

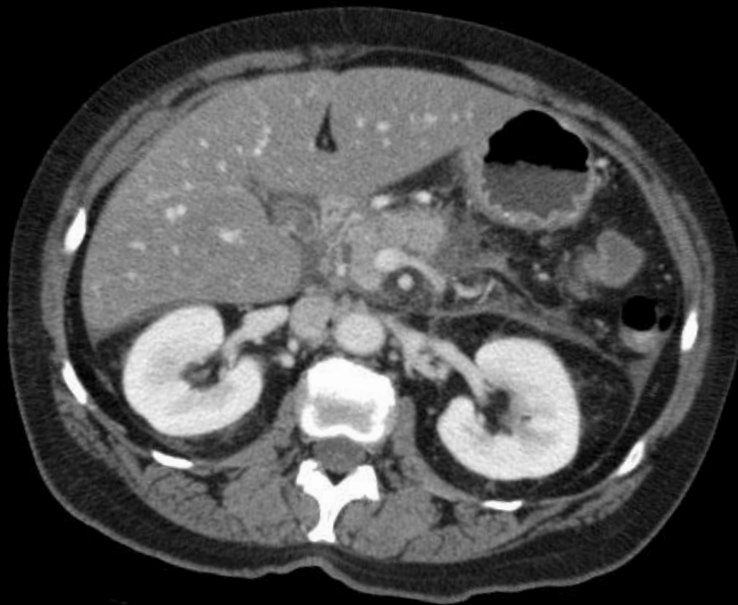
MRI Fat Phantom

Bogdan Dzyubak

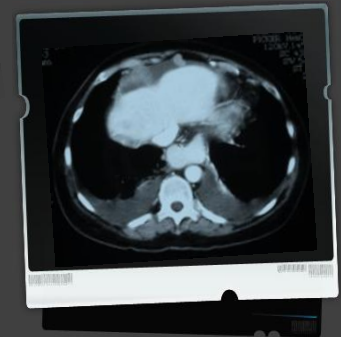
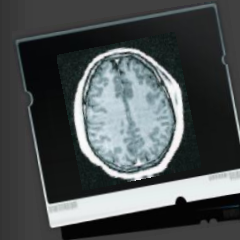
Joe Helfenberger

Nick Balge

Matt Parlato



www.mritutor.org/mriteach/5000/ct2.jpg



**Clients: Dr. Reeder, Dr. Block,
Catherine Hines**

Advisor: Dr. Chesler



Outline

- Project Description
 - Problem Statement
 - Motivation
 - Design Criteria
- Design
 - Basic Description and Layout
 - Outer Water-filled Case
 - Honeycomb Inner Structure
 - Material Selection
 - Emulsions
 - Basics
 - Liquid vs. Solid Phase
- Future Work
 - Semester Goals
 - Long-term Goals
- Conclusion

Problem Statement

- Client has developed an MRI procedure to quantitatively measure liver fat
 - Needs a way to evaluate procedure performance
- MRI “Phantom” is required
 - Phantom — Device used to simulate object of interest in an imaging procedure. Many times used for training and/or performance evaluation.
- A phantom is needed to simulate liver fat, allowing evaluation of this technique

Fatty Liver Disease

- Abnormal presence of fat in liver
- Causes/Associations
 - Alcohol
 - Obesity
 - Fat Distribution
- Problems
 - Impedes normal function
 - Prevents nutrient delivery



Diagnosis of Fatty Liver Disease

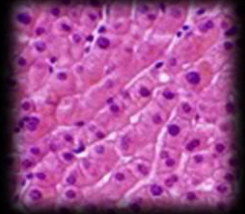
- **Currently: biopsy required for diagnosis**
- No early symptoms
- Dr. Scott Reeder
 - Advanced Algorithm
 - Detects Fat%



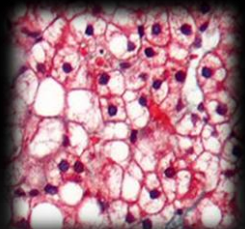
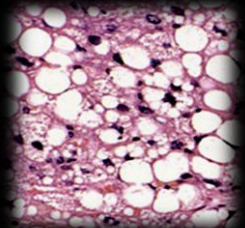
Relevant Fat Percentages

- Normal Liver Fat: 0%
- Abnormal Liver Fat:
 - Range: 5-30%
 - Maximum Observed: 50%
- Adipose Tissue: 90-95%

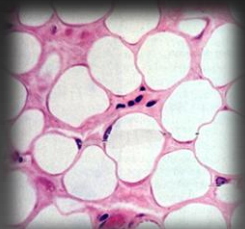
Normal Liver Cells



Fat Accumulation in Liver Cells



Adipose Tissue



http://en.wikipedia.org/wiki/File:Non-alcoholic_fatty_liver_disease1.jpg

http://en.wikipedia.org/wiki/File:Liver_steatosis_fatty_change.jpg

<http://www.uic.edu/com/dom/gastro/fac.banner.naflid.gif>

<http://media.photobucket.com/image/normal%20liver%20cells/jondopics/drugbio/liver6-1.jpg>

<http://www.hartnell.cc.ca.us/faculty/aedens/Bio6L/tissue-adiposeB.jpg>

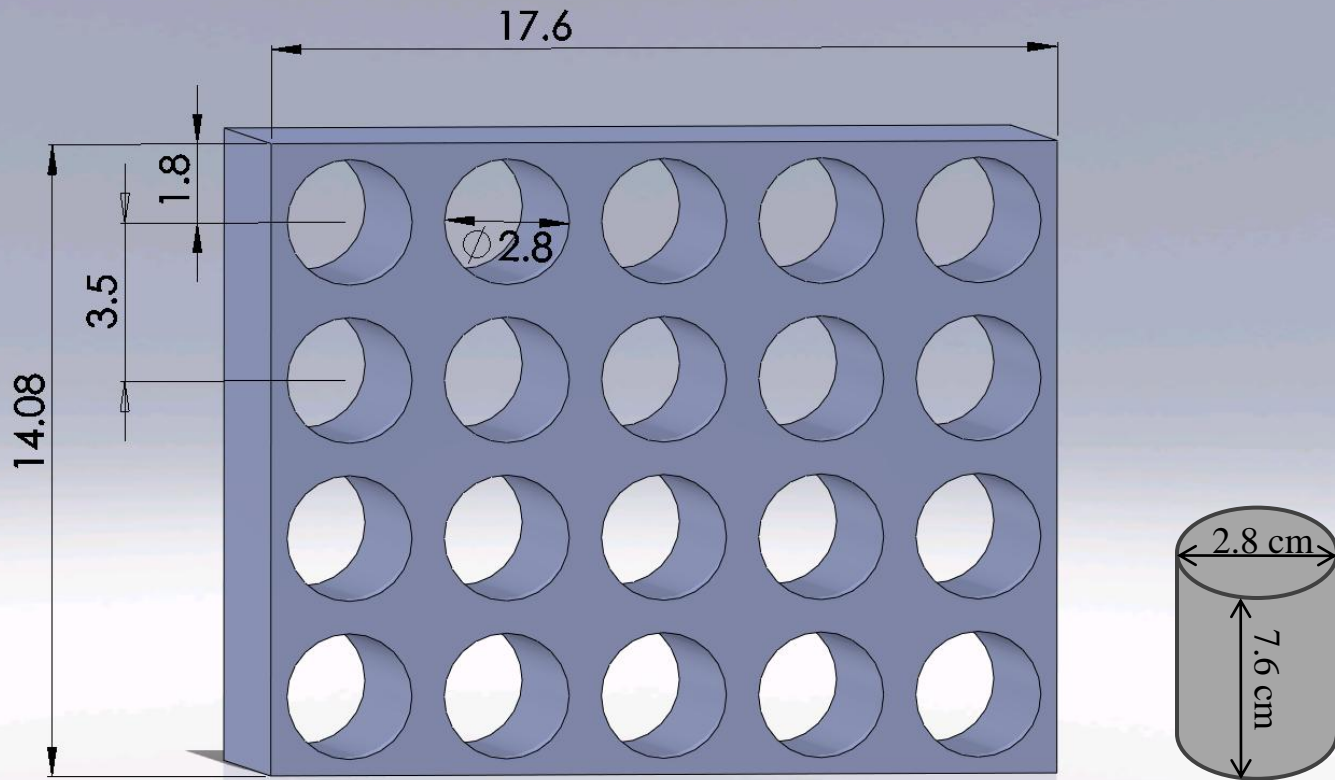
Design Criteria

1. Realistically simulate liver fat conditions
2. Be MRI compatible
 - No metal or other magnetic materials
 - Nothing that significantly distorts MR images
 - Physically fit within an MRI 1-channel head coil
3. Easy to use, transport, and store
 - Shelf-life of greater than 3 years
4. Highly reproducible
 - Every time the phantom is imaged, it must appear the same (error tolerance $\pm 0.3\%$)
 - If more are manufactured, they all must behave the same in MRI

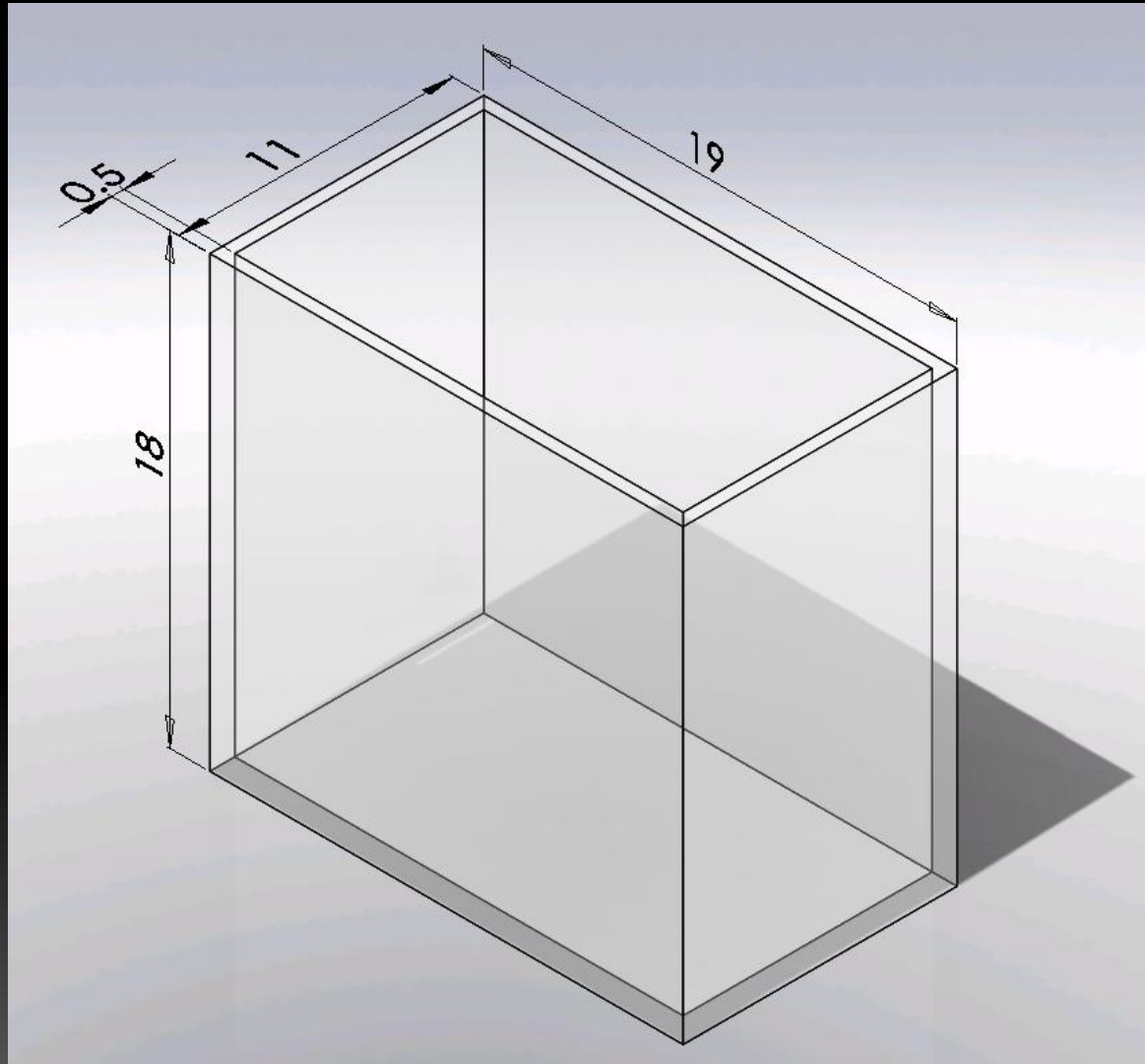
General Phantom Structure

- Samples enclosed in glass vials
 - Airtight and transparent
- Vials housed in plastic “honeycomb”
- Honeycomb submerged in acrylic water-tank
 - No sample-air interfaces
 - Water is doped with Gd to simulate liver conditions

Dimensions (cm)



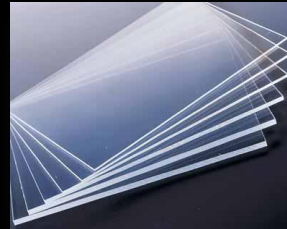
More Dimensions (cm)



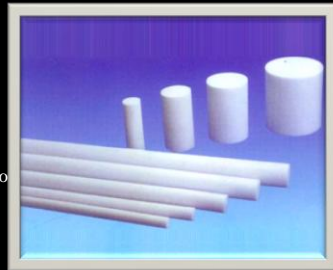
Material Selection

Outer Case – Acrylic

- Transparent
- Watertight seal



<http://www.ospreyco.com/images/acrylic-sheet-.jpg>



<http://www.tradevv.com/TradevvImage/productimages/PTFE-teflon-rod-A3e4d7.jpg>

Inner Structure – Plastic

- Machineable
- High density

Mixture Containers – Glass

- Water impermeable
- Transparent



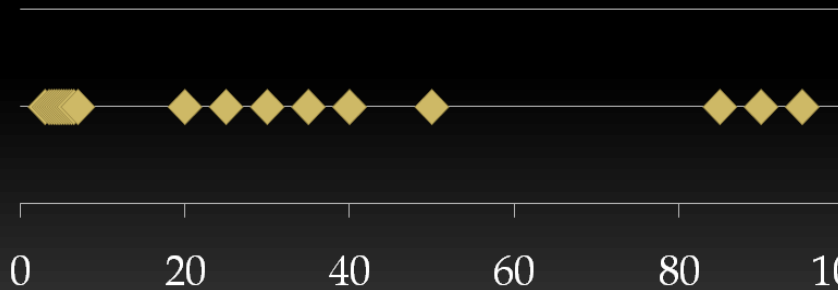
<http://www.sks-science.com/images/986491LRG.jpg>

No Metal!

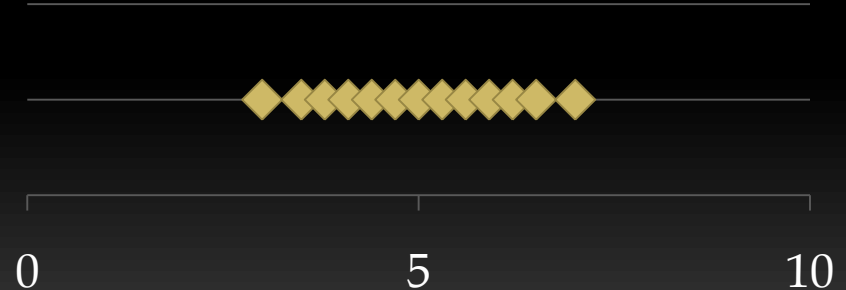
Samples

- 20 vials total
- Fat fraction distribution:
 - 0.3% intervals in 0% to 10% range
 - Sparsely sampled above 10%

Fat Fractions

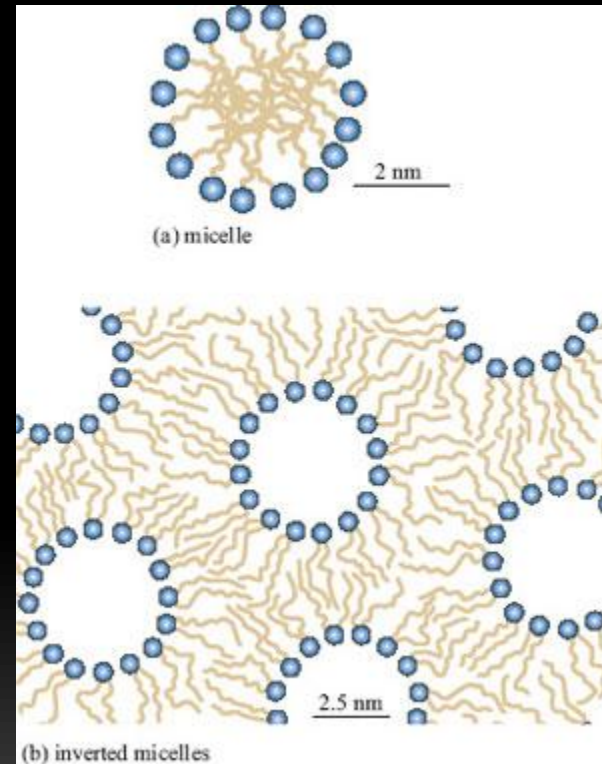


Fat Fractions (0-10%)



Oil-in-water Emulsion

- Water and fat are immiscible
- Emulsifier/surfactant required to mix
 - Ivory™ hand soap
- Density difference causes eventual separation
- Stabilizer is needed to maintain the mixture
 - Liquid Phase
 - Solid Phase



Emulsion Stabilizers

Liquid Phase

- Increases viscosity
- Air bubbles are mobile
- Easier to create and work with post-addition of stabilizer

Solid Phase

- Creates a cross-linked matrix
- Air stays in a fixed position
- **Generally longer lasting**

	Liquid Phase	Solid Phase
Mixture Duration (50)	25	40
Workability (20)	20	5
Ability to Manipulate Air (25)	5	25
Previously Tested (5)	0	5
Total (100)	50	75

Goals for this Semester

Prototype Construction

- Construction of prototype
 - Honeycomb
 - Outer Case
- Create fat-water solutions using standard analytical chemistry techniques

Prototype Testing

- Verify that method used to make phantom is highly reproducible and accurate
- Perform several MRI scans of the phantom
 - Run client's fat quantification procedure
- Evaluate ease of use, transport, and storage of current design



Future Work

- Correct unforeseen problems
- Include different emulsion additives
 - Addition of Fe^{2+} ions
 - Addition of physiological materials
- Include useful extras:
 - Handles
 - Water spigots
 - Case cover

Conclusion

- **Overall Goal: Construct a phantom for MRI fat-quantification calibration**
- Honeycomb design submerged in water-filled outer case
- Glass vials filled with solid-phase oil-in-water emulsion



http://www.sutterbuttesimaging.com/images/mri_scannerlg.jpg



Acknowledgements

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Catherine Hines

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Bibliography (references)

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<http://digestive.niddk.nih.gov/ddiseases/pubs/nash/>
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Questions?