

## AVIAN HARDWARE CONCEPT PAPER

Continuation of avian research in space is essential in order to answer a number of NASA critical questions. Various NASA and NRC advisory committees have identified the avian model as an excellent choice for various types of research. The Advisory Committee report (1998) from the Space Studies Board, "A Strategy for Research in Space Biology and Medicine in the New Century" states as one of its highest research priorities:

"Key model organisms should be grown through two complete life cycles in space to determine whether there are any critical events during development that are affected by space conditions. Because no critical effects have been seen in model invertebrates, the highest priority should be given to testing vertebrate models such as fish, birds, and small mammals such as mice or rats. If developmental effects are detected, control experiments must be performed on the ground and in space, including the use of a space-based 1-G centrifuge, to identify whether gravity or some other element of the space environment induces the developmental abnormalities."

Over the last twenty years other NASA advisory committees have identified a number of space related critical questions the avian model could be used to answer:

- How does gravity affect organogenesis and the development of anatomical structures?
- What will be the result of gravity-induced dy-synchrony (temporal or hormonal) during embryonic development?
- Which responses are transmitted maternally and which are intrinsic to the developing embryo?
- Which organ systems are dependent on the 1-G gravity field and vector?
- Will hatching or parturition occur normally?
- Are there critical windows of susceptibility for developmental processes, or is development affected in a gradient?
- If gravity-related effects exist, can they be reversed in the short or long term?
- Considering development as a series of stages or phases, beginning with pattern specification and progressing through differentiation, how will gravity affect selected phases in animals that represent different species and phyla?
- What are the effects of spaceflight radiation on male and female reproduction and the possible pathological effects of this to eggs, sperm, and developing embryos?
- How can animals be used to extrapolate probabilities of radiation risk to humans in space?

Many of these critical questions were identified over 15 years ago and, while there have been a number of life sciences payloads flown on the Shuttle over this time, very few if any of these questions have been answered completely. Scientists are constantly faced with numerous difficulties and constraints from the Shuttle platform and the lack of adequate hardware in which to conduct their experiments. Now the International Space Station is being built and there will be a permanently manned life sciences laboratory in space, the remaining factor needed to perform successful research is the availability of world class hardware.

If we are in fact going to perform research on the effects of low gravity on the multigenerational development of vertebrates, we need a suite of hardware that can accommodate all levels of development.

SHOT developed the Avian Development Facility (ADF) which incubates 18 quail eggs, fixes them at various stages of development and provides a 1-G control, also consisting of 18 eggs. If desired, all 36 eggs can be incubated as the experimental group. The ADF flew its first shuttle flight in December 2001 as part of NASA Ames Research Center's Space Station Biological Research Project (SSBRP). The ADF provides researchers with the capability to address the first critical step in understanding multigenerational development of the avian model. The ADF provides a "window" for study of embryogenesis in space. It provides the facilities for investigators to better understand and then to mitigate or nullify the forces of altered gravity upon embryos.

The ADF provides a unique opportunity to exercise precise control of experimental environmental parameters, such as: temperature, humidity, oxygen, carbon dioxide, centrifugation (utilizing side-by-side controls in microgravity), and refrigeration. No avian experiment hardware to date has provided this capability. The ADF will monitor embryogenesis during orbit, then if desired, fix specimens and shut down the experiment before leaving orbit. In effect, the ADF makes every attempt to minimize launch and re-entry effects in order to isolate and preserve the effects of the experimental variable(s) of the space environment.

The next piece of critical hardware needed to continue this research must provide the capability to support quail from post-hatch to adult. SHOT is currently performing research and development to provide NASA with an Avian Hatchling Habitat (AHH). The AHH will provide innovations for observing, measuring, and manipulating newborn hatchlings and/or adult quail in microgravity. Eggs could be incubated in the ADF and then transferred to the AHH for hatching and development, or quail hatchlings/adults could even be launched in the AHH. The current concept for the AHH will provide quail with food, water, and the basic environment needed to raise quail to adulthood. The AHH will include a waste handling system for the unique products of quail as well as the elimination of odors and options for individual or grouped housing. In addition, programmable temperature and lighting control will be available while video monitoring during day/night cycles will be utilized for observation of the quail. For complete multigenerational studies, the AHH can be used for breeding and laying eggs, since the AHH cage provides the flexibility of different housing configurations.

## **CONCLUSION:**

For the first time in the U.S. space life sciences history, avian hardware exists to provide researchers a low-gravity environment completely devoid of significant gravitational influence. Think of the concept where eggs are produced from artificially inseminated quail, the eggs incubated, and hatchlings produced all on-board the International Space Station in the U.S. Life Sciences Laboratory.