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Probing the Nanomechanical Behavior of Cells and Cell Nuclei

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Cells vs. Isolated Nuclei
Nanoindentation was performed on MSCs and isolated MSC nuclei. Noticeable structural differences were observed between whole cells and isolated nuclei, including a decrease in nuclear area.

Nanomechanical Properties of MSC Nuclei
Mesenchymal stem cells (MSCs) are multipotent, capable of differentiating into bone, cartilage, muscle, or fat cells. A combination of mechanical and chemical signals guide this transformation; the goal of this study is to understand how mechanical signals affect MSCs.

One measurable response seen in MSCs is a change in the elastic or Young's modulus (i.e., the “stiffness”) of the nucleus, which can be calculated from the slope of a force-displacement curve.

Rather than a sharp AFM tip, a 10 μm diameter glass bead is used to indent on nuclei because it has an ~5,000x larger radius of curvature. This disperses the applied force, preventing the probe from puncturing the cell membrane. It also allows a more holistic measurement of the nucleus’s mechanical properties.

Conclusions
• Removing the cytoskeleton causes the nucleus to shrink and significantly reduces nuclear stiffness.
• Extended LIV treatment introduces a stressful mechanical environment for the nucleus, triggering an increase in nuclear stiffness.
• Lamin A/C and Sun-1&2 provide structural support for the cell. When removed, nuclear stiffness decreases significantly. This suggests that these components also impart structure to the nucleus.

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