Frogs in Space – Teacher Notes

Much of the information in these Teacher's Notes has been adapted from 'The Frog in Space (FRIS) Experiment Onboard Space Station Mir: Final Report and Follow-on Studies', 1997, Yamashita, M, Izumi-Kurotani, A, Mogami, Y, Okuno, M, Naitoh, T and Wassersug, R, Biological Sciences in Space, Vol. 11, No. 4 (1997): 313-320

Frogs have been launched into space a number of times in the past for many different studies. In November 1970 NASA launched the Orbiting Frog Otolith spacecraft sending two bullfrogs into orbit in order to study the effect of microgravity on the frog's vestibular system in particular the effect of microgravity on the otolithic organs.

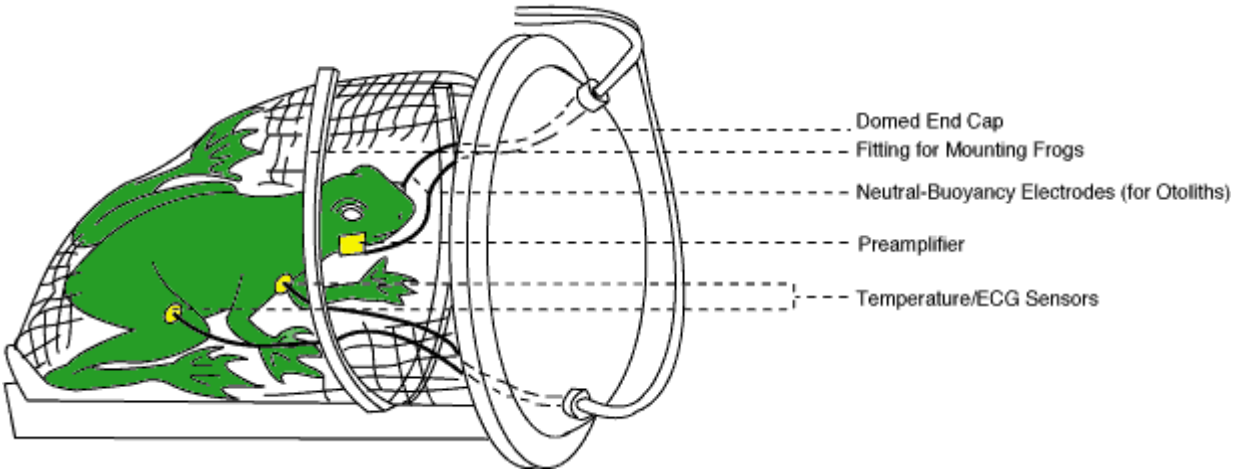

Figure 1: Orbiting Frog Otolith Package

The bullfrogs were used as their inner ear labyrinth has a very similar structure to humans. Also, because frogs are amphibious they could survive in air during pre-launch surgery and also in water during the flight. The satellite orbited the earth and through microelectrodes surgically mounted in the vestibular nerves running from the sensor cells in the frog's otolith organs the reaction of the bioelectric action within the frog's vestibular system could be measured during weightlessness. Then, through use of a centrifuge, the frogs would be exposed to artificial gravity in order to measure the difference. Unfortunately for the frogs onboard the vehicle was never intended to be recovered.

The focus of this lesson will be the Frogs in Space (FRIS) experiment performed by Japanese scientist aboard the Mir Space Station. In December 1990 the Japanese Institute of Space and Astronautical Science sent six adult Japanese tree frogs to the Mir Space Station for 8 days to observe and record their behavior in microgravity.

As we know all life on earth has developed in the 1 'g' gravitational field. The observation of the behavior of various species in microgravity can provide valuable insight into the

evolution and function of organisms. Frogs in particular are an interesting animal to study in microgravity as amphibian were the first creatures to leave the water and become land dwelling animals by supporting their weight on limbs. They also live in very diverse environments. Frogs begin life as tadpoles in water and become terrestrial after a metamorphosis period. Because air is 1000 times lighter than water amphibians must make many physiological adaptations as they emerge from water into terrestrial habitats.

The FRIS experiment revealed much about how amphibians behave in the absence of gravity. The experiment began as a small student proposed project to determine if frogs could hop in microgravity. The experiment was then refined by scientists who added more questions.

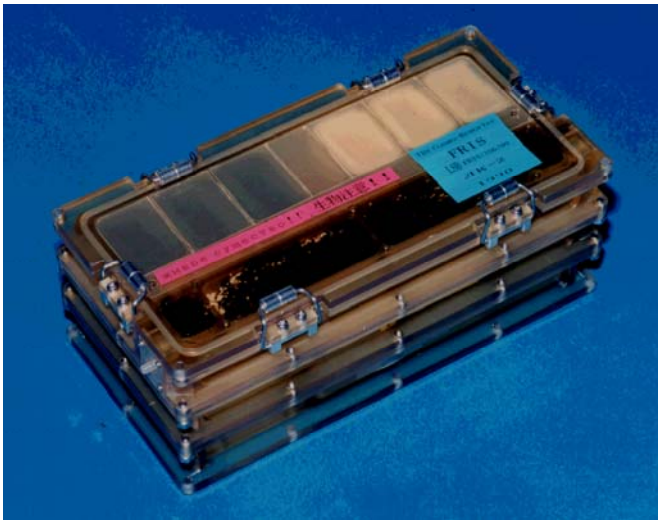

Figure 2: FRIS Life Support Box

The six frogs were housed separately in small compartments within a specifically designed Life Support Box (LSB) that transported them into orbit. The LSB provide air and moisture and some room to move. The LSB was launched on a Russian Soyuz spacecraft. When aboard the Mir Space Station the frogs were released into a clear glove box with a volume of 20 litres. The inside of the glove box was moistened by a wet sponge. The frogs were observed through the box every day. On the third day after launch the frogs were extensively observed, they were stimulated with various food sources and their behavior was videoed. This was repeated on the sixth day. A group of control frogs on Earth were subjected to the same set of stimuli as those in orbit.

The videos of the behavior of the frogs in microgravity was analysed extensively. It was found that when the frogs floated in microgravity they took the same spread limbed pose as when they freefall from trees on Earth, very similar to a skydiver. This was thought to be the frogs natural reaction to a decrease in gravity felt during freefall. They also moved their limbs in a motion similar to swimming though the movements were much bigger. It was discovered that these motions are used by frogs on Earth when they are upside down to turn their bodies up the correct way. They also moved their limbs in asymmetrical motion to attempt to stabilize rotation.

Over the course of the 8 days in orbit the frogs slowly declined in their attempts to jump into the air inside the box. This suggested that the frogs were beginning to adapt to the microgravity environment. In fact it appeared that the frogs adapted very well to the

microgravity environment. This was proposed to be the case because tree frogs have natural experience to changes in acceleration as they jump or fall from trees on Earth. The frogs were displaying their natural behavior based on the signals from their vestibular systems.

The frogs would also bend their heads backward strongly when sitting on surfaces. This posture is not normal on Earth except when retching or vomiting, this raised the possibility that the frogs may have experienced space sickness.

Figure 2: FRIS Recovery Box

For recovery the frogs were transported into a Frog Recovery Box (FRB) on their last day aboard Mir. The FRB was sealed but sustained the frog's life through special tablets that release oxygen when mixed with water. All six frogs were alive when recovered on Earth and were then observed directly after landing and then over the next 12 hours to observe their readaption to a 1 'g' environment. The flight frogs differed in posture and behavior from those control frogs kept on Earth. They moved slower and took longer between jumps. When the frogs were stimulated with a moving light the flight animals did not move their head to compensate like the control frogs. The differences in behavior began to fade after 2.5 hours and the flight frogs were displaying completely normal behavior after 12 hours showing their successful readaption to the 1 'g' environment. Two of the frogs were dissected and studies undertaken on their bones, tissue and internal organs.