Simulating Muscle Atrophy due to Microgravity and Ionizing Radiation

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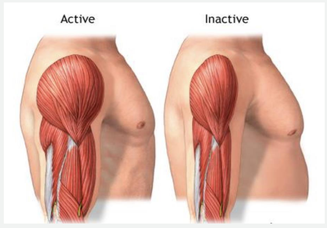
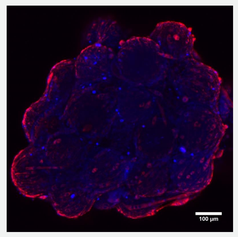
Introduction



Muscular atrophy is a serious issue for extended spaceflight. Understanding and preventing the role of ionizing radiation in skeletal muscle loss would preserve the strength and endurance of astronauts and enable longer duration space travel and exploration. Irradiation was performed in the USU material physics group's Space Survivability Test Chamber. C2C12 and CRL-1999 cells were exposed to dosages ranging from 0.5 – 36.8 Gy. Cell viability and growth rate were measured immediately following irradiation.

Ionizing Radiation

Cell Culture



C2C12 skeletal muscle cells were differentiated on microcarrier beads in an ultra-low attachment flask using DMEM F-12 10% FBS for 4 days then reduced to 2% FBS for 8 days.

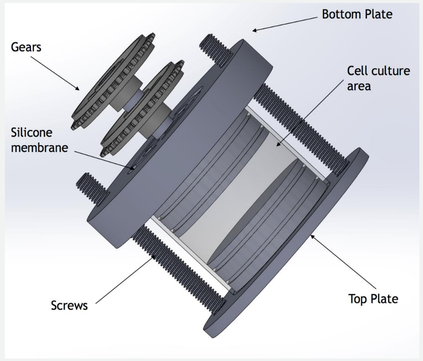
Irradiation

Cells were irradiated using Strontium-90 at a source-to-sample distance of 21.5 cm resulting in a dose rate of 1.6 Gy/hr. Experimental conditions are shown below.

Dosage Group	Radiation	Movement from Flask to Vessel	Microgravity Simulation
4 Gy	+	+	+
	+	+	-
	+	-	-
	-	+	-
	-	+	+
1 Gy	+	+	+
	+	+	-
	+	-	-
	-	+	-
	-	+	+

Rotary Cell Culture System

Device Fabrication



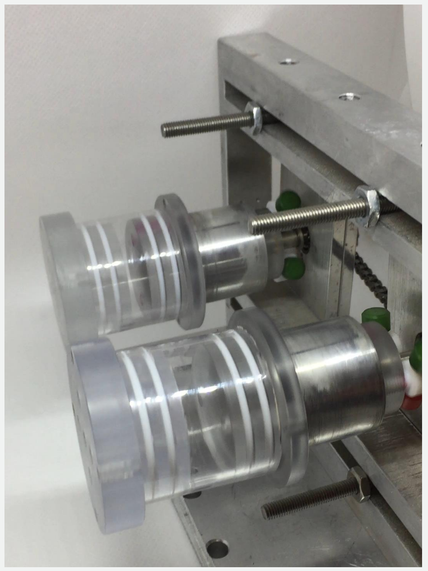


Figure 1. (Top) SolidWorks drawing of cell culture vessel.
Figure 2. (Right) Manufactured cell culture vessel attached to stabilization plates and gear chain for rotation.

Dosage Modeling

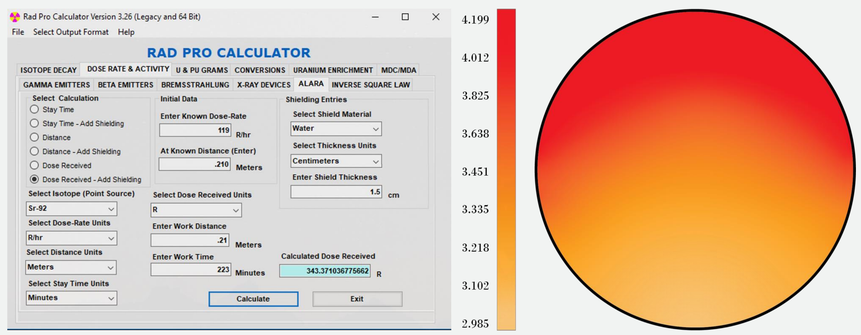
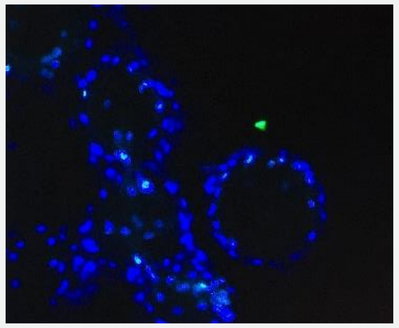


Figure 3. Beta radiation attenuates within the vessel due to shielding from culture media and polystyrene shell. Cell clusters not subjected to microgravity received an attenuated dose.

Results



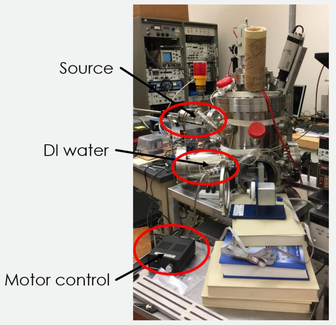


Figure 4. (Left) Cells exposed to 4.0 Gy under microgravity show dsDNA breaks stained with H2AX. (Right) RCCS models microgravity under ionizing radiation.

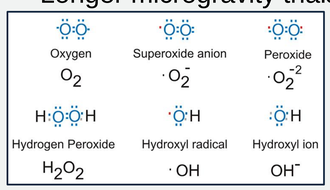
Conclusions and Ongoing Work

Conclusions

- Custom RCCS models microgravity and ionizing radiation simultaneously
- Ionizing radiation under microgravity conditions increases dsDNA breaks compared to microgravity alone

Ongoing Work

- Additional cell lines: aortic smooth muscle, cardio-myocyte
- Reactive oxygen species staining using CellROX Green
- Longer microgravity trials using lower dose rate irradiation



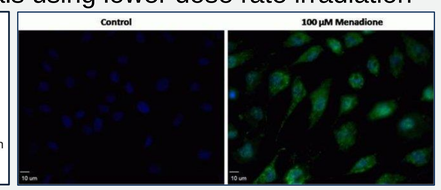


Figure 5. Radiation increases reactive oxygen species production which can be visualized using CellROX green stain.

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