The Microgravity Simulation Support Facility (MSSF) at Kennedy Space Center (KSC) was established to support visiting scientists for short duration studies utilizing a variety of microgravity simulator devices that negate the directional influence of the “g” vector (providing simulated conditions of micro or partial gravity). KSC gravity simulators can be accommodated within controlled environment chambers allowing investigators to customize and monitor environmental conditions such as temperature, humidity, CO₂, and light exposure. Tissue culture facilities, basic cellular and molecular analysis tools, and advanced confocal fluorescence microscopy are also available for investigators to conduct their research projects.

**Slow Rotating Clinostats**

KSC engineers have designed a slow rotating clinostat that allows researchers to subject biological specimens contained within ISS stowage lockers (containing hardware used for spaceflight experiments), or other large containers, to simulated microgravity conditions (see Figs. A, B). The clinostat rotates in one dimension along the horizontal axis at 2-4 rpm. Power is provided for built-in computers, lamps, fans, and auxiliary equipment. Adapters can be developed to accept various hardware configurations. Other slow rotating clinostats are also available for 10cm x 10cm petri plates and other containers specialized for particular life science model organisms (Fig. C).

**Rotating Wall Vessel (RWV) Bioreactors**

Rotating Wall Vessels (http://synthecon.com/pages/home.asp) or rotating wall bioreactors (initially developed by NASA) have been successfully used to investigate gravitational effects on biological specimens, cell cultures, aquatic organisms such as zebra fish eggs/embryos, tissue cultures, etc. Microgravity effects are simulated within liquid media by RWVs and are studied by aligning cultures on a rotating horizontal axis at a defined rotational speed that regulates the fall velocity, thereby allowing specimens to remain in constant free fall simulating near weightlessness conditions.

Some studies have shown that morphological and structural changes in cells cultured in rotating wall vessels resemble those observed in vivo after exposure to microgravity during spaceflight. RWVs can also produce a partial gravity simulation effect by either increasing or decreasing the rotation speed in combination with changing the density of the suspension fluid, and/or other means. Customized Synthecon Rotary Cell Culture systems (Fig. D) in MSSF can be operated vertically or horizontally, and are compatible with autoclavable Rotating Wall Vessels, High Aspect Ratio Vessels (HARVs), Slow Turning Lateral Vessels (STLVs), and disposable vessels.

**3-D Clinostats and Random Positioning Machines (RPM)**

3-D clinostats have two independently rotating frames that are mounted perpendicular to each other (Figs E, F). The term “3-D clinostat” is used when both rotating axes of the device are running with constant speed and constant direction. However, both frames can also be operated with different speeds and different directions, in which case the term “random positioning machine” is often used. Randomness is achieved when the rotational angle differs between the two axes and changes over time.

An experimental apparatus containing research specimens is placed within the inner of two counter-rotating platforms. Modifications to the inner platform can allow use of various hardware configurations (up to 1.5 kg). Two 3-D clinostats versions are currently available at KSC, the Airbus RPM 2.0 (Fig. E; www.airbusDS.nl) and the Space Bio-Laboratories, Inc. GRAVITE (Fig. F; http://www.spacebio-lab.com/ENG-index.html). Based upon operating configurations, treatments of simulated microgravity (<10⁻³ g), partial gravity, or hypergravity (to 2-3 g) can be achieved.

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Microgravity Simulation Support Facility

A. KSC Slow Rotating Clinostat; B. KSC Slow Rotating Clinostat in ISS stowage locker configuration; C. Other 2D clinostats; D. Synthecon Rotary Cell Culture System with autoclavable HARVs and STLVs; E. Airbus RPM 2.0 configured with experimental vessel; and F. Space Bio-Laboratories, Inc. GRAVITE 3D-clinostat in an incubator.