

Singapore International Science Challenge 2007 Science Challenge

The Scenario

A scientific study, published in the journal *Proceedings of the National Academy of Sciences* in March 2007, reported that many of the world's local climates could be radically changed if global warming trends continue. Many regions would experience biome-level changes.

Scientists have recently discovered a unique mammal in the tundra. This mammal has an average length of 10 centimetres, including its tail. The tail of this mammal can be as long as its body. This creature has yet to be given a scientific name but the scientists who made the discovery are affectionately calling them "**snow puppies**". With the changes in climate, likelihood of species extinctions is increased. There is now renewed interest to study more intensely on the tundra ecosystem and *snow puppies*.

It is observed that the *snow puppies* live in eusocial colonies of up to 80 within each colony dominated by a single breeding pair. They have a highly unusual set of physical traits, including a nearly cold-blooded metabolism, that enables them to thrive in a harsh, underground sub-arctic environment.

Snow puppies live in burrows in arid tundra. The tunnel systems can stretch up to 5 kilometres in cumulative length. Scientists are intrigued by their complex systems of burrows which are an engineering feat. They continually dig tunnels in search of insects and edible roots and at the same time evade the deadly jaws of arctic foxes and wolves. Their large, protruding and powerful teeth are used to dig. While digging, their lips are sealed just behind their teeth to avoid filling their mouths with soil. Their legs are short and they have white thick fur. The *snow puppies* spend virtually their entire lives in the total darkness of underground burrows.

By 2100, global temperature will increase by 2 to 5 °C from to current temperatures. For survival, the *snow puppies* would have to adapt to these climate changes.

The Challenge

Students are to propose theories and explanations on various features and behaviour of the *snow puppies* as well as on the environment these creatures live in. Students would have to apply their understanding of science and make predictions. They will be judged on the robustness of their reasoning and the clarity of their presentation.

The Challenge

Typical snow puppies individuals are 8–10 cm long and weigh 30–35 g. Queens are larger and may weigh over 50 g, the largest reaching 80 g. Individual snow puppies are found to live much longer than other mammals of comparable size.

Suggests some possible mechanisms that might account for the long lifespan of snow puppies.

The *snow puppy* is well adapted for the limited availability of oxygen within the tunnels that are its habitat. Its blood has a very strong affinity for oxygen, increasing the efficiency of oxygen uptake. It has a very low metabolic rate for an animal of its size, thus using oxygen minimally.

Suggests some possible mechanisms that increase the efficiency of oxygen uptake in snow puppies.

Snow puppies have a complex social structure in which only one female (the queen) and one male reproduce, while the rest of the members of the colony function as workers. The workers are divided along a continuum of different non-reproductive worker-caste behaviours instead of discrete groups. Some function primarily as tunnelers, expanding the large network of tunnels within the burrow system, and some primarily as soldiers, designed to protect the group from outside predators.

Explain the seemingly altruism of the workers helping the queen snow puppy. Do their behaviour contradict with the Theory of Evolution by Natural Selection? Suggest some reasons why the snow puppies would evolve to become eusocial.

Branching, interconnected networks of tunnels link up nest areas, toilet chambers, and food sources. Major 'highway' tunnels are wide enough for two snow puppies to travel side by side and include turnouts for the animals to back into and change directions while smaller side tunnels are less than 5 cm across.

Suggest how the snow puppies' tunnel system would be like in order for them to survive the harsh cold of the tundra and yet allow sufficient air circulation in the tunnels.

The *snow puppy* is unique among mammals as it is virtually cold-blooded; it cannot regulate its body temperature and requires an environment with a specific constant temperature in order to survive. Fortunately, the temperature in underground burrows remains relatively high at about 25 °C to 30 °C.

By 2100, the temperature of the tundra would increase by 2 to 5 °C from current temperatures due to global warming, suggest how the snow puppies need to change the design of their tunnel system in order to survive in the future?