

UNIT 6.1

Rat Physiology in Space

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Vocabulary:

- Living System
- Metabolism
- Proprioception
- Pituitary Gland
- Vestibular Apparatus
- Muscle Contraction
 - Slow Twitch
 - Fast Twitch



Purpose:

Overall, the laboratory rat is the single most used and most important species for studying space physiology. This lesson is intended to first convey basic information about its physiology in Earth's gravity, which hopefully will facilitate development of appropriate space platforms and related paraphernalia and procedures. Secondly, the scientific significance of the rat to space research will be shown by reviewing the physiological responses of the rat and other mammals, including man, to microgravity.

Background:

Laboratory rats survive over a wide range of environmental conditions but some of the conditions (e.g., flash of light during darkness, no water, abnormal temperature) compromise science so that the effects of microgravity may be obscured by other environmental factors. Neither NASA nor space physiology needs uninterpretable data.

For optimal science, rats should be exposed to a temperature of 22° – 25° C, humidity of 30 – 70%, 10 – 20 air changes per hour, constant or regular access to water and food (hard food or something hard to chew on), and a regular light cycle. If feasible, rats are much more tractable and seem to do better if group housed. Preflight handling by humans also gentles the rats.

Specimen Preservation: Live Rats

- If the above guidelines for rat husbandry are met, rats will fare very well between loading and insertion of the vehicle into orbit (20–30 hours) and during orbit. Procedures to shorten the time between loading and launch would facilitate science.
- By the third day of flight the animals appear to have adapted to weightlessness as adjudged by food and water consumption (rats do not vomit but do grind their teeth when “motion sick”). The biggest problem thus far has been in keeping the temperature down during flight.
- Depending on the type of vehicle used the reentry, g forces vary from 3g to about 15g and the time between touch down and access to the animals averages four hours for both Shuttle flights and Russian biosatellite flights. Shortening that interval would materially help the science yield.

Specimen Preservation: Tissues

For International Space Station (ISS) experiments many of the rats will be sampled in space and the harvested tissue preserved for later analysis either on the ISS or on Earth. Depending on the tissue and type of analysis, the specimen is chilled, frozen, or chemically preserved.

Information about the Laboratory Rat

- **Taxonomy**
 - Phylum: Chordata
 - Subphylum: Vertebrata
 - Order: Rodentia
 - Family: Muridae
 - Genus: Rattus
 - Species: Norvegicus
 - Strains: Many
 - Rats first used in science around the year 1857 and were albino members of wild populations of “Norway” rats.
- **Types of Rats**
 - Currently there are literally many dozens (hundreds?) of inbred or hybrid strains of rats, which vary slightly in their physiology, growth rates, temperament, etc.
 - Genetically modified rats: There are currently an increasing number of rat strains (e.g., Wistar, Sprague-Dawley) in which a gene has been intentionally deleted (“knockout”) or added (transgenic) which greatly increases their utility for particular types of experiments. The numbers of knockout and transgenic mice strains is much greater than for rats.
- **Characteristics of Laboratory Rats**
 - Life span: About 3 years
 - Pregnancy: 22 days; birth weight about 7 grams; typically have 8-10 pups
 - Reproduction: Vagina opens at 36–38 days at which age they can start to breed. Most females begin to cycle regularly at 50-60 days of age. Reproductive cycles (estrus cycles) are either 4 or 5 days (strain dependent) and continue for about one year and then begin to become irregular.
 - Adult Weights:
 - Females: 250 –300 grams
 - Males (grow continuously): 600 –700 grams
 - Diet: Omnivores
 - Active at night

Physiological Responses to Microgravity

- Space motion sickness?
- Loss of salts (sodium/potassium)
- Water loss
- Decreased number of red blood cells
- Cardiovascular deconditioning
- Immunological changes
- Reduced bone growth/strength
- Loss of skeletal and cardiac muscle
- Endocrine/metabolic changes
- Neural (spinal cord/brain) changes
- Abnormal tissue repair

Reference Materials:

(Human physiology) *Biomedical Results from Skylab* R.S.Johnson and L.F.Dietlein, eds. Scientific and Technical Information Office, NASA, Washington, DC, 1977 NASA SP 377

Final Reports of the U.S. Experiments Flown on the Soviet Biosatellite Cosmos 2044 (Two volumes) J.P.Connolly, R.E.Grindeland, and R.W.Ballard, eds. NASA Technical Memorandum 108802, 1994

“Comparison of hyper- and microgravity on rat physiology; an overview,” R.Grindeland *Aviation, Space Environ Med* 1998 69(6 Suppl). The entire issue is devoted to this comparison with papers by a number of authors on a number of tissues.

Journal of Applied Physiology, v81, No 1, July, 1996. Contains many reports on results from the SLS2 flight (rat and human data).

