# The Bion Project and the History of Post-Spaceflight Primate Anesthesia

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The 1973–1996 Bion Project was a combined Soviet-Russian/American program during which a variety of biomedical experiments were conducted (**Fig. 1**).[3,11] There were 22 rhesus monkeys flown during 11 missions into low Earth orbit, each for 5–22 d (**Fig. 2**). On return to Earth, the first 10 pairs were subjected to ketamine and isoflurane general anesthesia, on day 2 or 3 postflight (R+2 or R+3), to perform biopsies, bone density measurements, and to retrieve implanted monitors. The 11th pair underwent the same procedures on the first day postflight (R+1) after the 15-d orbital flight of Bion 11. One of the rhesus monkeys (#357, also named Multik) died in the immediate postoperative period. Because the procedure was administered on R+1 versus R+2 or R+3, concerns were raised that the death was due to unresolved physiological changes following 2 weeks of spaceflight, and that general anesthesia was possibly more dangerous when performed closer to recovery (McSwain N. Personal communication. NASA Working Group: Anesthetic considerations during and immediately following spaceflight. 2002). U.S. participation in Bion 12 was canceled due to the adverse publicity following the death of the primate. Over 20 years later, concerns continue to be expressed over this mishap and the safety of anesthesia during or shortly after spaceflight. The only other experience with anesthesia in association with spaceflight has been the limited use of intra-abdominal ketamine in rats onboard the Shuttle Neurolab mission in 1998.[4]

Animals have been used extensively as test-subjects since the beginning of spaceflight to probe hazards and study the physiological effects of weightlessness.[2,3] Numerous primates were flown by the U.S. in ballistic flights and into low Earth orbit, starting in June 1948 with the rhesus monkey Albert to a suborbital altitude of 39 miles aboard a V2 rocket. Subsequently, several monkeys were flown in the 1950s and 1960s, many of which did not survive the flight, primarily from spacecraft failure, hypoxia, or heat exposure.[6,7] In May 1959, monkeys Able and Baker were the first primates to be recovered alive after a suborbital flight.[5] On R+4, Able underwent a minor surgical procedure to remove implanted electrodes, but died unexpectedly during the anesthesia[5] from what appeared to be ventricular fibrillation after trichloroethylene (a volatile liquid anesthetic agent) was sprayed into her cage to sedate her.[2] The autopsy did not reveal any obvious cause of death, although trichloroethylene is known to increase the risk of cardiac dysrhythmias.[13] Besides procedural anesthesia in the postflight period, many of the monkeys were anesthetized during the flight itself, to mitigate stress. Details are difficult to come across, but the sedation was probably barbiturate-based as it was standard veterinary procedure at the time. Further notable primate flights include the suborbital flight of the chimpanzee Ham on a Mercury-Redstone (MR-2) rocket in January 1961 and the orbital flight of Enos in November 1961 onboard a Mercury-Atlas (MA-5).[6] During Project Mercury, it became well established that humans could survive the rigors of spaceflight and flight research with monkeys faded into the background.

In 2002, NASA and NSBRI (National Space Biomedical Research Institute) assembled a working group, chaired by Dr. Norman McSwain, to review the case of Bion rhesus monkey #357 and produce a conclusion regarding the safety of anesthesia after spaceflight. The results of the report were never officially

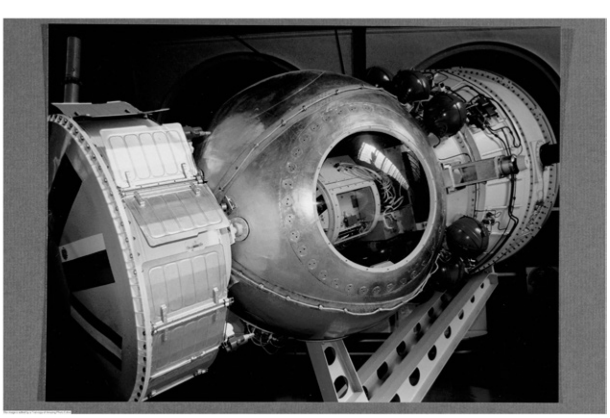

**Fig. 1.** The Bion spacecraft was 16 ft in length and weighed 10,000 lb. The central reentry descent module was 7.5 ft in diameter and weighed 5000 lb with an internal volume of only 5 cubic meters.

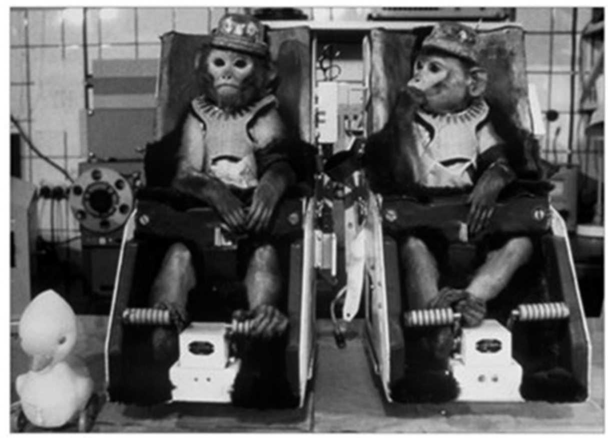

**Fig. 2.** A typical Bion payload of two rhesus monkeys. Usual weight was 10-15 lb each.


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published due to the death of Dr. McSwain (McSwain N. Personal communication; 2002). The report provided extensive details about the case: the animals were flown to Moscow after recovery in Kazakhstan and displayed the usual signs of motion sickness and facial edema, but with normal vital signs. In particular, monkey #357 was woken up after the initial anesthesia, and reanesthetized and reintubated a few hours later for logistical reasons (lack of access to the operating room). The events leading to the death are also well described, and began when the monkey, while awake in the postoperative period, vomited and aspirated before going into hypoxic bradycardia. A case for an increased likelihood of postprocedure nausea and aspiration could certainly be made due to postspaceflight neurovestibular dysfunction. The postmortem examination confirmed the presence of bronchopneumonia. The veterinarian involved noted that the monkey displayed an unusual lack of responsiveness to resuscitative drugs (epinephrine, atropine, and doxapram). The working group analysis concluded that this was probably due to severe hypoxia and not because of spaceflight related physiological changes. One could reasonably argue that carrying the same procedure on another monkey that hadn't been exposed to spaceflight would have led to similar complications. The authors of the NASA working group concluded that the Bion monkey death was not related to space-altered physiology, but that anesthesia will be more demanding during periods where the patient is transitioning from space to the terrestrial environment or viceversa and that inadequacies in any area by the providers (training, experience, or equipment) could increase the risk of a poor outcome. Motivated in part by the Bion Project, several studies concerning anesthesia during spaceflight have been produced in an effort to better understand the limitations and risks.[1,8–10,12]

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