

artist, Luke Jerram, also raises the issue of how the artificial colouring of scientific imagery affects our understanding of phenomena. Jerram is exploring the links between the artworks' beauty, what they represent and their impact on humanity. The works are currently on show at the Smithfield Gallery in London and the swine flu virus has been acquired for display by the Wellcome Trust.

The question of pseudo-colouring in biomedicine and its use for science communicative purposes is a vast and complex subject, he believes.

In response to this, Jerram has created a series of transparent, three-dimensional, sculptures.

The sculptures were designed in consultation with virologists from the University of Bristol using a combination of different scientific photographs and models.

Jerram said: "It's great to be exploring the edges of scientific understanding and visualisation of a virus. Scientists aren't able to answer many of the questions I ask them, such as how the RNA is exactly fitted within the capsid? At the moment camera technology cannot answer these questions either. "We can photograph a virus with an electron microscope, but it's sometimes difficult to see what is going on inside it because the technology is at the very edge of its capability and the resolution is not quite good enough. So you end up having to jump from what you can see to what you can infer from the chemical modelling," he says.

"There's sometimes a gap and a certain amount of guesswork, and that edginess is quite interesting for me."

"I'm also pushing the boundaries of glassblowing. Some of my designs are simply too fragile and gravity would cause them to collapse under their own weight."

He hopes visitors will get a sense of the beauty of virology. "But there is also that fascinating tension between something that is very beautiful but which is also dangerous and having a terrible impact on humanity."

Nigel Williams

## Quick guide

### Norway rats

Bennett G. Galef

**Why 'Norway' rat?** The Norway or brown rat, as it is sometimes called, is not always brown, did not originate in Norway and was classified first as *Mus* and later as *Epymus* before the Linnean classification as *Rattus norvegicus* by Berkenhout in 1769. The appellation 'Norway rat' derives from Berkenhout's assumption that the first *R. norvegicus* arrived in the UK on lumber ships from Norway, although *R. norvegicus* was probably not present in Norway in mid-18<sup>th</sup> century, when the species first invaded Britain. Wild *R. norvegicus*, the forebears of all laboratory rat strains whether albino, hooded, black or agouti, are thought to have originated somewhere in Asia, possibly in the plains of northern China. So, perhaps, we should call them Chinese rats.

**What are wild Norway rats like?**

Adult male Norway rats weigh an average of 350 g and adult females about 250 g. Although adult males weighing 500 g or more have been captured in the wild, reports of rats as big as cats are either wildly exaggerated or refer to very small cats. Norway rats are most successful in temperate zones and are largely replaced in the tropics by the lighter, more gracile black rat, *Rattus rattus*, and Polynesian rat, *Rattus exelans*. In areas such as northern Montana, Alberta, Greenland and northern Siberia that have extremely harsh winters, Norway rats can survive only by overwintering in human habitations, though colonies of Norway rats living outdoors have been reported in both South Georgia Island (53° S) and Nome, Alaska (52° N).

Female rats become sexually mature at about three months of age, can breed throughout the year and can produce as many as five litters that average six or seven pups per year. Annual mortality in the wild is estimated at 95 percent, with few individuals surviving for more than one year, although in the laboratory, genetically wild rats can live to three years of age.

In environments where food is abundant, such as urban areas or garbage dumps, rat colonies are generally large, strangers are not excluded from established social groups and males compete for females in estrous. Within colonies dominance hierarchies are formed with larger animals generally dominant over smaller ones.

Each colony inhabits a burrow system from which foragers emerge at dusk, and to which they return between foraging bouts that generally extend through the hours of darkness, peaking at dawn and at dusk. These burrow systems serve as information centers where foragers can exchange information about the current availability of foods. Although the main foods of rats are grains, they are opportunistic foragers reported diving for mollusks in Italy, feeding on sparrows and ducks in Germany and capturing fingerling trout in North American hatcheries.

**How were rats first domesticated?**

Domestication of Norway rats (Figure 1) has been hypothesized to have occurred in the 19<sup>th</sup> century as a by-product of the 'sport' of rat baiting. In one version, a large number of rats was placed in a pit with a dog, usually a terrier of one breed or another, and spectators wagered on the number of rats the dog would kill in a fixed period of time. The record set in 1862 by Jacko, a cross between an English bulldog and a black and tan terrier, was 60 rats killed in 2 minutes and 42 seconds. The suggestion has been made that uncommon albino rats, captured during trapping of the thousands required for baiting, were displayed outside betting establishments, and that these albino rats became the ancestors of at least some of today's domesticated strains. Domesticated albino rats were first used in laboratory studies of nutrition at Clark University in Worcester, MA and 5 years later in Willard Small's studies, also at Clark, of the behavior of rats in mazes. The title of the horror film "Willard" is unlikely to have been a coincidence.

**What are rats good for?** Norway rats have played an important role in both biochemical and behavioral studies. For example, classic work on behavioral regulation of the intake of food, water, and both macro- and



Figure 1. Domesticated Norway rats, if handled from an early age, make affectionate pets and can even be taught to walk on a leash.

micro-nutrients used rats as subjects. Pioneering studies of circadian rhythms, play, sexual behavior, maternal behavior and aggression and their physical substrates were all heavily dependent on work with rats. Studies of development, animal learning and, more recently, animal cognition have also relied heavily on data from Norway rats. During the 1930s and 1940s, when studies of rat behavior peaked, more than 60 percent of all articles published in the leading animal psychology journal of the time, the *Journal of Comparative and Physiological Psychology*, reported studies that used rats as subjects.

**Why were rats so popular in studies of behavior?** There were a number of factors. Domesticated rats breed readily in the laboratory throughout the year and thrive on relatively cheap, low-protein diets. They are easy to handle and behave normally in the presence of humans. Further, the Behaviorists' assumption that general laws of behavior could be studied in any species made convenience an important determinant of choice species for behavioral research. Changes in the interests of behavioral scientists, together with the marked increase in the cost of breeding and maintaining rats in the laboratory, and development of knock-out strains

of mice have markedly reduced the importance of rats in behavioral research. Although the study of rat behavior and its physical substrate continues in numerous laboratories, currently fewer than 10 percent of the papers in the *Journal of Comparative Psychology* in 2001 employed rats as subjects.

**What are rats bad for?** Though precise figures are not available, Norway rats and their congeners are rumored to destroy 15 percent or more of agricultural production in some Third World countries. In addition to their well known roles as reservoirs of microorganisms that cause a number of diseases (such as Weil's disease, rat-bite fever, Q fever, trichinosis and so on), despoilers of stored foodstuffs and invaders of human habitations, rats are also a major threat to many avian species, especially those that breed on islands. The introduction of rats into areas historically devoid of mammalian predators, and consequently inhabited by birds without appropriate defenses, has had disastrous consequences for eggs and young, particularly those of ground-nesting avian species.

**Why are rats so hard to exterminate?** Although it is not difficult to reduce temporarily the size

of troublesome rat populations, total extermination of pest populations of rats is difficult indeed. Wild rats are cautious animals, avoiding contact with any new object or food in their environment. Individual variation in such "neophobia" assures that catching or poisoning the last rats in a population is difficult, and the ability of a small number of survivors to replenish a reduced population in short order makes long-term control of the size of pest populations demanding. Further, rats are able climbers, burrowers and swimmers, making their long-term exclusion from cleared areas challenging. The province of Alberta, Canada has been successful in eliminating rats because of restricted invasion routes and a harsh climate that requires rats to overwinter in human habitations where they are particularly vulnerable to control measures.

The neophobic behavior of rats together with their remarkable ability to learn to associate ingestion of a new food with subsequent illness has led to development of anticoagulant rodenticides which, because they are slow acting, have the potential to circumvent the rat's ability to learn to avoid repeated ingestion of fast-acting toxins when aversive effects are experienced before lethal quantities are eaten. Unfortunately, some rats, sometimes called "super rats" in popular articles, have developed genetic resistance to warfarin and other first-generation anticoagulants. The arms race continues.

#### **Where can I find out more?**

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