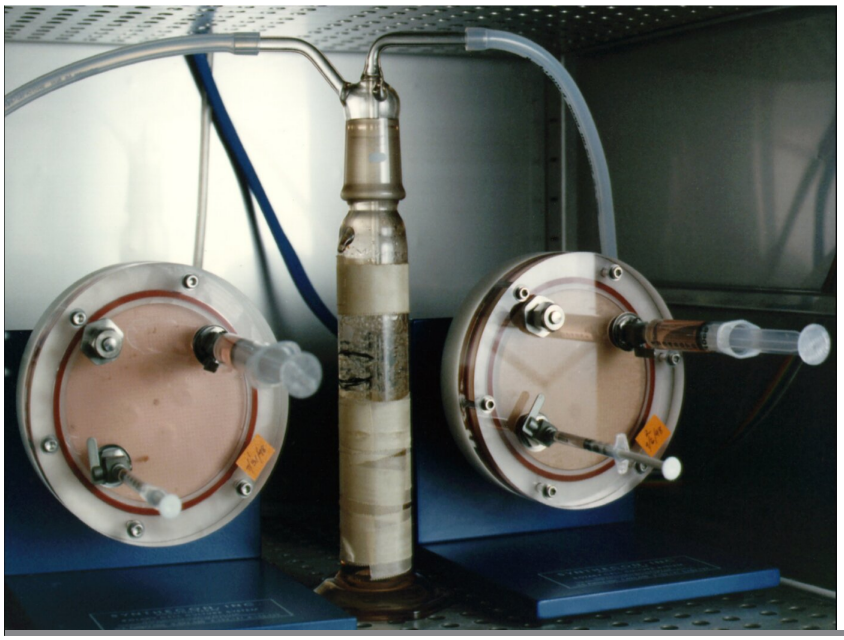


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

## Health, Medicine and Biotechnology

# 3D Mineralized Bone Constructs

Human bone-like structures grown in a lab can eliminate in vivo testing

Innovators at NASA Johnson Space Center have developed a technique to grow 3D tissue constructs, similar to human bone, in a laboratory environment. Problems arise when studying both the normal state and pathophysiology of bone. As an organ system, it is slow growing, so the time to study and observe a response to a particular stimulus is relatively long. Our bioengineers have discovered that osteoblast and osteoclast cell types can be induced to aggregate into large spheroids in a specific spatial relationship under certain culture conditions when placed in a rotating-wall tissue-culture vessel (shown above). The ability to construct a 3D model of such mineralized tissue on-demand, using a co-culture of human cells that differentiate and spatially arrange themselves in a physiologically relevant manner, is a major step forward in how the process of bone formation and remodeling can be studied.

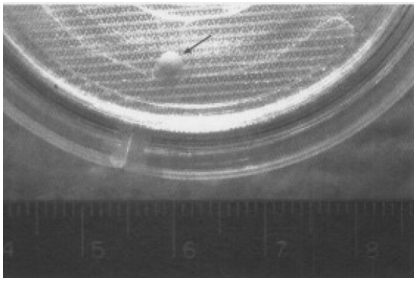
### BENEFITS

- Builds better representation of in vivo bone formation processes compared to traditional osteoblast only models
- Low-cost alternative for studying the process of bone loss and formation
- Rapid on-demand 3D model construction
- Provides a model for studying both normal bone physiology and pathological responses observed in disease states
- High economic platform for drug discovery
- Allows for easier study of interface between bone and prosthetic devices

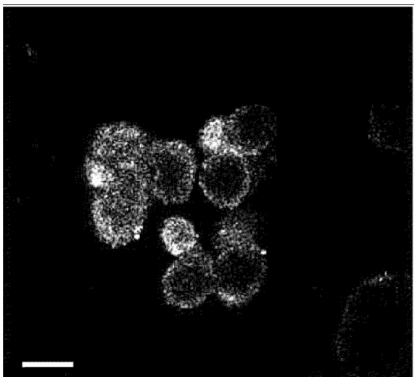
## THE TECHNOLOGY

One of the central objectives of this project was the development and characterization of a 3D mineralized tissue model system in which the effects of mechanical load (e.g., compression loading, tension, vibration, etc.) on the cellular responses of osteoblasts and osteoclasts could be investigated. After introducing mineralization agents to the culture, the constructs take on a bone-like appearance and have a more rigid structure suitable for being tested. Testing of the mineralized constructs confirmed the presence of calcium through a crystalline matrix histochemical stain. The central core is void of necrotic material, instead filled by a crystalline matrix with embedded nucleated cells. Remarkably, the nucleated cells do not express osteoblast markers, indicating differentiation to the in vivo cell type known as the osteocyte. In addition, as is characteristic to native periosteum, osteoclast precursor cells were imaged and proven to naturally arrange as an outer layer of the mineralized bone tissue construct. Development of this model will provide a unique venue for testing proposed countermeasures to space flight-induced bone loss. It will also allow a mechanistic approach in the modulation of cell signaling at the cellular level within the bone matrix.

The Development And Characterization Of A Three-Dimensional Tissue Culture Model Of Bone is a technology readiness level (TRL) 6 (system/subsystem prototype demonstrated in a relevant environment). The innovation is now available for your company to license. Please note that NASA does not manufacture products itself for commercial sale.



Shown: human primary osteoblast/osteoclast 3D construct development following 21 days of culture (~4 mm diameter spheroids).



Shown: mineralized 3D bone constructs fluorescently stained to track osteoclast precursor cells, revealed as white portions in the image.

## APPLICATIONS

The technology has several potential applications:

- Medical Devices: orthopedic research and product development
- Pharmaceuticals: drug discovery
- Research: bone function and formation studies; bone physiology and pathological responses to environmental influence and insults such as radiation

## PUBLICATIONS

Patent No: 8,076,136; 8,557,576

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NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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## More Information

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