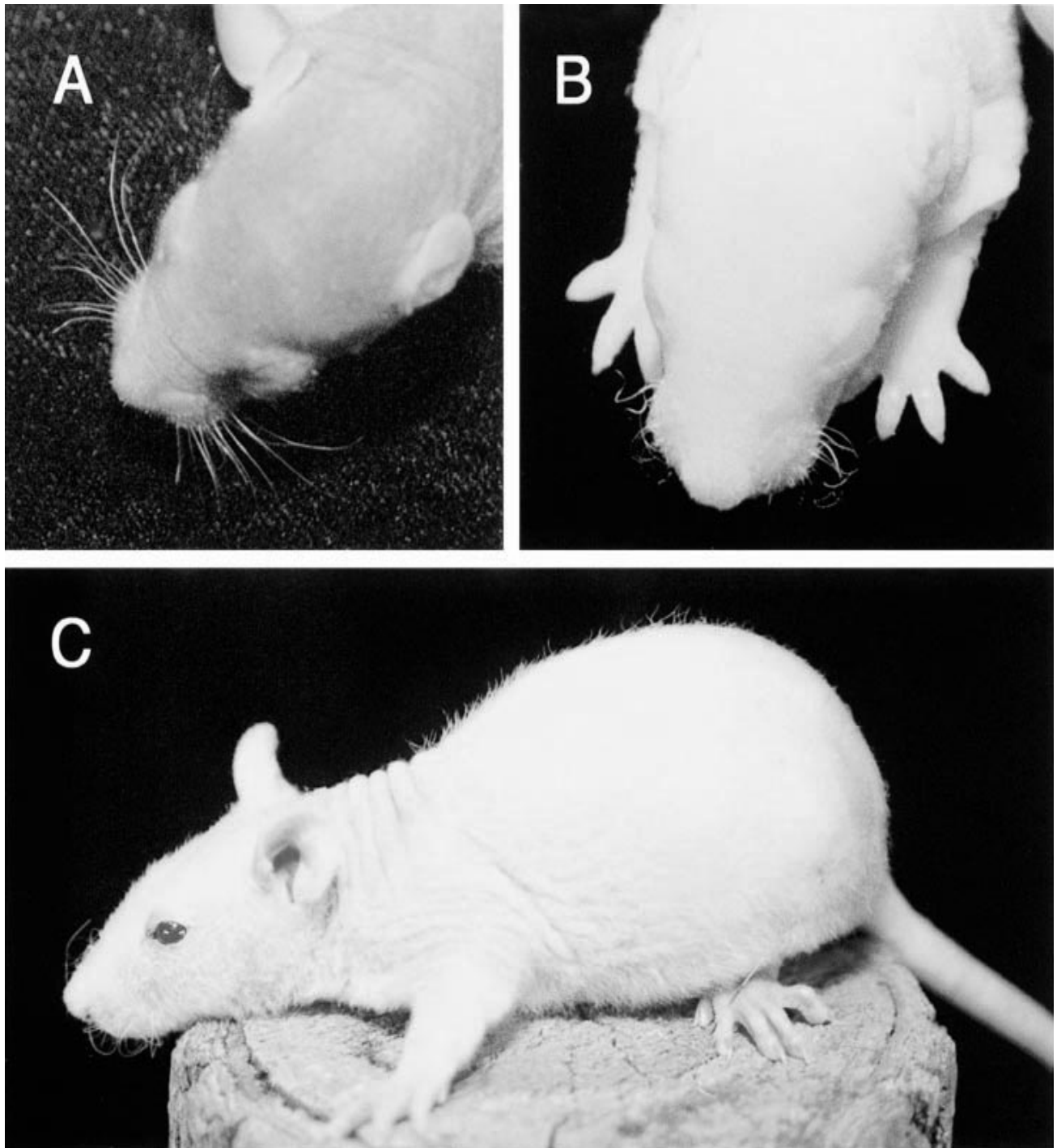


Figure 2. The CR hairless mutation and fuzzy (fz) do not complement. (A) A 10-day-old wild-type (hooded) CR hairless heterozygote (genotypically  $fr^{CR}/$  ; see Discussion for an explanation of allele symbols), produced in a (CR BN) F1 female CR hairless male backcross. (B) An age-matched hybrid rat (genotypically  $fr^H/fr^{CR}$ ; see Discussion) produced by crossing a fuzzy female (Hsd:FUZZY-fz) with a CR hairless male (CrI:CD(SD)-hrBR). The severity of the hypotrichotic phenotype in these  $fr^H/fr^{CR}$  hybrids appears intermediate between that of CR hairless (more severe hypotrichosis; see Panteleyev and Christiano 2001) and fuzzy rats (less severe hypotrichosis, see Palm and Ferguson 1976). (C) A hybrid ( $fr^H/fr^{CR}$ ) female at 40 days of age.

Ahearn et al. 93 (3): 210. (2002)

When the fuzzy rat is still in the nest, it at first appears to have curled fur and short curled whiskers. Depending on the allelic version of the mutation, hair may begin to be lost anywhere from the 2<sup>nd</sup> week to the 3<sup>rd</sup>, but by the 4<sup>th</sup> week, they are all essentially hairless.

In the laboratory, the fuzzy rat has some health issues that must be taken into consideration. The females tend to have irregular cycles, coming into heat approximately every 8 to 14 days (at least double that of a normal rat's 4 days). In some lines, the females have trouble lactating. In both sexes, the adrenals and kidneys are enlarged, and they often succumb to kidney disease by 18 months of age. Heterozygous rats, that is, rats which have normal fur and carry one copy of the fuzzy mutation, can have slightly enlarged kidneys and adrenals as well.

Different modern lines have proven to involve different alleles, which can affect such things as the degree of hairlessness and whether the mother is able to lactate or not. One of the old lines had unusually long nails and female sterility, but it was never determined if these additional traits were due to an allelic variation, or a linked mutation. Some fanciers, opposed to the breeding of hairless, have claimed that up to 75% of these rats suffer severe dental malocclusion and require tooth trimming, but I've never come across any evidence to support this claim. Perhaps the two traits, hairless and malocclusion, coincidentally occurred in the same line, possibly with some linkage (in the way that dumbo ears and the colour mink may exist together in a line, but are not caused by the same mutation.)

## **Rowett Nude**

Rowett nude rats, also called athymic nude, spontaneously appeared at the Rowett Research Institute in Aberdeen, UK in 1953. The line was lost in the 1960s, but the mutation was re-isolated in the 1970s and has been bred extensively for research, particularly in immunology.

The Rowlett nude rat has two copies of the recessive mutation *rnu* on chromosome 10. Most females are unable to lactate. These rats also have an abnormal thymus; it is enlarged and mostly replaced with brown fat, which leads to depressed T-cell function and poor immunity. Allelic variations are also known; for example, in the 1970s, an allelic form spontaneously appeared in a colony in Wellington, New Zealand.

Rowetts are virtually hairless, with short, curled whiskers. Bred by laboratories, they sometimes find their way into educational settings, where they may be adopted by students. Patchwork rats may owe their appearance to an allelic variation of Rowlett nude as well (see the section on Patchwork Rats for a more detailed description).



A hooded Rowett nude rat from Harlan Labs.  
Notice that pigment and white spotting can be seen on the skin, even when there is no fur.



**Fig. 1.** The  $rnu^{nz}$  rat and the wild-type strain from which it was derived.  
From Anthony Douglas-Jones, Et Al. Characterisation of the ( $rnu^{nz}$ ) Nude Rat

### **Naked**

Like the other hairless mutations, naked also affects the whiskers, which are twisted. These rats are a bit smaller than their normally furred siblings. The naked rat's juvenile coat is quickly lost at three weeks of age. The newly exposed skin is yellow and dry, but it later becomes pink and soft. Some light fuzz comes in after four weeks, only to be quickly lost again. This cycle repeats for several months.

Naked is epistatic to ("masks") the "hairless" mutation (as described by Castle and King) from the age of six weeks onward, by preventing the adults from developing the thickly wrinkled skin associated with it. A photo of one of Castle and King's naked rats can be found along side the section on Patchwork rats, due to the similarity in appearance.

### **Shorn**

This mutation spontaneously appeared in a rat colony at Central Connecticut State University in 1994. Rats with the recessive shorn mutation ( $shn/shn$ ) have an almost complete absence of hair, abnormal hearts and abnormal kidneys. They rarely live past twelve months of age.

### Vibrissaeless

This mutation, symbol *vb*, is a recessive hairless mutation which also causes a lack of whiskers. Females are unable to lactate. The nails also tend to easily break off.

### Hirosaki Hairless

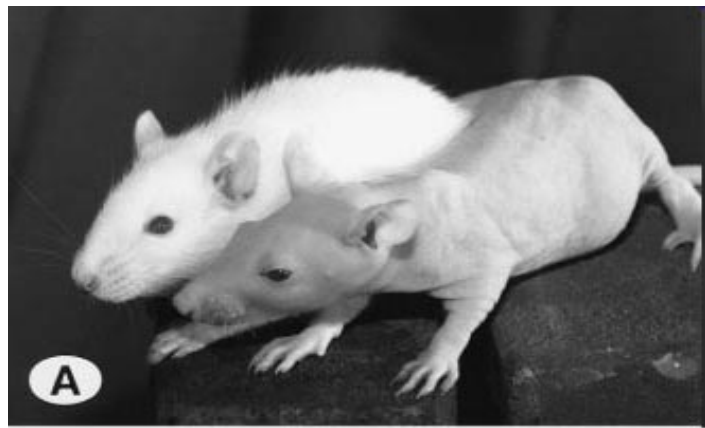
In 1985 a male hairless rat mutant was discovered in a breeding colony of Sprague-Dawley rats at the Hirosaki University in Japan. Bred against known hairless mutations it was found to be non-allelic; later it was identified as a mutation on chromosome #7 and given the symbol of *krt83*; the symbol stands for keratin because in this rat, the genes that code for keratin in the hair were not expressed. In addition to hair loss, the females have underdeveloped mammary glands and are unable to nurse their young.

### Lanceolate hair

The rats affected by this mutation (*lah/lah*), have generalised hairlessness, with some partial hair growth, particularly on the head; the hair is also quite rough and has a distinct shape when viewed close up which is where the name comes from (it is 'lance like', thick at the distal end and thin at the bottom). These rats also have thicker, stiffer skin. It's been mapped to chromosome 18.

### Dominant Hairless

A dominant form of hairlessness has been identified in the rat and given the symbol *Ht*. Heterozygotes have hypotrichosis and whiskers are lightly wavy. The Homozygotes have atrichosis; their whiskers are very curled and short whiskers. The homozygotes die before weaning. This mutation is mapped to chromosome 10, but it is not allelic to Rowett, nor does it have an abnormal thymus like the Rowett does.



(A) An *shn/shn* rat (foreground) with an *shn/1* littermate control at 4 weeks of age. (B) A closer view of the same mutant rat.

Moemeka et al. 89 (3): 257. (1998)



**Fig. 1.** Three phenotypes of the same litter in WBN/11a-*Ht* rats at 14 days old. *Ht/Ht* rat shows atrichosis and hyperkeratosis like ichthyosis (top). *Ht/+* rat shows hypotrichosis (middle) and *+/+* rat shows no abnormality (bottom).

From: Akimoto, Toshio. Locus of Dominant Hairless Gene (*Ht*) Causing Abnormal Hair and Keratinization Maps to Rat Chromosome 10



## Masked

The hair begins to fall out of these rats around four weeks of age. They also have a thickening of the eyelids, are very susceptible to *Pasteurella pneumotropica* infections which antibiotics fail to abolish, and have an exudates which forms a characteristic brown crust around the eyes and nose. A recessive, the symbol is *mk*.

## The Hairless Debate

There are several arguments against the breeding and showing of hairless rats. First, hairless rats have missing or shortened whiskers. Whiskers are used by the rat to feel and “see” their immediate surroundings; a rat with short or missing whiskers is believed to be disadvantaged. The whiskers on the hairless rats usually seen in the fancy tend to be short and curled; this is similar to the whiskers of a Rex rat, and most fanciers do not see any sign of disability in the Rex.

Another argument against hairless rats is that they lack fur to protect them from the environment. While this is certainly true in the wild, our rats are kept in artificial conditions. A pet owner can design the environment to prevent discomfort, as fanciers of other species are familiar with (eg: some fish can be kept in room temperature water while others need heaters; some reptiles have special requirements for temperature, humidity and/or lighting.). It is not difficult to address a hairless rat’s needs. For example, placing a rough tile or brick under the water bottle and food dish will keep rats’ nails filed, which prevents scratches to the rat’s skin (and to their human’s as well). Owing to the lack of fur, hairless rats’ bodies must work harder to keep warm; they have a higher basal metabolic rate than furred rats. Keeping the cage away from drafts, providing warm nesting materials such as fleece, and perhaps providing an extra treat or two than given to a furred rat is usually enough to keep a hairless rat happy and warm.

An argument of great concern is that hairless rats can make quarantines ineffective, increasing the chances of viruses such as SDA being spread. This can only happen with one kind of hairless rat, the Rowett (and possibly the Patchwork, if it is an allele of Rowett). The Rowett has a fatty thymus, which interferes with the immune system. When they become ill, their symptoms are usually much more severe than that of their normally furred littermates, and they are much more likely to die from common infections. Their presence in a pet home can have a dramatic effect on quarantine procedures. Compared to normal rats, it can take more than three times as long for these rats to fully recover from a virus and stop spreading it.

If you have a rat that you know is from a laboratory or educational institution, or that appears to have a patchwork coat, or even a hairless rat of uncertain background, it is best to assume that it is a Rowett and take the extra precautions. Read up on SDA, Sendai and other rat viruses, and on how to quarantine. At the very least, quadruple all recommended quarantine times. It may in fact be best to consider your house under permanent quarantine for the entire life of the hairless rat.

Many fanciers’ with hairless lines have successfully gone through quarantine after exposure to SDA or Sendai; this success would not have been possible if these fanciers’ hairless rats were Rowetts. If greater reassurance is wanted, a blood test can be done to see if there is a normal amount of T-lymphocytes in the blood. While this is not a genetic test, normal levels do at least rule out the Rowett mutation.

The forth argument against hairless rats is that they have health problems, and shortened life spans, for which reason some people feel it is cruel to breed these rats. Shorn rats, for example, have drastically shortened lives

due to malformed kidneys and heart (12 months). Fuzzy rats also have kidney abnormalities, although their life span is a bit longer than the shorn rat's (18 months). What goes unstated when this argument is made against the breeding of hairless rats, is that these figures are based on *laboratory* rats, not on analysis of the life-spans and health of hairless rats in the *pet* fancy.

Neither pet nor feeder breeders should ever breed a rat that gets ill easily, repeatedly, or for longer than it's companions as this would select for unhealthy genetics, creating a colony of poor quality. A breeder should always select for sturdy health and longevity in all their rats. If a breeder's line of hairless rats proves to be as healthy and long lived as their furred relatives, then this argument is without merit.

## Which Hairless do we have?

Above, I covered several hairless rat mutations, but Rowett and Fuzzy are the most commonly bred by lab suppliers (the general public can even purchase these lab lines, if they are willing to spend the money). Some who argue against keeping and breeding the hairless use limited and misleading information. For example, I've seen fanciers insist that only three mutations existed, (Rowett, fuzzy, and shorn), and since shorn is not widely available via lab suppliers, while the others are, the fancy must have Rowett and fuzzy, and *nothing else*. The idea that the fancy can only have what the scientific community has described (or in this case, only the most commonly described) is erroneous; to hold such a view, we'd have to likewise refuse to acknowledge the existence of dumbo eared rats, or down-under spotted rats!

Due to a lack of records, we cannot point to examples of spontaneous hairless mutations in the pet fancy, but given the wide array of hairless mutations the scientific community has encountered (one recent scientific article reports over twenty-five! (Kim et al, 2004)), it is not unreasonable to assume that it has happened. The



hairless rats bred in the fancy could very easily owe their appearance to mutations, or alleles, not yet reported on in the scientific community.

I have bred hairless rats since the mid 1990's, and worked with several other fanciers who have bred them. In most cases, the hairless rats obtained from different North American sources, both pet and feeder breeders, directly or through pet shops, produce more hairless when bred together. So it appears that there is one mutation, or allelic versions thereof, widespread in North America. Occasionally, hairless rats (*not* double-*rexes* as shown by breeding results and pedigrees) when bred together produce some furred offspring; this is not commonly seen, but it does demonstrate that there is at least one other hairless mutation in the pet population. In other parts of the world, other hairless genes may be more common.

Hairless rats in my part of the world can be accurately described in terms far less frightening than the descriptions of the lab lines. They tend to be slightly smaller than their littermates. They have short, curled whiskers. The degree of hairlessness varies: some have very short, soft fuzz over most of the body, while others may have just a little fur around the pubic area and the muzzle. The quality of their skin varies: some remain soft and pink, while others develop a dry yellow build up of dead skin and oils on the back (this is more common in males, but does not occur in all males). A warm bath with gentle scrubbing will remove this. Females do not have trouble getting pregnant, nor do they have trouble raising litters; breeders have told me this was a problem in the past, which suggests that different allelic variations existed, and breeders selected for the allele that did not cause breeding or lactation problems. Happily, these hairless rats tend to have normal life spans. Although they can be bred in any colour or marking, there is a slight trend towards light coloured eyes (*c*, *p* or *r* mutations); it's not clear from records if this is due to the breeders' selections, or if it indicates weak linkage, which would mean that the fancy's hairless gene was on chromosome 1.

Obviously, the hairlessness in our rats is not caused by the dominant hairless mutation. Mutations with very short life expectancies, such as *shorn* and *Rowett*, are likely not pursued by breeders. These two hairless mutants also have abnormal organs. On one occasion, a pet owner had a post-mortem done on a hairless rat they adopted from me. The rat died because the first vet they went to incorrectly neutered the rat. They consulted a second vet who thoroughly examined the body to rule out any abnormalities in the organs, which could have complicated the surgery, but found none. If this hairless line was based on the *shorn* or *Rowett* mutations, an abnormal heart or thymus would have been identified.

Fuzzy is often assumed to be the mutation that fanciers have, and my observation that there *might* be linkage with mutations on chromosome 1 could support this, and is worth further investigating. Additionally, different fuzzy alleles reported in scientific literature as interfering with, or not interfering with, reproduction and lactation, match up with the fancy having been able to select for a hairless rat without problems in these areas.

**“*One* striking fact concerning the mutations of the rat is that they may occur again independently of an original and earlier occurrence. King has demonstrated this in her own studies for *c*, *a*, *h* and *r*, also for *Cu2* observed as occurring independently in New Haven, Conn., by Whitney. The blue mutation (*d*) originally observed by Roberts in 1929 was shown to have occurred independently later in New York (Curtis and Dunning, 1940). Curly, as well as Curly2, has made a second independent appearance, at Madison, Wis., (personal communication from Dr. A. B. Chapman).”**

**Castle, W. E. The Domestication of the Rat.**

Fuzzy, however, is reported to succumb to kidney disease by 18 months of age. This does not match up with my experience. As I selected for health in my lines, my hairless rats improved in each generation as much as their furred siblings did. Does this rule out the fuzzy mutation? Actually, it does not. It may in fact be possible that we are working with a more benign allele than exists in labs. Alternatively, breeders may have selected for other genes that suppress the kidney problems, resulting in hairlesses with normal life spans.



The fancy has already proven that it is capable of improving the health of varieties, even when the health problems are due to the very mutation that defines them. For example, rats homozygous for the red eye mutation (which gives us colours like beige and fawn) have the rat equivalent of Hermansky-Pudlak syndrome in humans. It is characterised by the lightened hair and eye colour, progressive pulmonary fibrosis (lung scarring), bleeding diathesis, and other abnormalities. These rats were once a difficult variety to work with



because of their tendency towards poor respiratory health and bleeding problems during birth, surgery or following injury. Today, while our rats still have the condition, it is mild enough that most fanciers never have to worry about those life threatening complications. This is thanks to the hard work of breeders. This is work that they can, and have repeated. Blue rats have also been known to have bleeding problems, as well as pink eyed whites (due to linkage with Warfarin resistance), and these conditions have been successfully minimised or eliminated in many lines maintained by responsible fanciers.

While it is impossible to know without genetic testing, there are two likely answers to which hairless mutation(s) are common in North America. One is that our rats possess a mutation that has not yet been described in



scientific literature and is not accompanied by serious health problems. Alternatively, we have an allelic variation of a scientifically known mutation (likely fuzzy) in which health problems are very mild or non-existent. While the scientific community, in attempt to understand and find treatment for human illnesses, focuses on health disorders which shorten the life span, pet breeders can instead focus on sturdy health and longevity, using selection to remove or minimise health problems, while retaining the unique appearances so many fanciers admire.

Coats Recognised for Show in a Sampling of Clubs based on standards found on their official websites, accessed 11/08										
Club	Standard	Rex	Teddy / Velveteen	Satin	Silky	Velvet	Harley	Hairless	Double Rex	Longhaired
Australia										
ANRA	X	X		X	X			X		
RMAV	X	X								X
New S. Wales										
NSWFRMC:	X	X			X			X	X	
England										
NFRS	X	X		X *						
North America										
RatsPacNW	X	X	X	X			X	X	X	
AFRMA	X	X		X				X		
AARC	X	X		X				X	X	
RSA	X	X		X				X		
RMFE	X	X	X	X *		X *		X		

\* - Not fully standardised. It is listed under New, Provisional or Guide Standards.

## Suggested Reading:

Anonymous. Catching Rats' Twitchy Whiskers in Action. ScienceDaily. Feb. 28, 2008 <http://www.sciencedaily.com/releases/2008/02/080227121901.htm> - accessed March 1<sup>st</sup>, 2008.

Anonymous. Advice for the Novice Breeder The National Fancy Rat Society August 2006 <http://nfrs.org/geninfo.html> - accessed January 2nd, 2009.

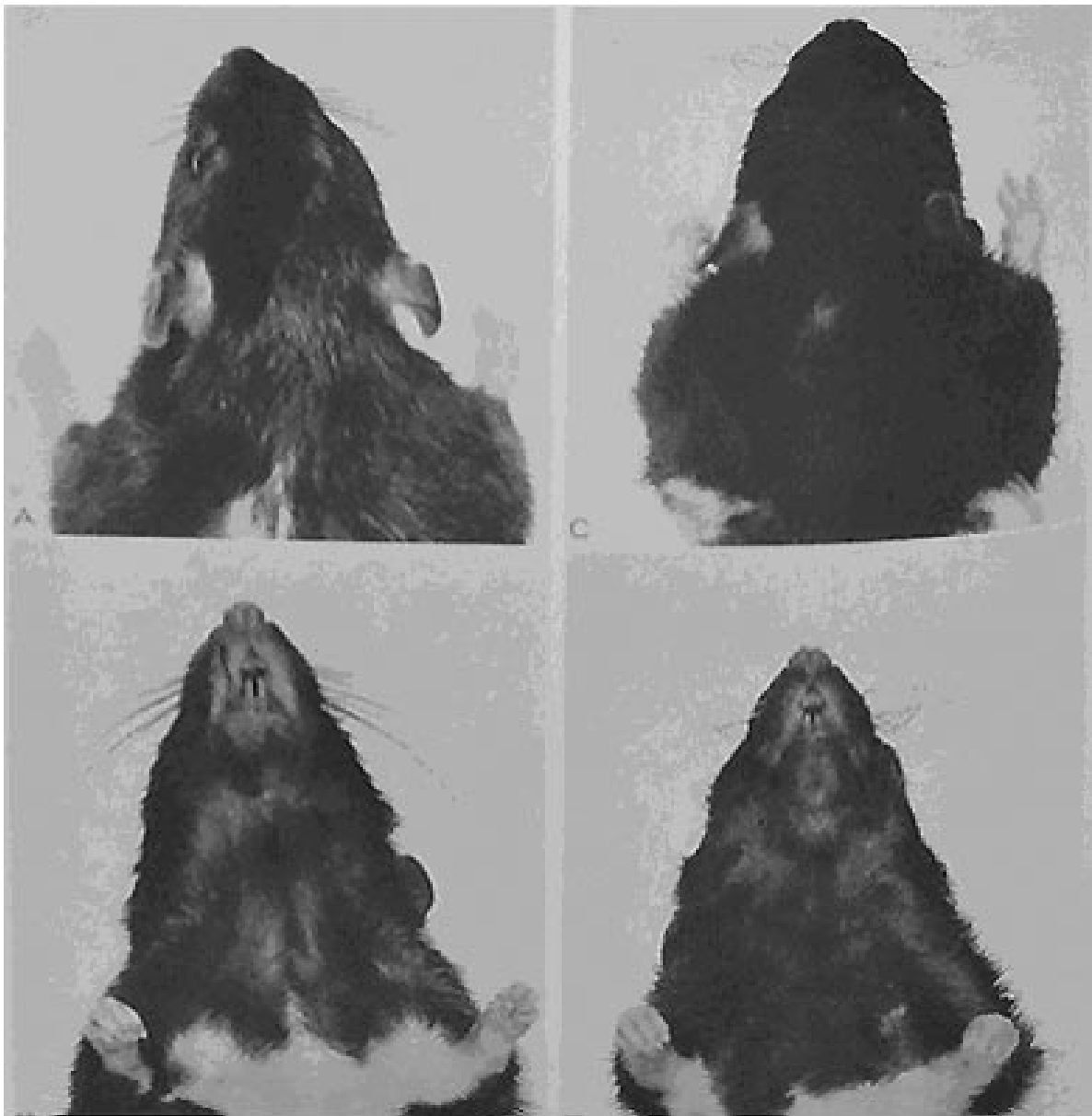
Royer, Nichole. Rex Rats. AFRMA Rat & Mouse Tales. 1999 Spring. <http://www.afrma.org/rexrat.htm> - accessed March 1<sup>st</sup>, 2008.

Hanson, Anne. Where do different rat coat types come from? September 2004. <http://www.ratbehavior.org/CoatTypes.htm> - accessed December 10th, 2008.

Bordeau, Cait. Understanding Basic Rat Genetics: A beginners guide to rat genetics in three parts, Part One. Rat & Mouse Fancy Report, Volume 2 Issue 4, 2001. <http://rodentfancy.com/pets/2008/01/27/understanding-basic-rat-genetics> - accessed December 10th, 2008.

# Some of the Known Coat Mutations in the Rat

On the following pages are a list of some of the mutations affecting the rat's coat, which have been scientifically described. These may not all exist in the fancy, and some may be extinct. It is not unheard of for mutations to reappear, though. Past history of mutations may also provide insight into what to look for with new mutations.



Normal (left) and Curly-2 (right) rats.

Gregory, P. W., and Blunn, C. T.,  
"Curly2, a Recent Dominant Mutation in the Norway Rat," *Jour. Hered.*, 27, 39 (1936).

Name	Symbol	Inheritance	Effect & Notes
<b>Cowlicked</b>	<i>cw</i>	recessive	Creates a whorl of hair on the mid dorsal line
<b>Curly</b>	<i>Cu1</i>	semi-dominant	The whiskers are slightly curled at the tips. The growth of the coat is impaired. The growth of the guard hairs is very impaired, most of which are missing. The curling is apparent at 2 weeks, after ~10 days it fades becoming downy. By 7 weeks the curl returns. A <i>Cu1/+ Sh/+</i> rat is even more curly than a plain <i>Cu1</i> or plain <i>Sh</i> rat. Originated in the 17 <sup>th</sup> generation of a captive wild-caught colony 1920-1930's Wistar Institute. Recorded by Dr. Helen Dean King. <i>Linked to b (brown); s (silvering) and Sh (shaggy) are also on this chromosome.</i>
<b>Curly2</b>	<i>Cu2</i>	semi-dominant	Whiskers are short and bent. Most guard hairs are missing, the few remaining are curly. More curly than <i>Cu1</i> or <i>k</i> , but generally very similar to <i>Cu1</i> . Originated in Long Evans captive gray stock, 1935 at Davis, California. Recorded by Blunn and Gregory.
<b>Curly Vibrissae</b>	<i>cv</i>	recessive	Has a small number of short and/or curly vibrissae around the nose, and those on the cheek & above the eyes are also short and curled; no vibrissa appears on the lower mandible. Although hair growth seems to be retarded, the outer hairs showed nearly normal length by 10 weeks of age. The outer hairs of matured <i>cv/cv</i> rats appear silky and translucent. Adults tends to loose of hair on the head and or back. Lactating females usually lose their abdominal hair.
<b>Fuzzy</b>	<i>fz</i>	recessive	First coat develops normally, then failure of coat to develop after first moult (around 4 <sup>th</sup> week) other than a few straggling guard hairs. The kidneys and adrenals are larger in both heterozygous and homozygous rats. Some allelic variations loose their coat at 2-3 weeks, and are essentially hairless by 4 weeks of age. Adult skin is thick, wrinkled. Some lines have an irregular estrual cycle, and females may not lactate properly. Most rats identified as hairless ( <i>hr/hr</i> ) have proven to actually be alleles of Fuzzy (and corresponds to that of <i>fr</i> (frizzy) in the mouse). <i>Linked to albino (c)</i>
<b>Dominant Hairless</b>	<i>Ht</i>	Dominant (homozygous-lethal)	<i>Ht/-</i> rats are hairless with lightly waved whiskers. <i>Ht/Ht</i> rats are hairless with very short, curled whiskers; they die before weaning <i>Chromosome #10, not allelic to Rowett.</i>

Hairless

??

recessive

A line of lab rats historically designated as *hairless* (*hr*) was found to actually be an allele of *Frizzy* (*fr*). In most literature, mention of hairless will be found to actually be synonymous with frizzy.

However, at least one rat designated as hairless is likely not a frizzy allele. A highly wrinkled hairless was discovered to be linked to *naked* (*n*) and *wobbly* (*wo*) through test crosses performed by King and Castle. Hairless and wobbly were also found not to be linked to albinism, which is not what would be expected if this hairless mutation had been a frizzy allele.



**ADULT HAIRLESS RAT**

Figure 6

Adult hairless rat, showing the thick warty and wrinkled skin which is almost devoid of hair except for the vibrissae.

**THREE NEW MUTATIONS OF THE RAT**

W. E. COLE, EUGENE H. DEMPSTER AND HAROLD C. SHUBACK\*

While appearance alone does not prove homology, it is often what first suggests it, leading to breeding tests to find out. The photograph of the hairless rat that Castle and King worked with shows striking resemblance to the *hairless rhino* mutation in mice (see blow); rhino is an allele of the hairless mutation in mice. This temptingly suggests that a rhino-like mutation at the hairless locus has occurred in rats. Although it is likely extinct today, a remutation is always possible.

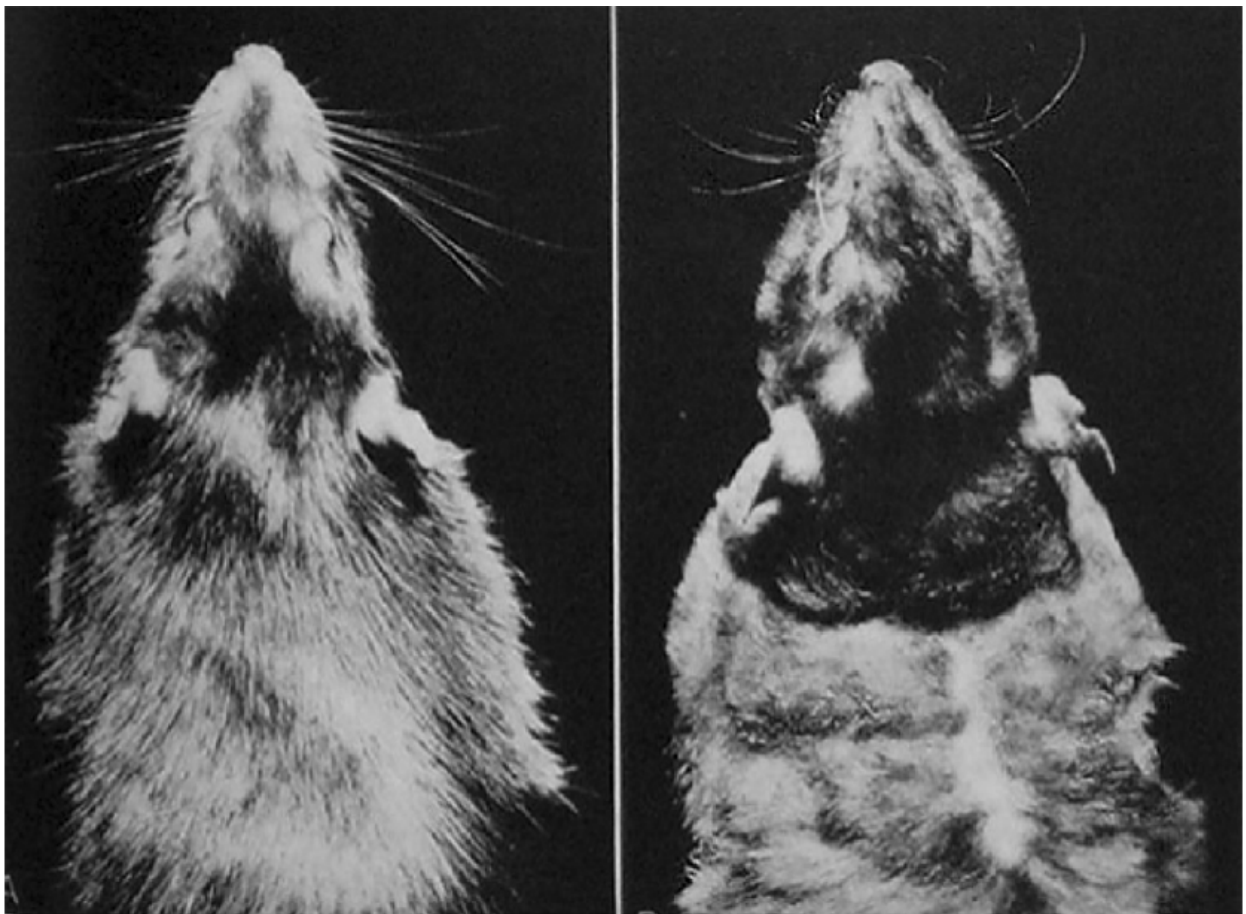


**Above:** a mouse homozygous for the Hairless Rhino allele ( $hr^{rh}/hr^{rh}$ ).

Mouse Genome Database (MGD) at the Mouse Genome Informatics website, The Jackson Laboratory, Bar Harbor, Maine. World Wide Web (URL: <http://www.informatics.jax.org>). [December, 2008].



<b>Harley</b>	?	recessive	Somewhat longer, wispy fur.
<b>Het-Rex / Homo-Rex</b>	?	semidominant	Lightly waved fur in both hetero and homozygous forms.
<b>Hirosaki Hairless</b>	<i>krt83</i>	recessive	homozygotes are hairless and affected females cannot lactate.
<b>Kinky</b>	<i>k</i>	recessive	Whiskers curled. Woolly, short and dense fur on young rats. Adult's fur is rough with some thinning patches on shoulders and hips. Originated in a domesticated strain, 1935 at Ann Arbor, Michigan. Recorded by H W Feldman. <i>Linked to Stub Tail</i>



Normal and *Kinky (k/k)* rats.

Feldman, HW. 1935.

<b>Lancelate</b>	<i>lah</i>	recessive	Sparse fur, and thick, stiff skin. The hair that is present is rough, with a lance-like shape. <i>Chromosome 18.</i>
<b>Naked</b>	<i>n</i>	recessive	Whiskers are twisted; coat is lost by 3 weeks. Skin is yellow and dry/rough at first but later turns pink and soft. Some fuzz reforms mostly on legs, chest, tailbase. Smaller in size than nonaffected littermates. Epistatic to (“masks”) the frizzy mutation (previously identified in literature as <i>hairless</i> ) from age 6 weeks onward ( <i>fz/fz n/n</i> rats do not develop the yellow scaly skin associated with <i>frizzy</i> ). Discovered in April 1950 in a litter born to a pair of rats, the sole survivors Dr. Shurrager cross bred stock for a study of the relationship between body temperature and audiogenic seizures; she found that naked rats were inferior to their normal litter mates in size and survival value. <i>linked to “hairless” (as described by Castle &amp; King) and wobbly (wo); <u>not</u> linked to albino</i>
<b>Ragged</b>	<i>rg</i>	recessive	Rats have ragged juvenile coats. Most of the hair on the back is transitionally lost around 5 weeks of age and re-covered with ragged hair thereafter. Eyelids become thickened at 3 weeks of age. Sebaceous glands are enlarged & increased in number on the back. <i><u>Not</u> linked with the non-agouti (a), albino (c) or hooded (h)</i>
<b>Rex</b>	<i>Re</i>	Semi-Dominant	Coat is curly and shorter than normal. Typically soft in young rats, it becomes rough textured in adults. Guard hairs are few or absent. The vibrissae are short and bent. When Homozygous, the coat is more severely affected. Whiskers significantly reduced/missing and very short, tight-curved. <i>Re/Re</i> appear similar to <i>Re/-</i> rats until 4 weeks, when the coat is rapidly lost. Females tend to be more

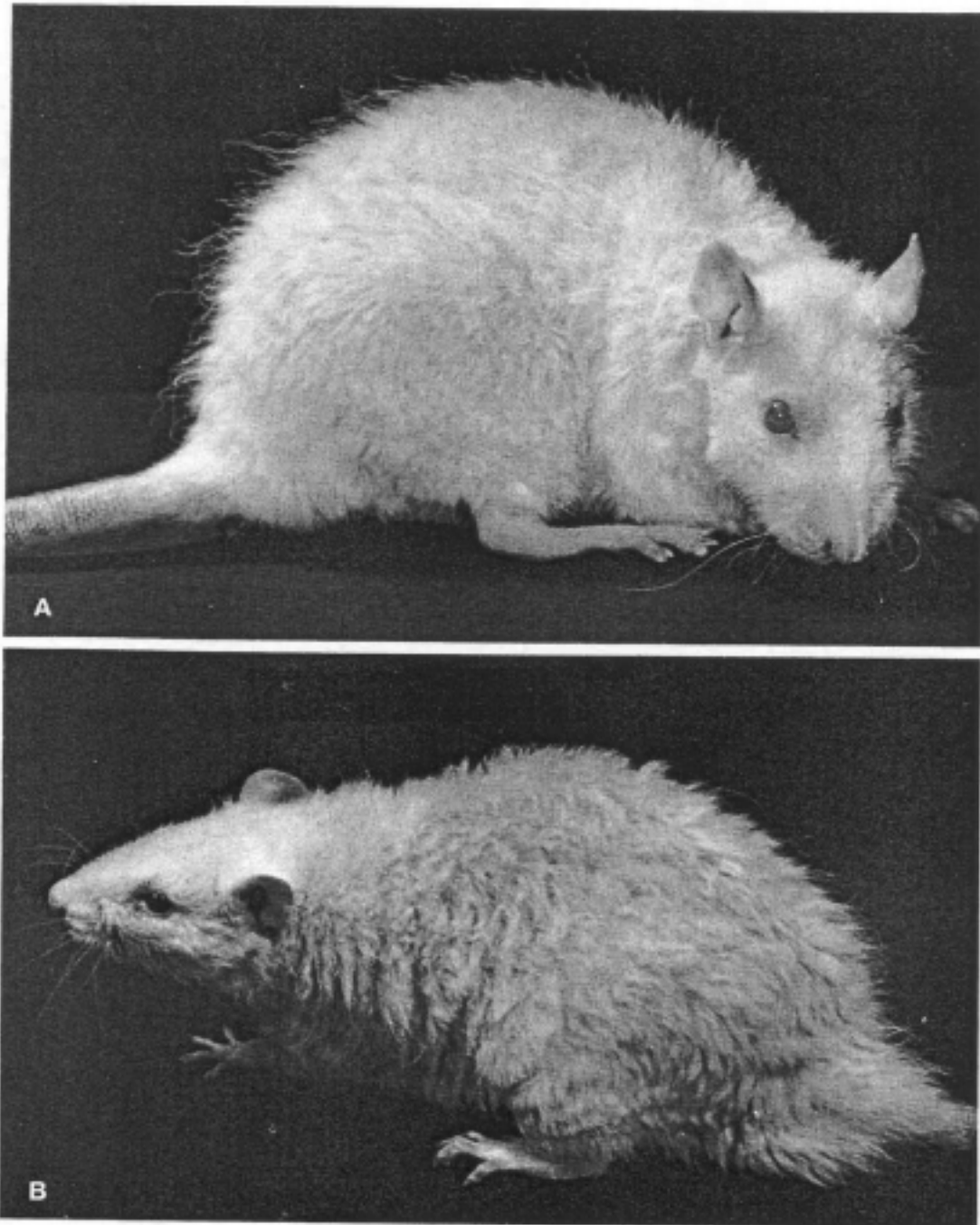


**Sparse and wavy hair rat (swh/swh) with normal sibling at 4 weeks of age.**

Kuramoto et al. 96 (4): 339. (2005)

<b>Rowlette nude</b>	<i>rmu</i>	recessive	hairless than males. Found in a random bred albino Sprague-Dawley line in 1974; reported by Roy Robsinson  Affected animals are hairless and most (though not all) females are unable to nurse. These rats have poor immunity due to depressed T-cell function and replacement of thymus with brown fat. The name and symbol has changed over the years, so it may be listed in journals as <i>Whn</i> which stands for “Winged-helix nude”, or <i>Foxn1</i> <i>Chromosome #10</i>
<b>Satin 1</b>	?	recessive	Homozygotes have glossy, satin fur
<b>Satin 2</b>	?	recessive	Homozygotes have fine, slick hair and slightly crimped whiskers
<b>Shaggy</b>	<i>sh</i>	recessive	Homozygous rats have curly fur, between Cu1 (less curly) and Cu2 (most curly), though it is more similar to Cu1 than Cu2. A <i>Cu1/+ Sh/+</i> rat is even more curly than a plain Cu1 or plain Sh rat. Originated in Domestic Stain at Wistar Institute, 1946. Recorded by Dr Helen Dean King <i>Found on the same chromosome as: b (brown), s (silvering) and Cu1 (curly-1)</i>
<b>Shorn</b>	<i>shn</i>	recessive	There’s almost a complete lack of normal hair on the homozygote. Distinct from frizzy and Rowett nude <i>on Chromosome #10</i>
<b>Sparse and Wavy</b>	<i>swh</i>	recessive	Homozygotes have sparse and wavy hair, due to hair follicles being reduced in both number and size. Has associated hypoplasia of the sebaceous glands and the subcutaneous fat tissue. Weight gain is impaired. Female rat’s have hypoplastic mammary glands and cannot lactate. Spontaneously arose in the WTC inbred rat strain colony at the National Cancer Center Research Institute in 1998. <i>Chromosome #17</i>
<b>Teddy</b>			<i>See Velvetene.</i>
<b>Tremor</b>	<i>tr</i>	recessive	Causes the homozygous rat to have epilepsy (whole body tremors), bent overhairs, bent whiskers, and spongiform encephalopathy of the central nervous system. Affected rats are also sterile.
<b>Wavy</b>	<i>wv</i>	recessive	A curly or woolly coat. Each hair may have between 1 to 6 waves or kinks in it. Coat is generally thinner and less curly than that of Rex ( <i>Re/-</i> ). Whiskers are wavy or bent, reduced in size and thickness. Combined with Rex ( <i>Re/- wv/wv</i> ), The coat is very sparse, amounting to little more than a thin, downy covering over the body. Originated in a litter in which 4 out of 12 offspring were affected; the litter was the result of two feral rats, trapped on farms near Welshpool, Wales. Recessive wavy-like coats do appear from time to time in the UK but it is unknown if it is this mutation. <i>Not linked with the non-agouti (a)</i>

<b>Velveteen</b>	?	<i>semidominant</i>	Heterozygotes are downy-soft, wavy fur; lightly curled whiskers. Normal guardhairs. Homozygotes appear mock-hairless.
<b>Vibrissae-less</b>	<i>vb</i>	<i>recessive</i>	Homozygotes are hairless and lack whiskers.
<b>Zitter</b>	<i>zi</i>	<i>recessive</i>	Causes epilepsy (whole body tremors), bent overhairs, bent whiskers, and spongiform encephalopathy of the central nervous system.



**FIGURE 1** A Shows a homozygous wavy (*wv wv*) rat. B—heterozygous rex (*Re/+*) rat.

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