Microgravity

Gregory Nelson, Ph.D. Loma Linda University

Microgravity is intended to provide a brief overview of how reduced gravity levels can affect physical systems, in general, and biological systems, in particular. The term microgravity is used to denote the situation where gravity levels (inertial acceleration) are much less than the 1 x **g** (9.81 m/sec^2 or 32.17 ft/sec^2) experienced at the surface of the earth. True weightlessness is not practically achievable in earth orbital spacecraft as there is always some drag due to the upper atmosphere and operations aboard spacecraft cause spikes in acceleration of the order 10^{-6} to 10^{-4} x g to any object that is not free floating. Care should be taken in referring to a "microgravity environment" vs. a "spaceflight environment" because of the total series of launch / orbit / recovery environments that astronauts or a flight experiment may encounter.

A series of examples are presented to illustrate how various forces experienced on the earth's surface become re-ordered in terms of their relative importance to a microgravity environment. In particular, density driven convection and sedimentation are no longer dominant forces. Unfamiliar forms of convection such as Marangoni convection (surface tension driven) become important and electromagnetic forces assume a different relative importance. This leads to different phase separation phenomena such as stable foams and aerosols as well as altered flame morphology. A series of calculations by Gunther Albrecht-Buehler are presented to show how spheres of liquid of different dimensions respond to the different gravity environments.

Next, examples from experiments conducted in space are presented showing how polymerization of proteins, cell morphology, bacterial growth, protozoan animal movement, gene expression, and fungal and plant growth respond to altered gravity levels or "gravity unloading." Examples of effects on humans are shown illustrating physiological adaptations to the musculoskeletal system and vestibular or balance system.

To emphasize the difference between the practical "spaceflight environment" and the idealized "microgravity environment" measurements of other spaceflight variables and their mission profiles are presented emphasizing acceleration, vibration and acoustic noise. Finally three examples of ground based experimental models are shown to illustrate how hypogravity environments may be simulated using clinorotation, rotating bioreactors and hindlimb suspension.