Smart 2011(RET)Project

- Dr. Vikram Kapila, Project Advisor
- Mechatronics Laboratory
- Department of Mechanical Engineering, NYU Polytechnic
- Funding Provided by the NSF SMART Program

Analysis of Soft Materials Using Microindentation and Nanoindentation

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Analysis of Soft Materials Using Microindentation and Nanoindentation

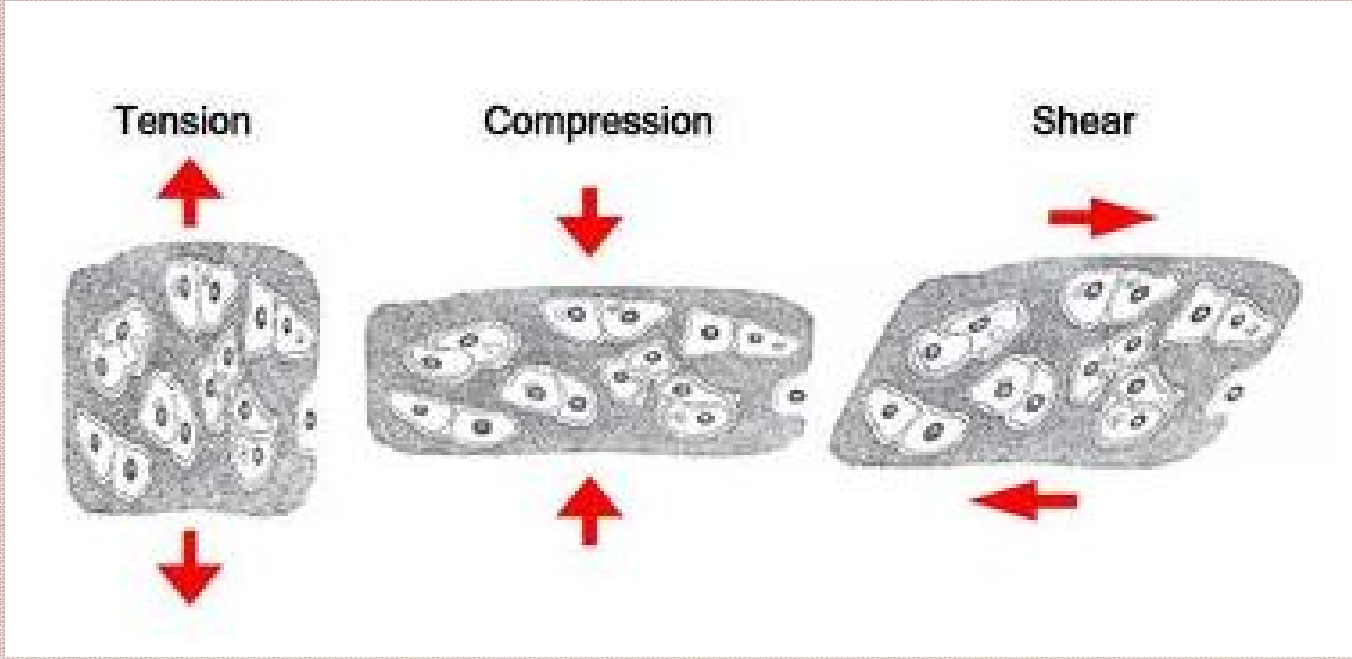
- **Background**
- MicroIndenter
  - Initial Testing
  - Soft Material Testing
- NanoIndenter
- Conclusions
- Lesson Plan

Background

- **Why analyze soft tissue?**
- Cartilage does not regenerate in adults. Once you are fully grown you have all the cartilage you'll ever have

Background

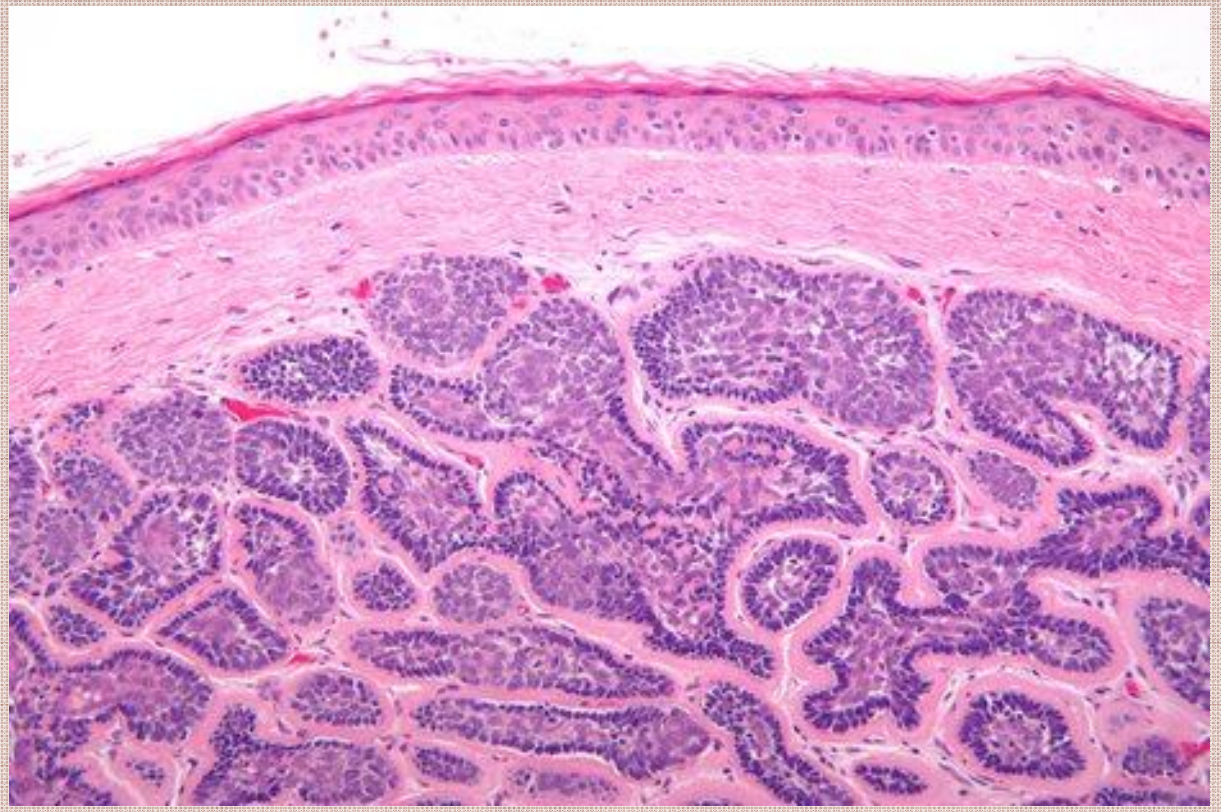
- Why analyze soft tissue?
- Understanding the properties of soft tissue in the body allows for better diagnosis and analysis of body systems



Background

Why analyze aqueous soft tissue?

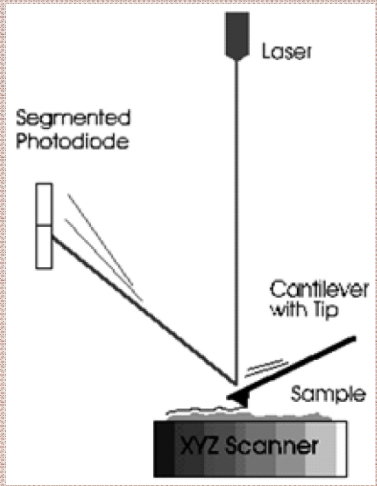
- Normal body tissue is not dry, it functions in an aqueous environment

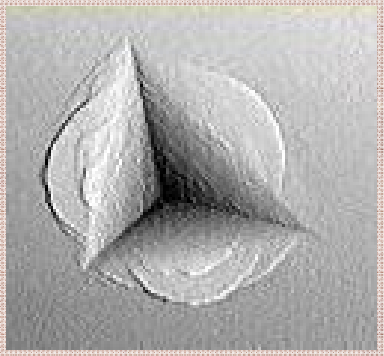


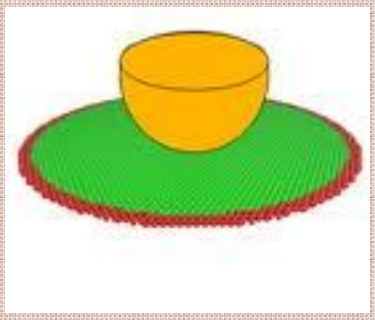
Background

Methods of Material Testing:

- Atomic Force Microscopy
- MicroIndentation
- NanoIndentation







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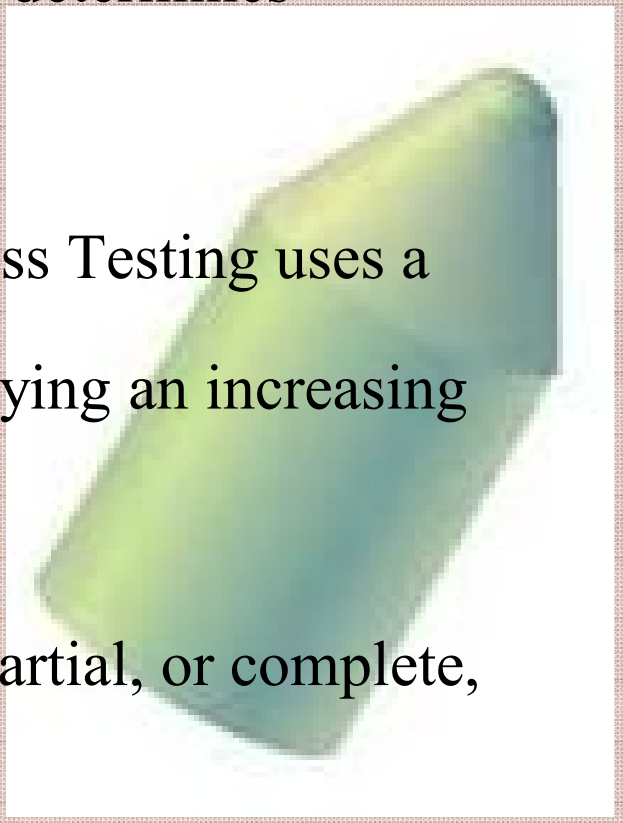
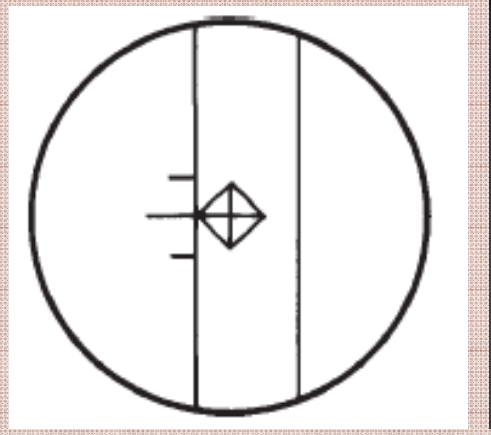
DIGITAL MICROHARDNESS TESTER

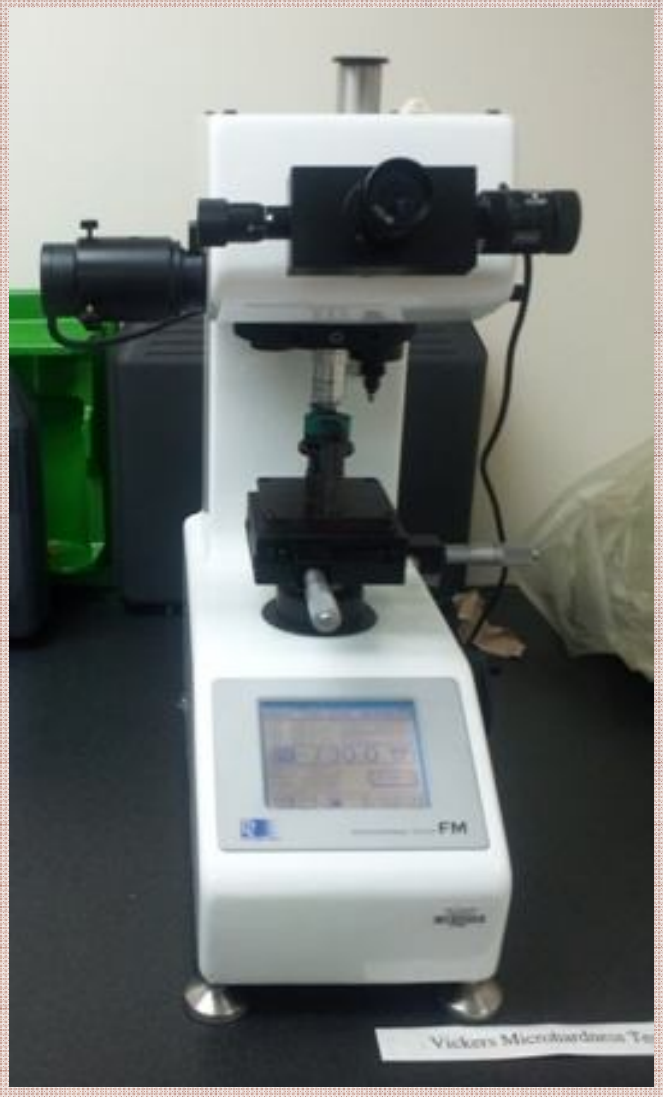
- Microindentation Hardness Testing quickly determines mechanical properties
- Microindentation/Macroindentation Hardness Testing uses a indenter tip to drive into the sample by applying an increasing load to a preset value
- The load is then gradually decreased until partial, or complete, relaxation of the sample has occurred.



MicroIndenter Initial Testing

- Digital Vickers Hardness tester
- 40x & 10x Lens Microscope
- Diamond Indenter





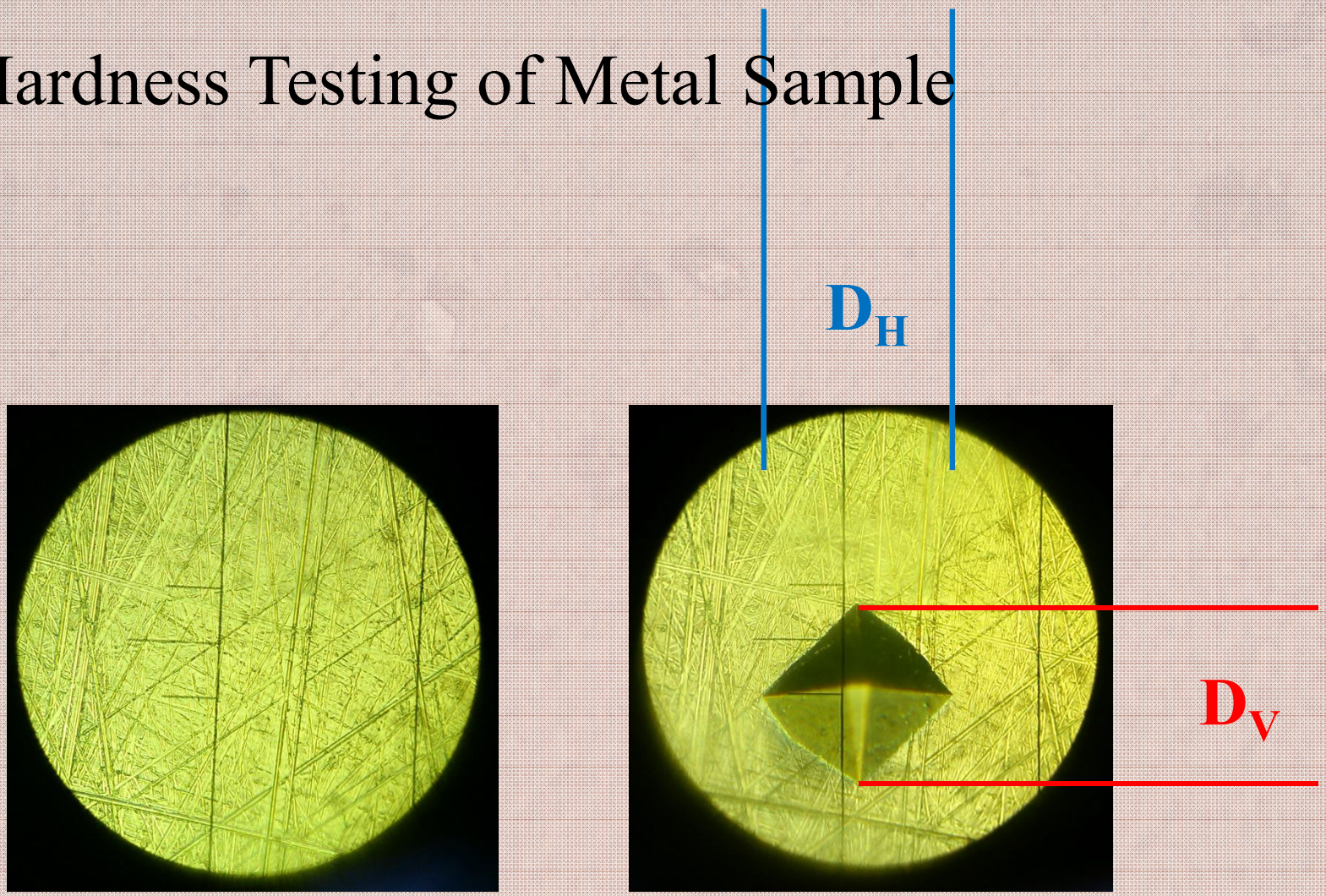
MicroIndenter Initial Testing

- Analog Dials for length and width of indentation measurement

- Image extraction uses optical (not digital) microscope

MicroIndenter Initial Testing

- Hardness Testing of Metal Sample



MicroIndenter Initial Testing

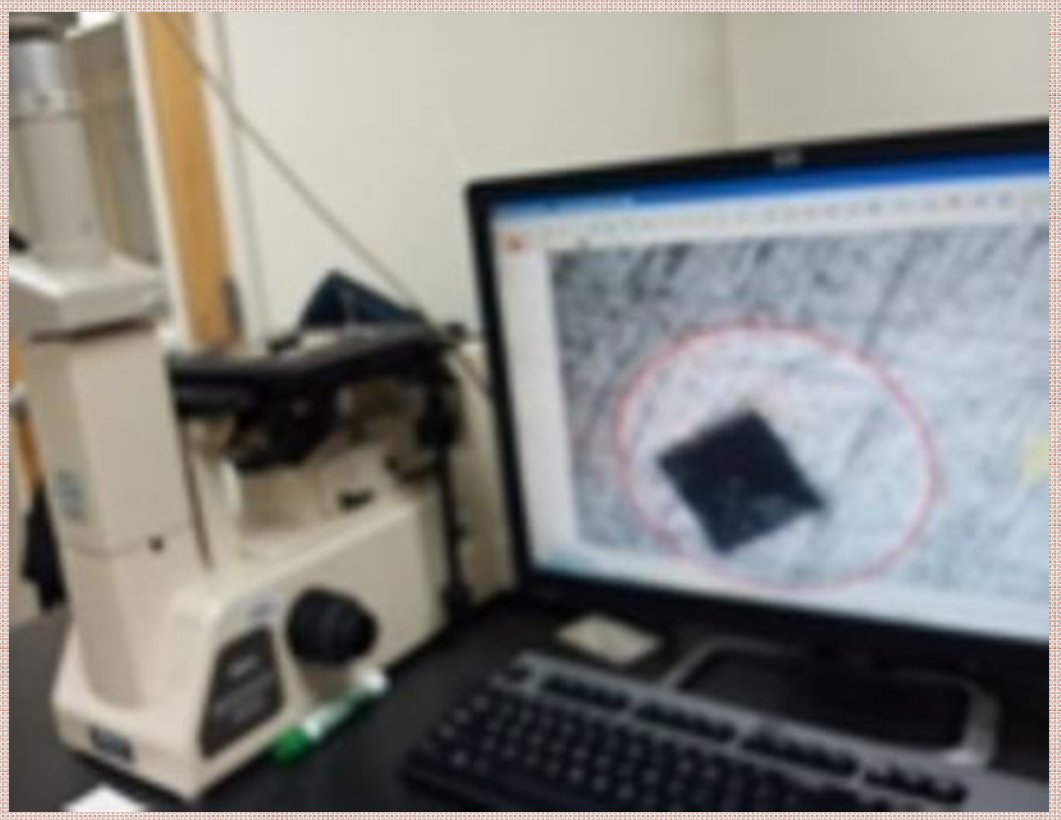
Image Analysis Using Nikon Epiphot 200

Advantages:

- 5x, 10x, 20x Lens
- Analysis software

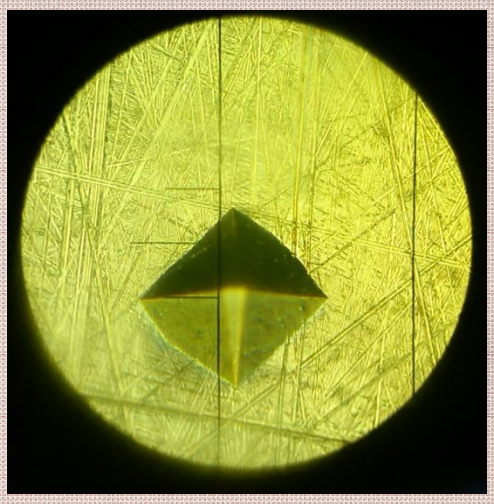
Disadvantages:

- Samples must be placed upside-down



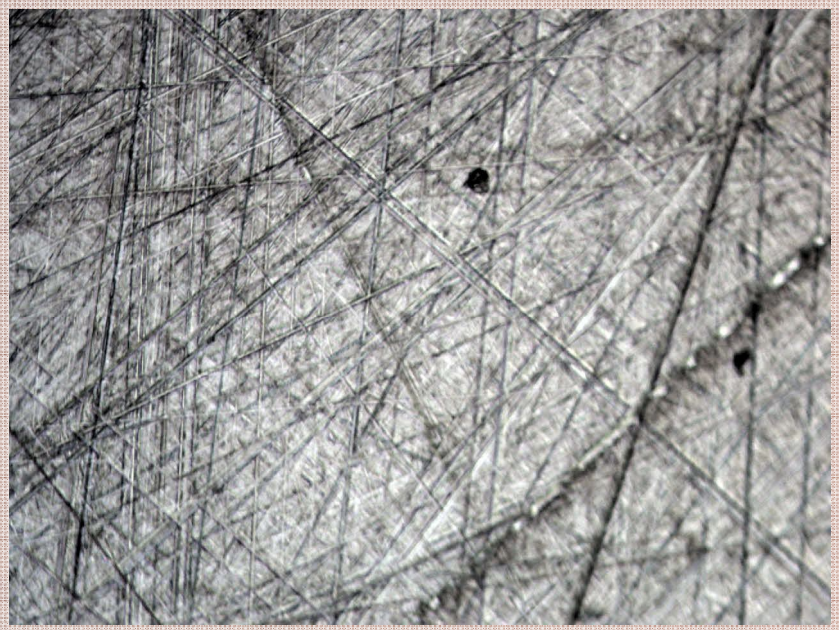
MicroIndenter Initial Testing

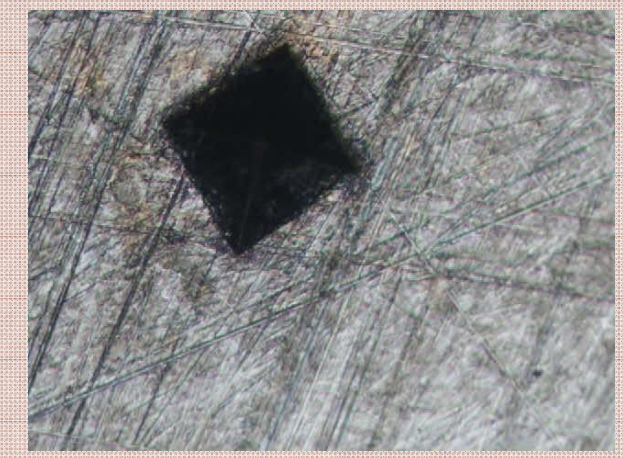
Sample Image:
Polished Coin



Digital Hardness tester

Digital Image Analyzer





Digital Image Analyzer

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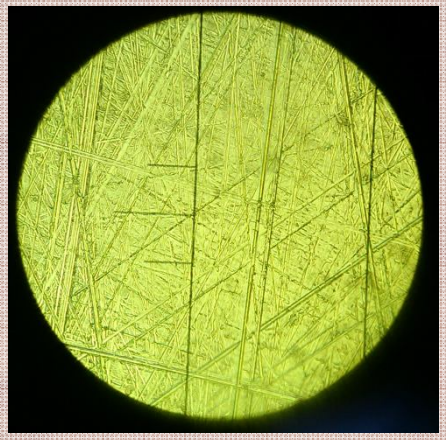
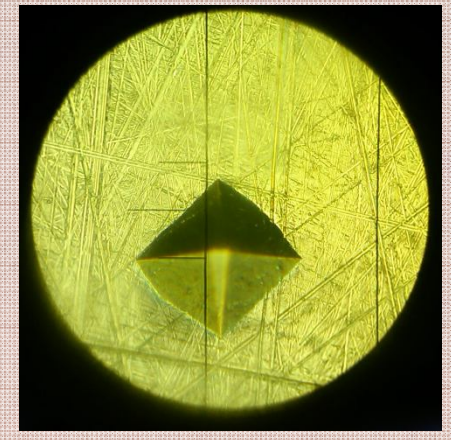
Soft Material Testing

Pre-Indentation

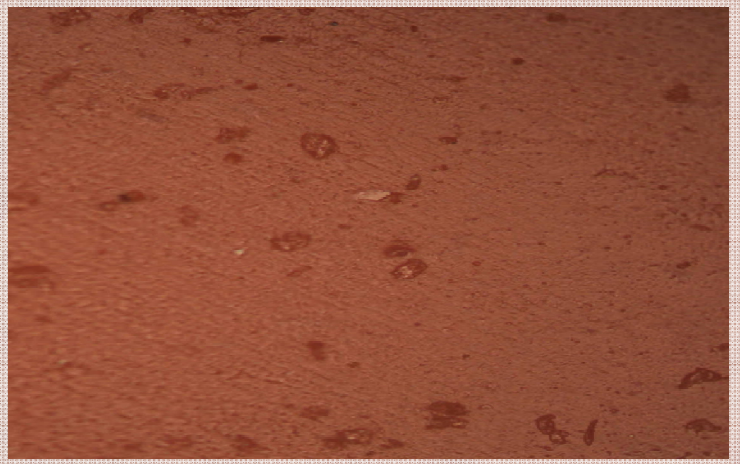
Post-Indentation

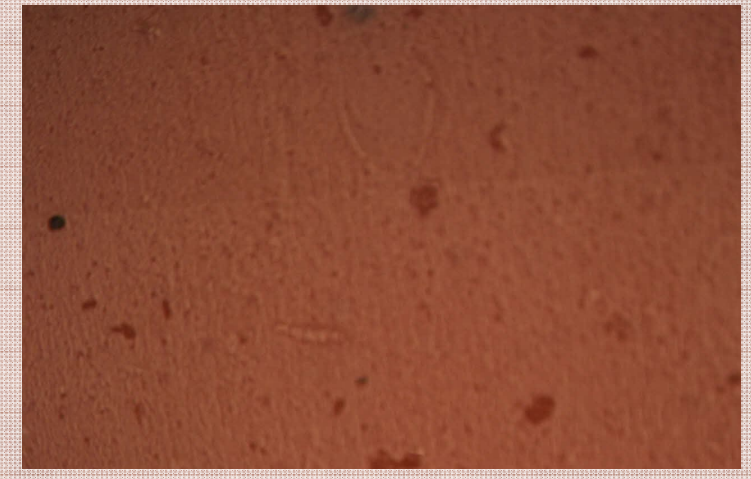
Hard Material





Soft Material

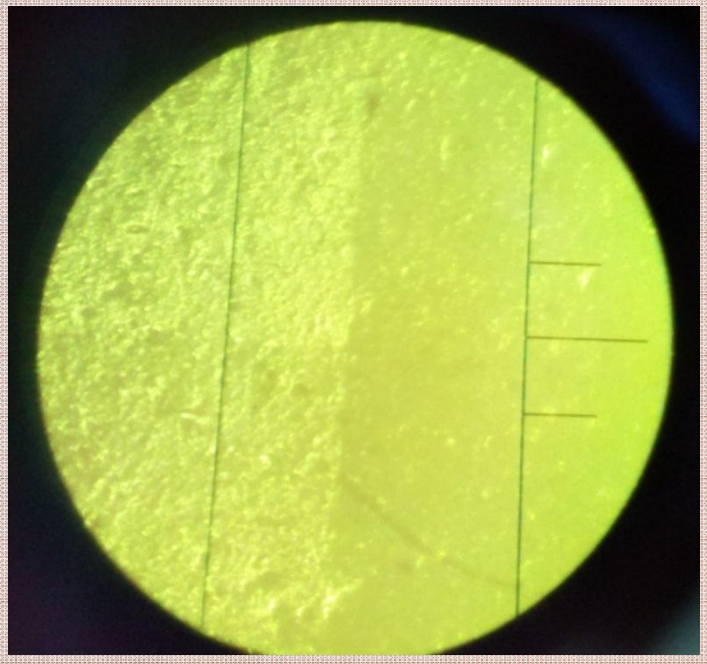




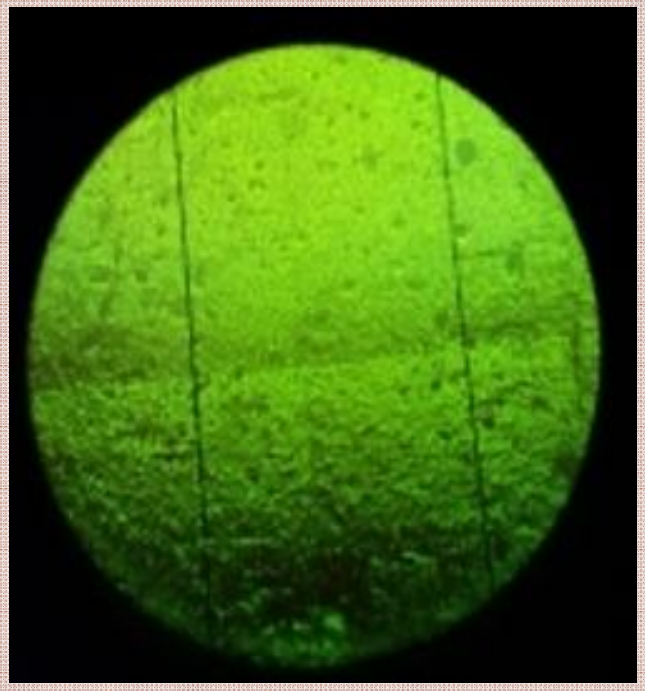
Soft Material Testing

- Medium Soft Silicone Rubber
- Durometer Rating: Medium Soft, 40A

Initial Imaging

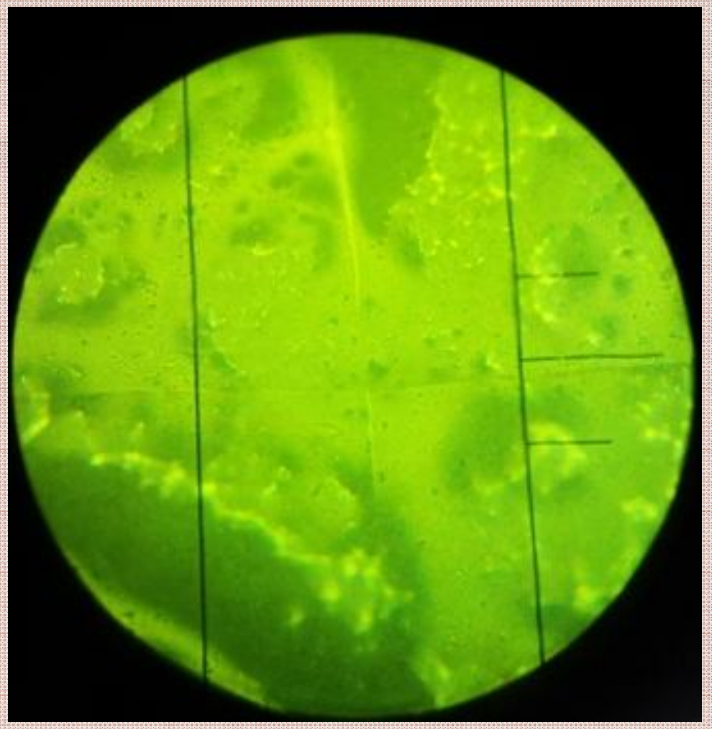


"Freeze" Imaging



Soft Material Testing

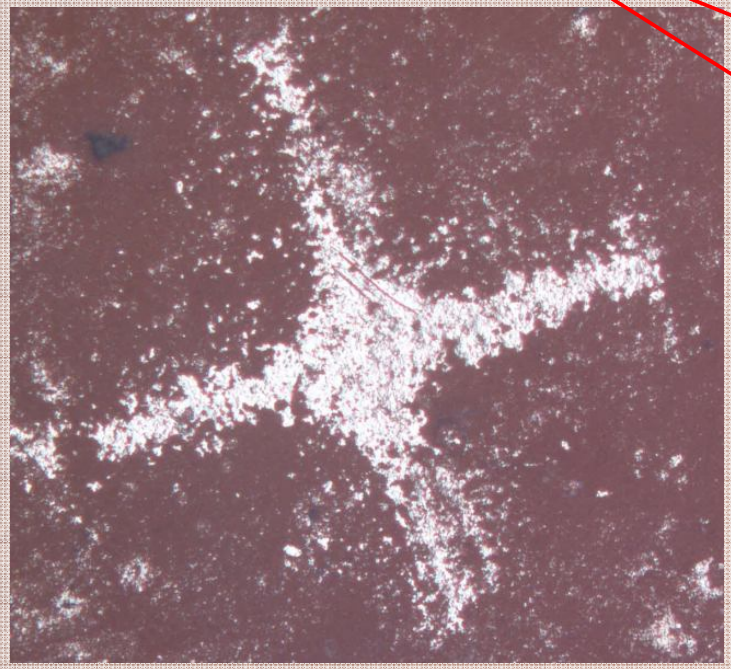
To simulate aqueous environment of body tissue, samples are immersed in PBS (Phosphate-Buffered Saline)

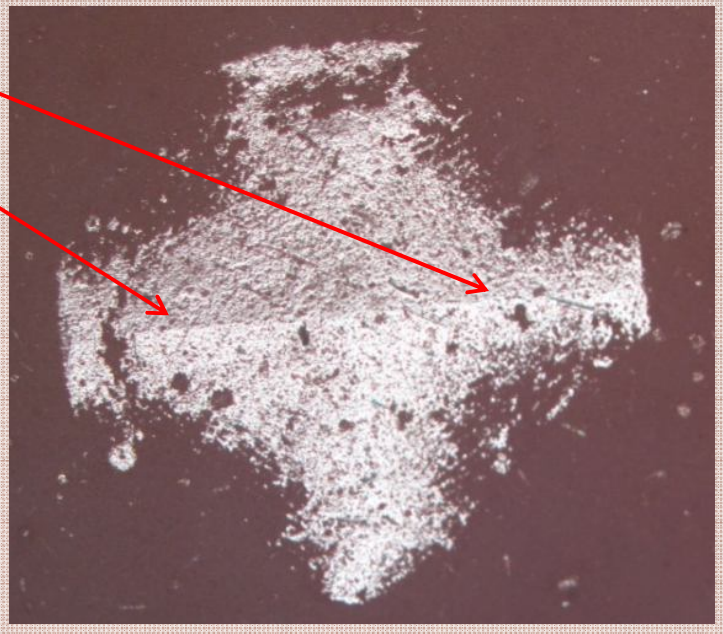


After being removed from solution, water evaporated in some samples, leaving a white residue (salt)

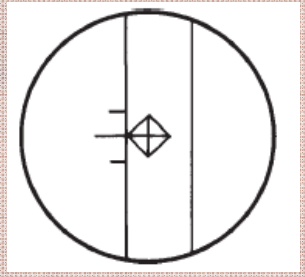
Soft Material Testing

Note visible crease characteristic of diamond nanoindenter tip





3.0N Force Applied

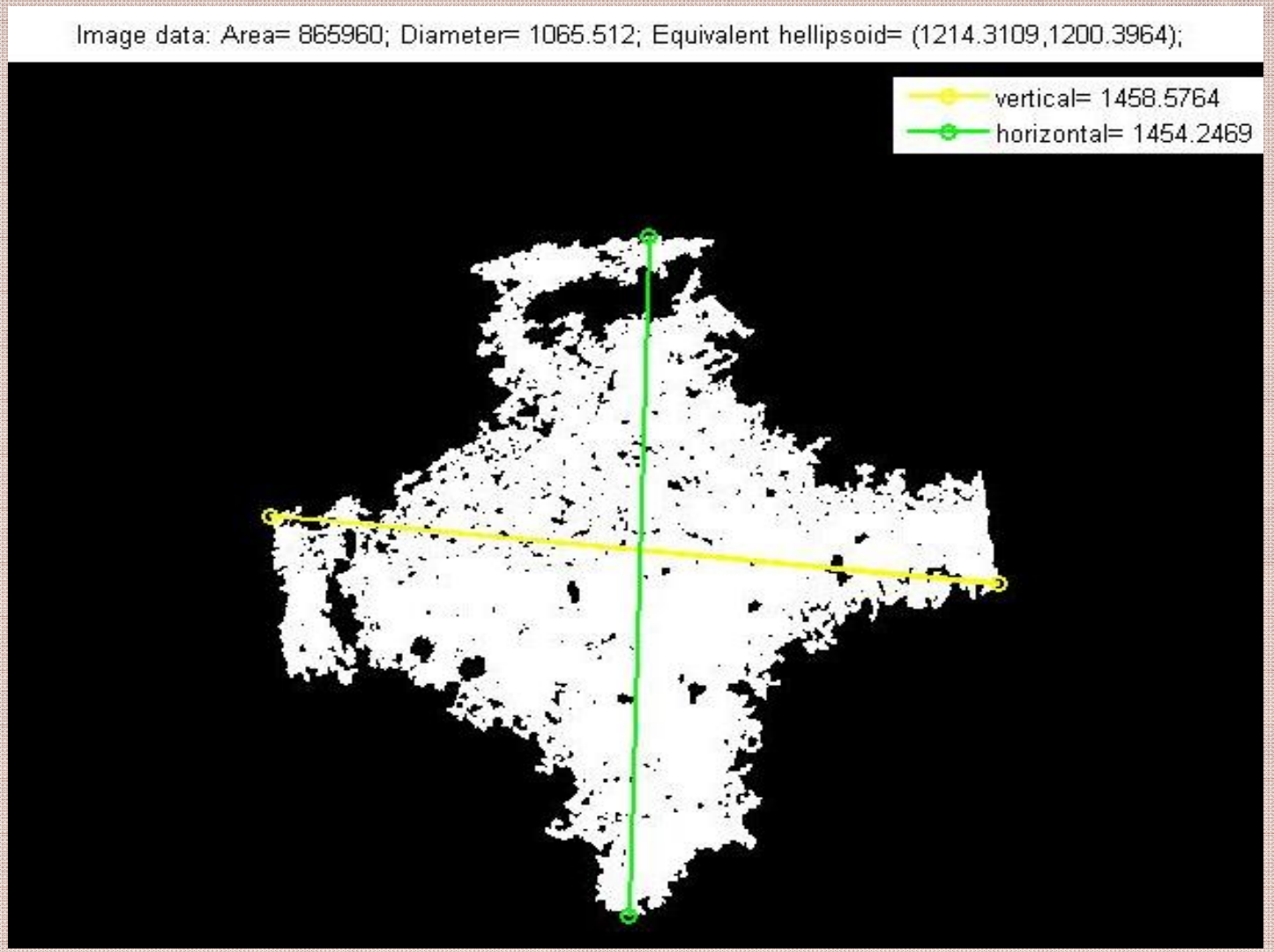


9.8N Force Applied

Soft Material Testing

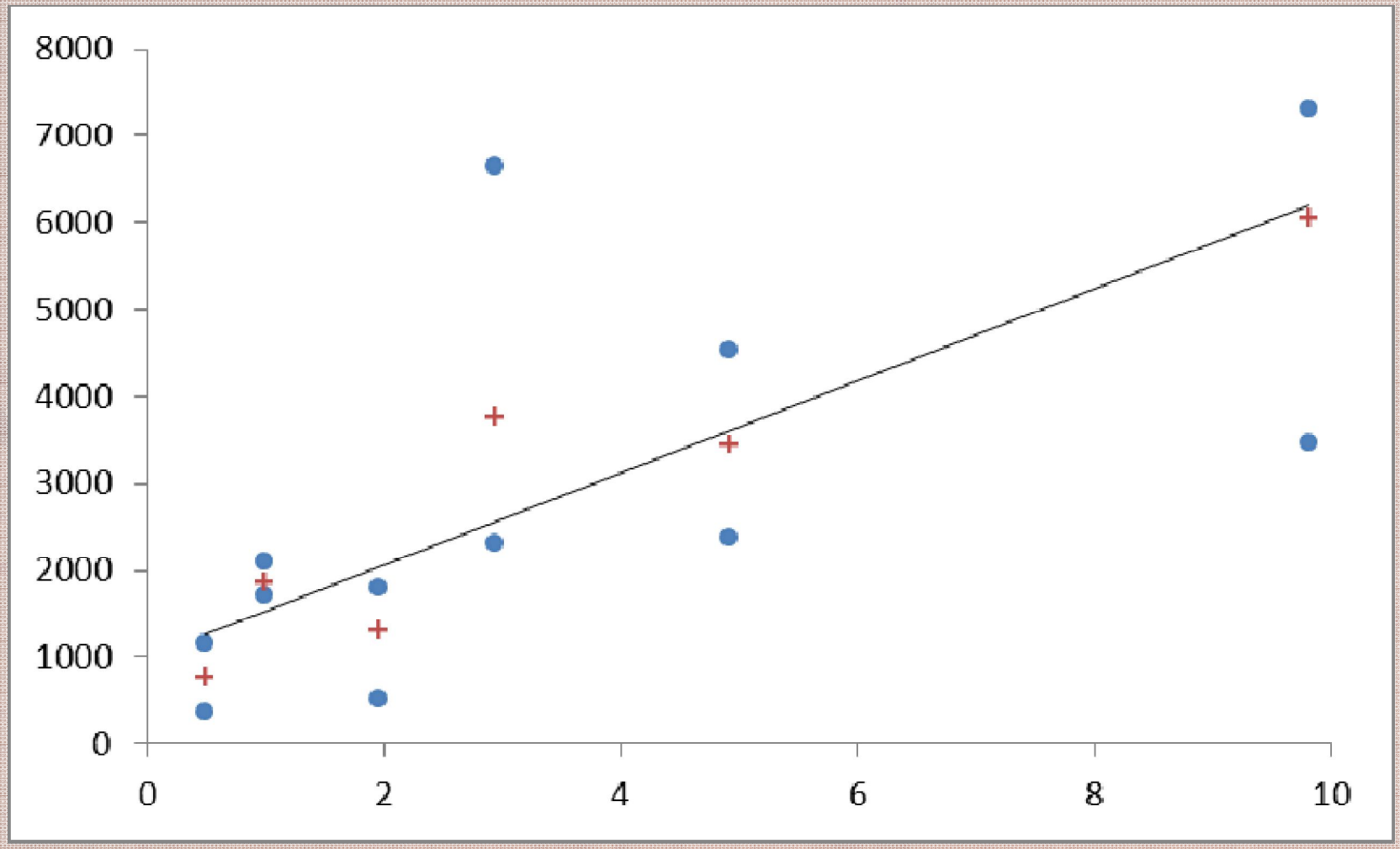
Use Digital Image Analysis to Measure:

- Area
- Diameter
- Horizontal
- Vertical



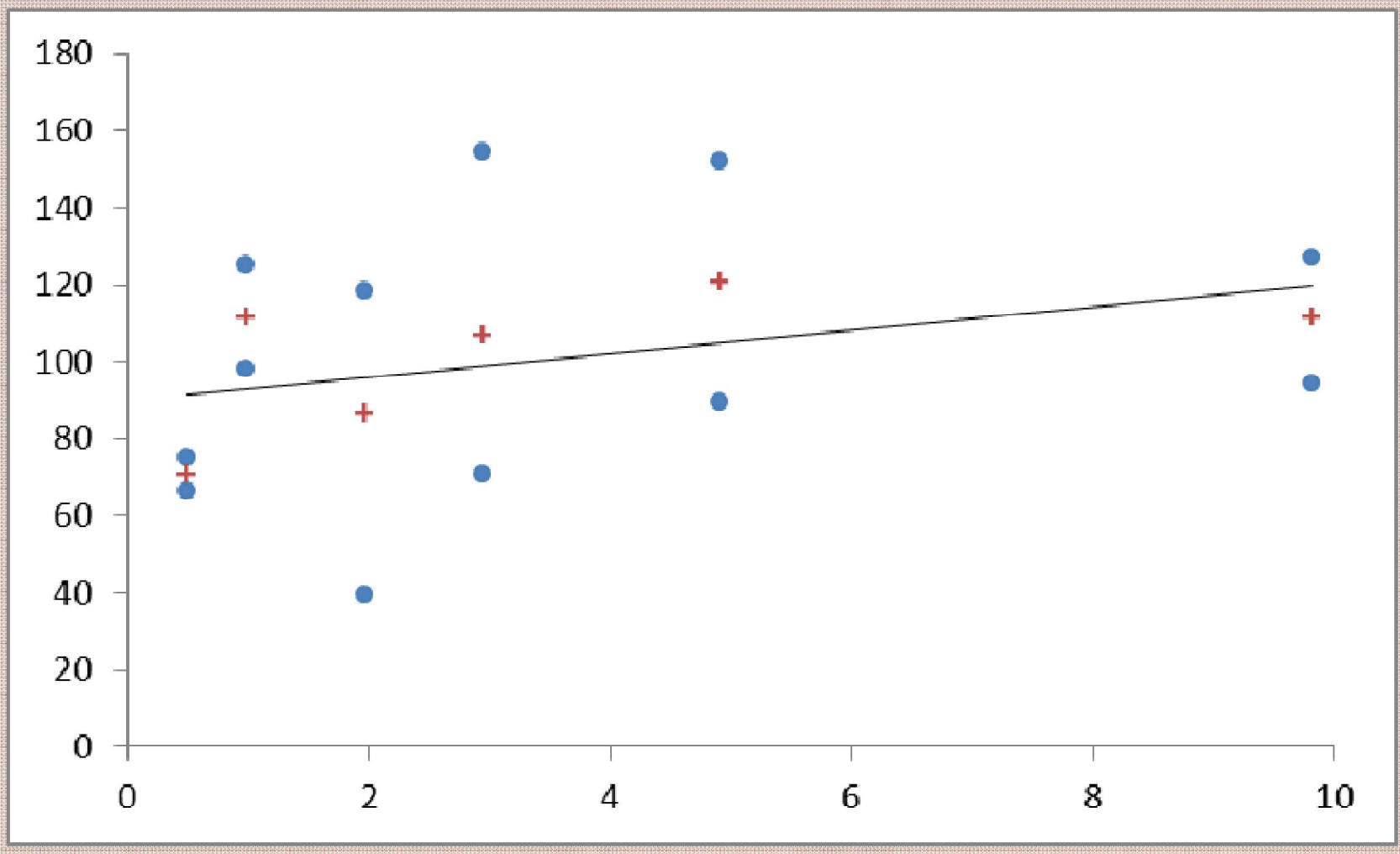
Soft Material Testing

As Indentation Force increases, Area of Salt Residue Increases



Soft Material Testing

Indentation Force is independent of Diameter of Salt Residue Pattern



Soft Material Testing

- MicroIndenter clearly affects soft material measurably
- Goal: Connect microindenter effect with Soft Material Properties
- Method: NanoIndentation Analysis

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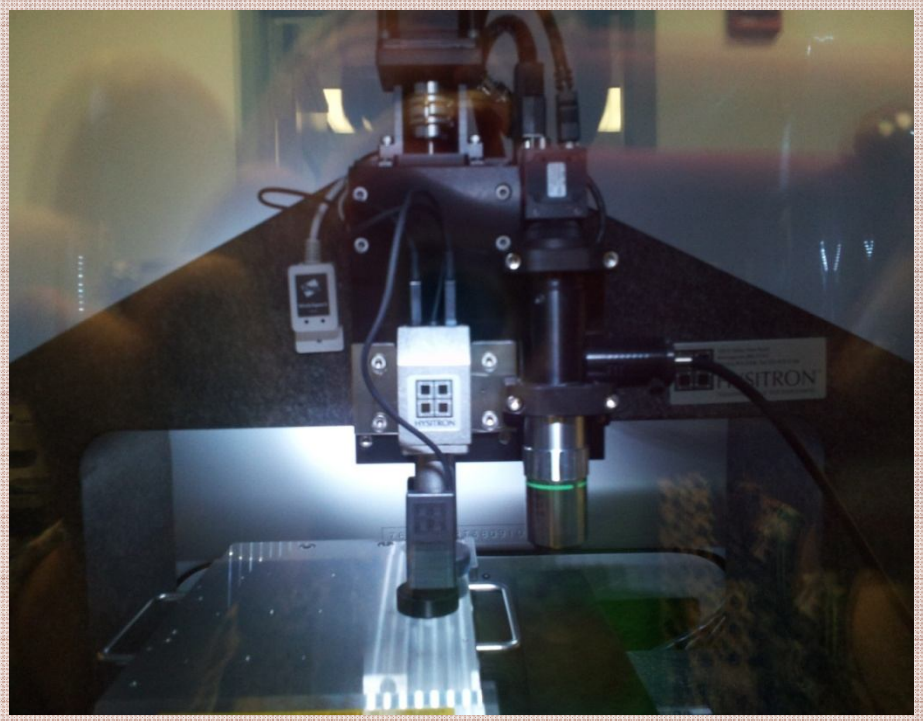
NanoIndenter

Hysitron TriboIndenter TI-950

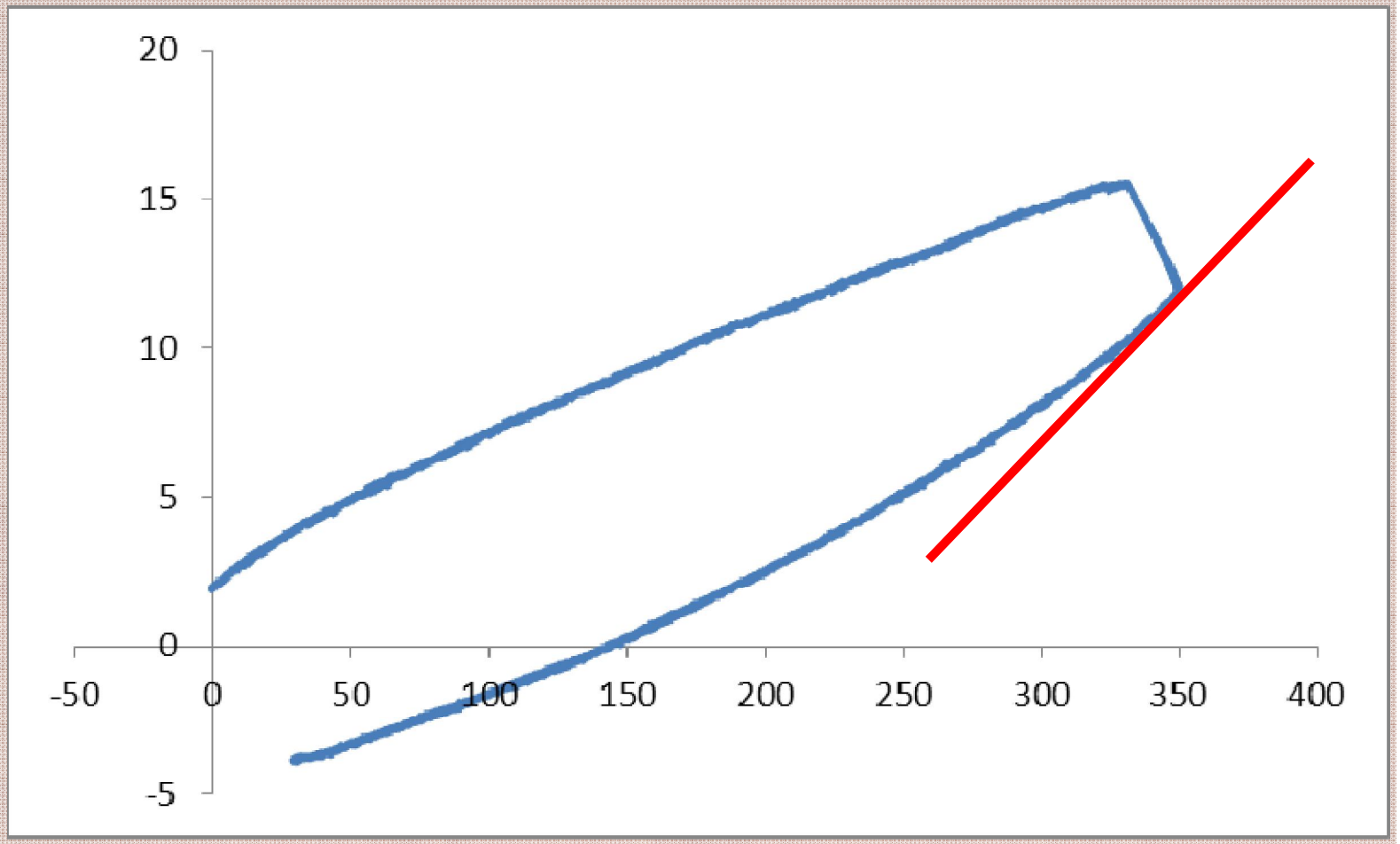


Special thanks to Dr. Paulo G. Coelho and Karanjit Kamboj of the NYU College of Dentistry

NanoIndentater

Data can be analyzed to find:

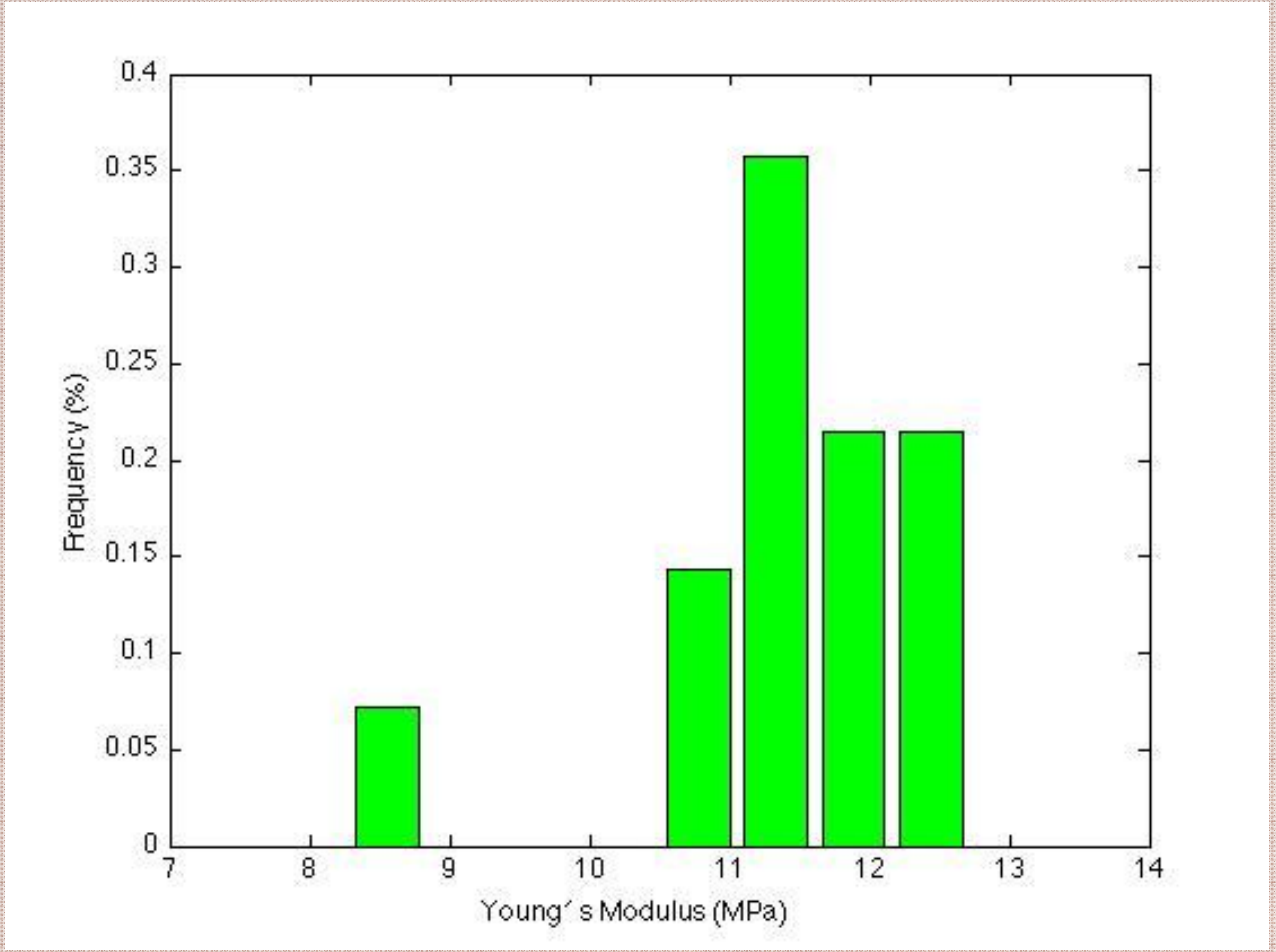
Young's Modulus



NanoIndentater

Data can be analyzed to find:

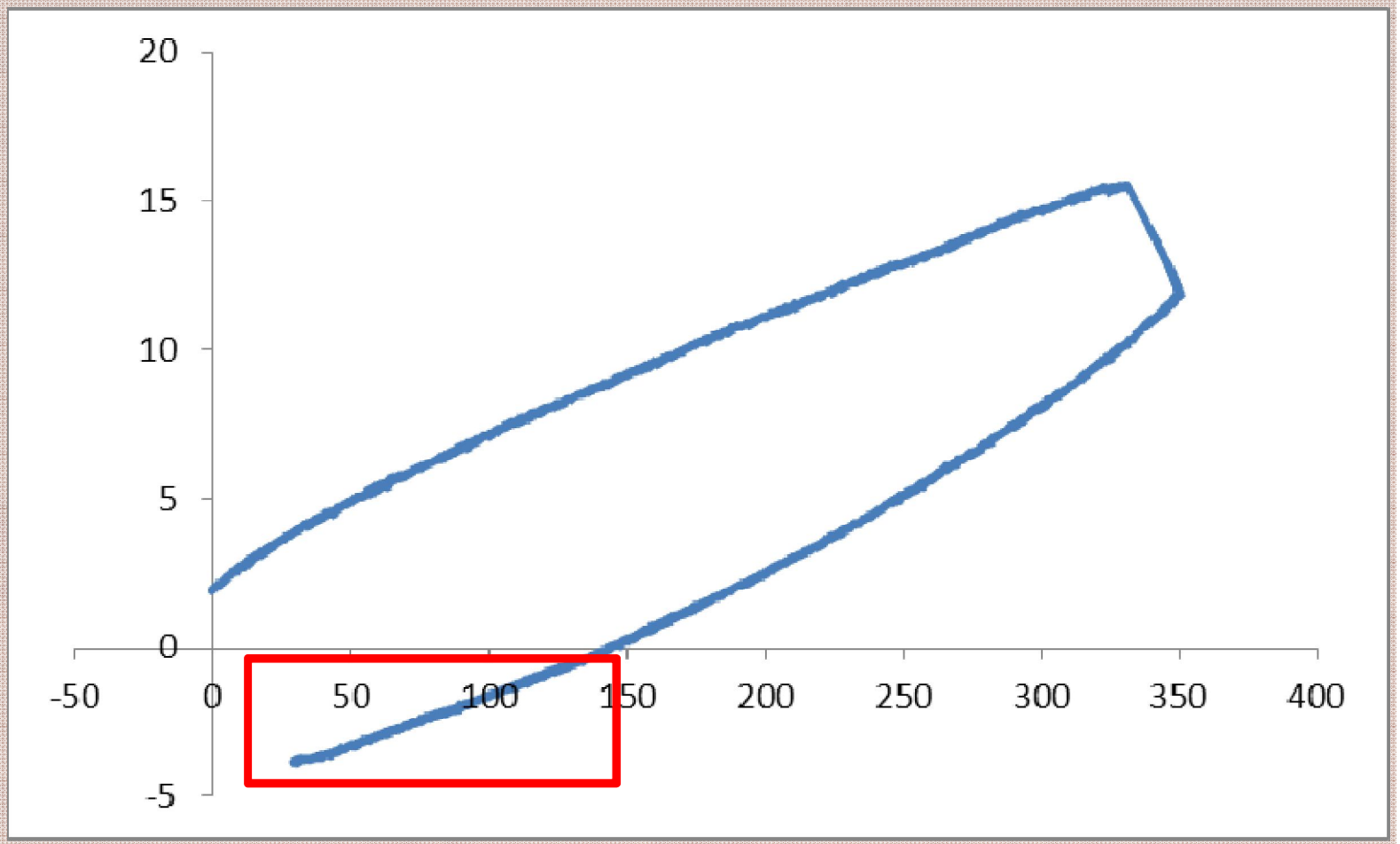
Variability in Young's Modulus



NanoIndentater

Data can be analyzed to find:

Adhesion Behavior



Conclusion

- Consistency of MicroIndenter results encouraging
- Further Experimentation to confirm of NanoIndenter test to MicroIndenter test
- NanoIndenter testing of treated/hydrated samples necessary to draw further conclusions

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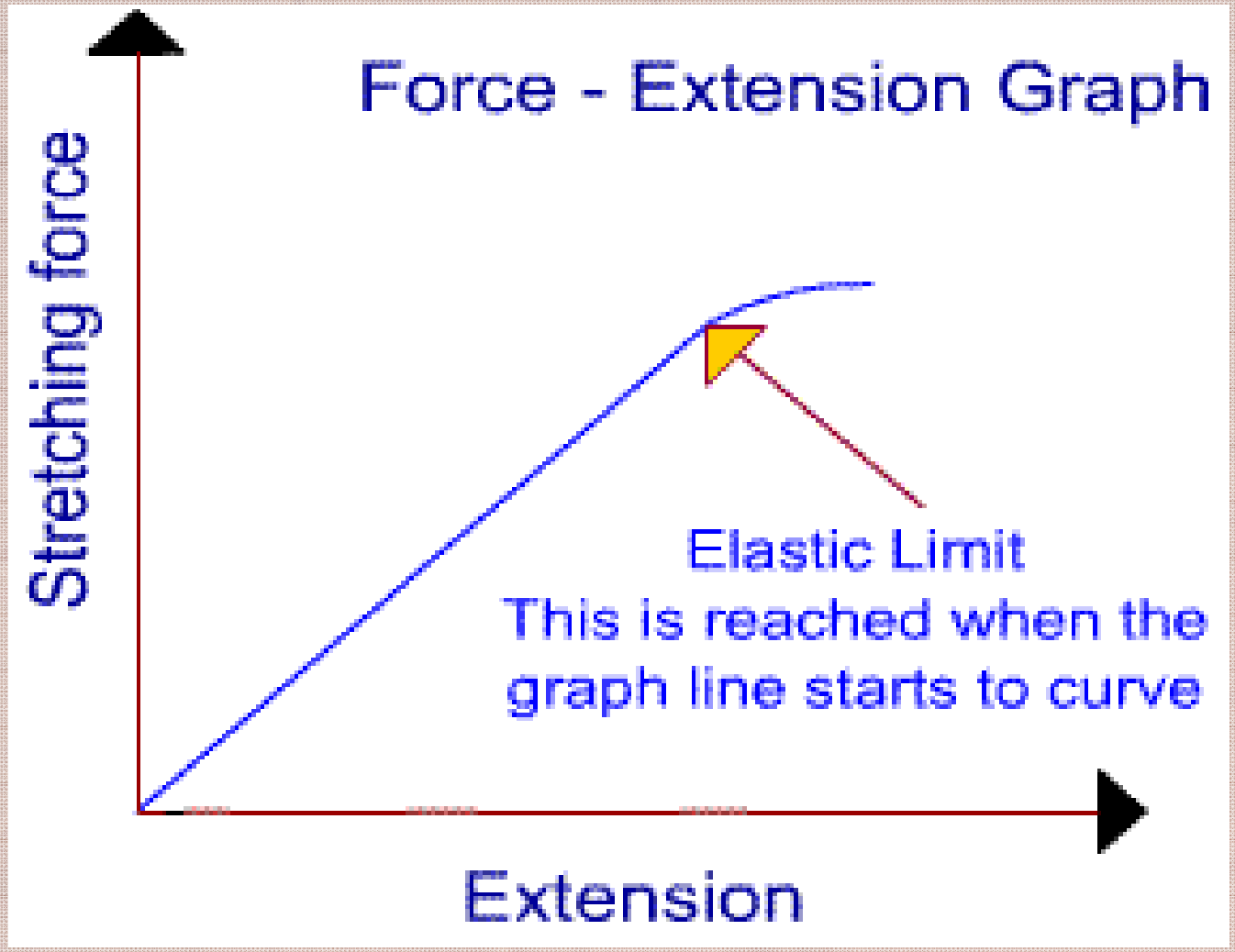
The Young's Modulus of Jell-O

- Materials:
- Force sensors
- Rulers
- Liangfeng, Jell-O, Gelatin, Agarose

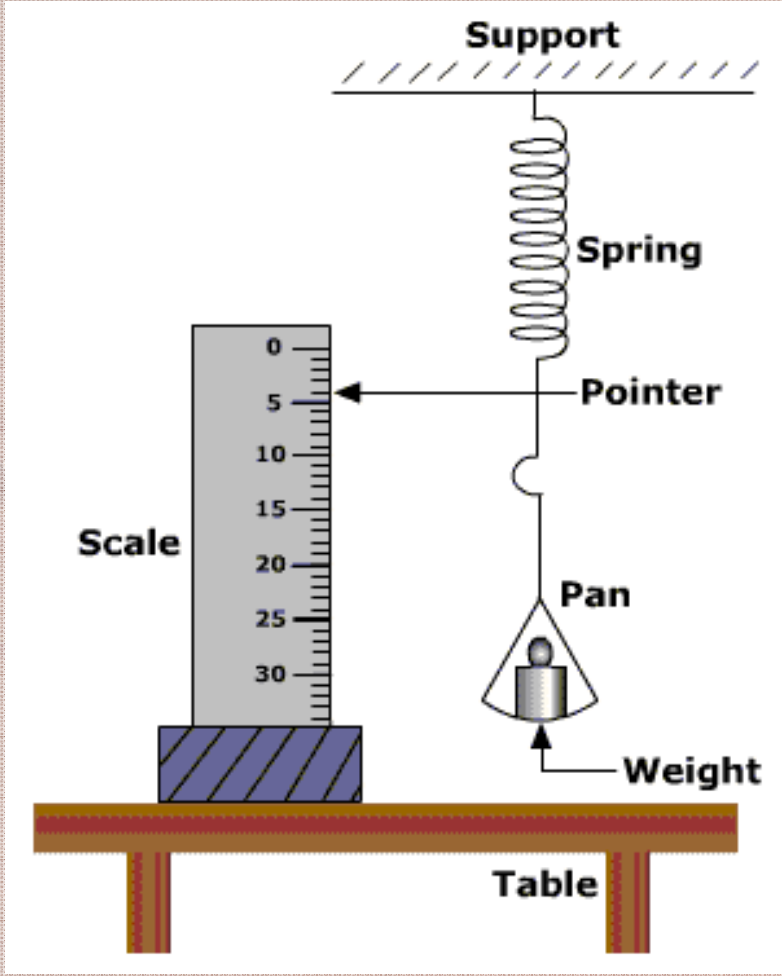
The Young's Modulus of Jell-O

Linear Relationship between Load and ΔLength



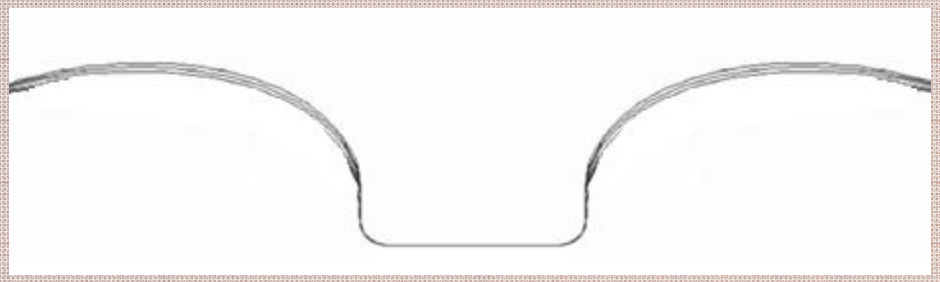
The Young's Modulus of Jell-O

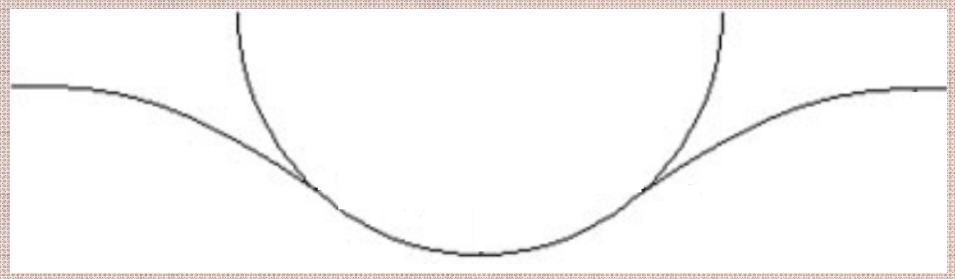
Typical Lab Setup



Modified Lab Setup

The Young's Modulus of Jell-O





- To minimize pressure or stress, use a tip
- Examples:
  - Ping-Pong Ball
  - Plastic bottle cap

The Young's Modulus of Jell-O

Basic Level Results:

- *F vs* ΔL Graph

Advanced Level Results:

- Stress/Strain Computation
- Stress/Strain Graph

ACKNOWLEDGMENTS

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Prof. Remi Dingreville, Research Advisor

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Mechatronics Lab Techies: Jared, Lin,David

Special mentions: Dzhoung others graduates