

Radiometric quantification of intramuscular pH to diagnose acute compartment syndrome (ACS)

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Diagnosing Compartment Syndrome

- Diagnostic issues and challenges of acute compartment syndrome (ACS)
- Current understanding of ACS
- Requirements for ACS technology
 - Continuous biochemical monitoring
 - Ability to reach fascial compartments of varying depths
 - High grade of accuracy
- Comparison of various probe configurations
 - Hydrogel-Dye Microenvironment
 - Reflective pH-reactive adhesive
 - Microdialysis Spectrometer
- Proposed design for diagnosis

Current diagnosis of Compartment Syndrome

Clinical Examination

5 P's OF CIRCULATORY CHECKS

- P Pain
- P Paresthesia
- P Paralysis
- P Pulse
- P Pallor



Intracompartmental Pressure Reading



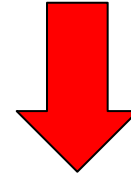
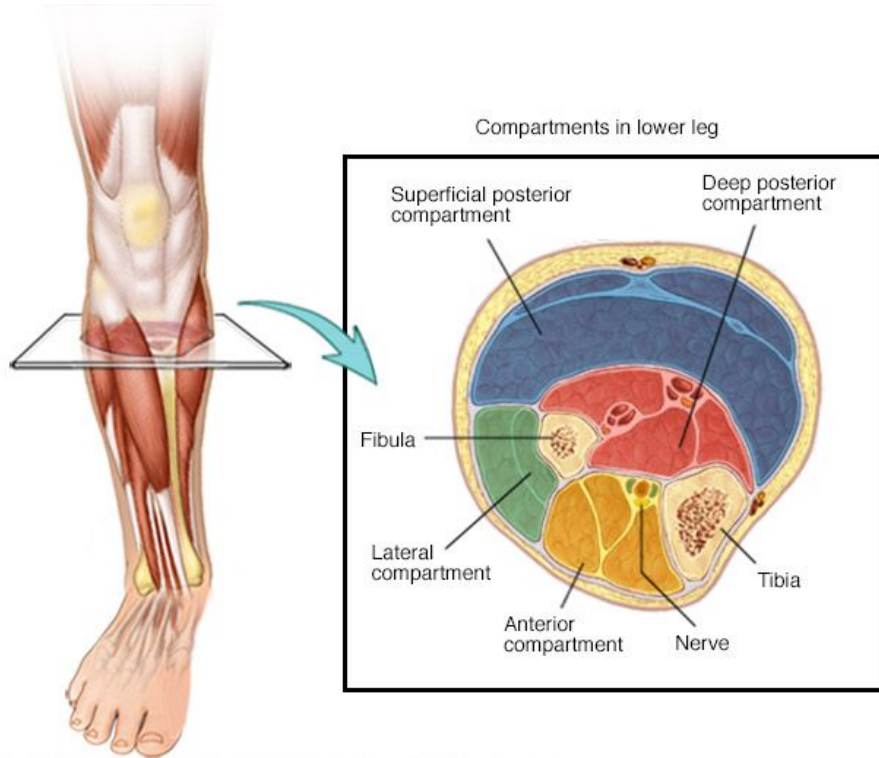
35%

False-positive diagnosis

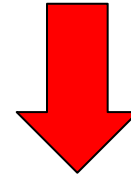
(Doro etl. al)



Acute Compartment Syndrome



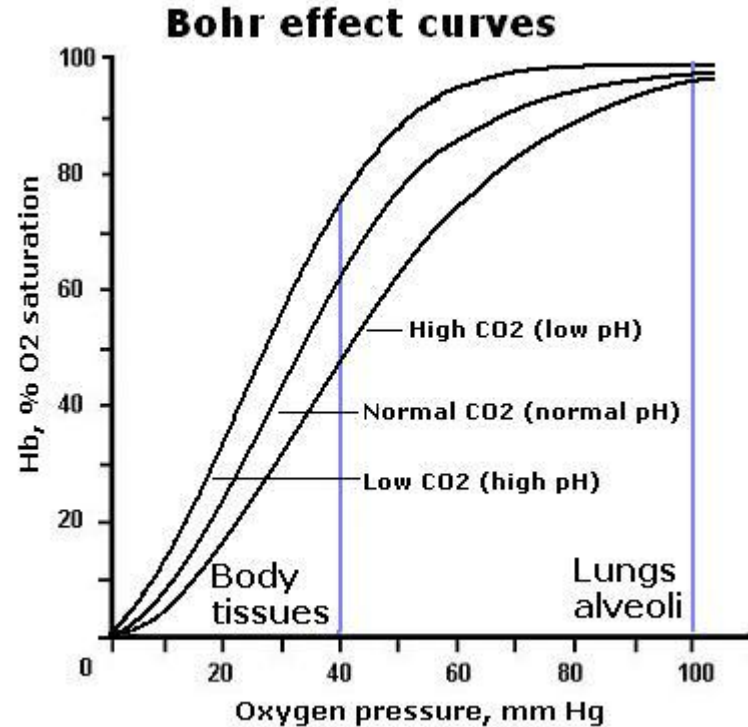
pH



Glucose

pH as a Biomarker

- Lack of O_2 leads to lactic acid byproduct
- The Bohr Effect
 - $\downarrow \%O_2 = \downarrow \text{pH}$
- Reactive with a variety of dyes
- Normal pH ~ 7.35
 - Measurement of relative change to this standard



Requirements for ACS Technology

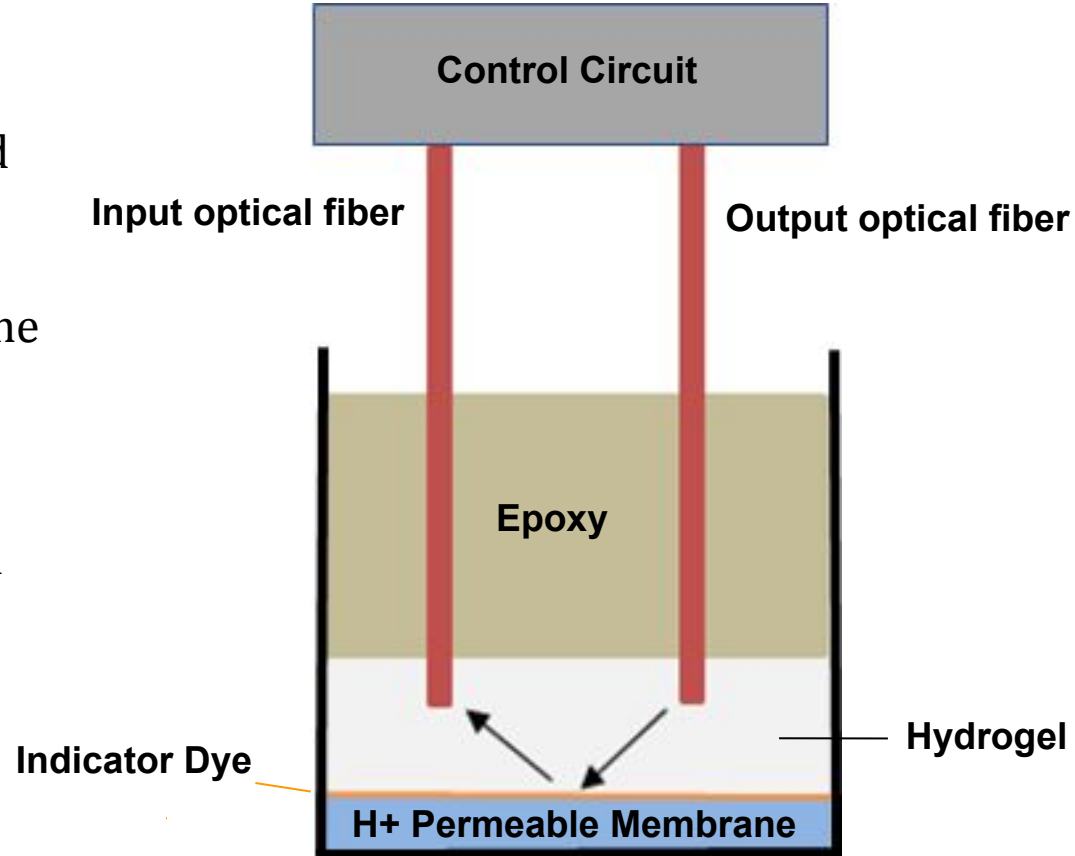
- Continuous biochemical marker monitoring
 - 1 sample/10 minutes
- Depth below skin
 - 1-5 cm
- Standard of care
 - 16 gauge needle max
- Easy to use
- Cheap and disposable



Hydrogel-dye Microenvironment

Configuration

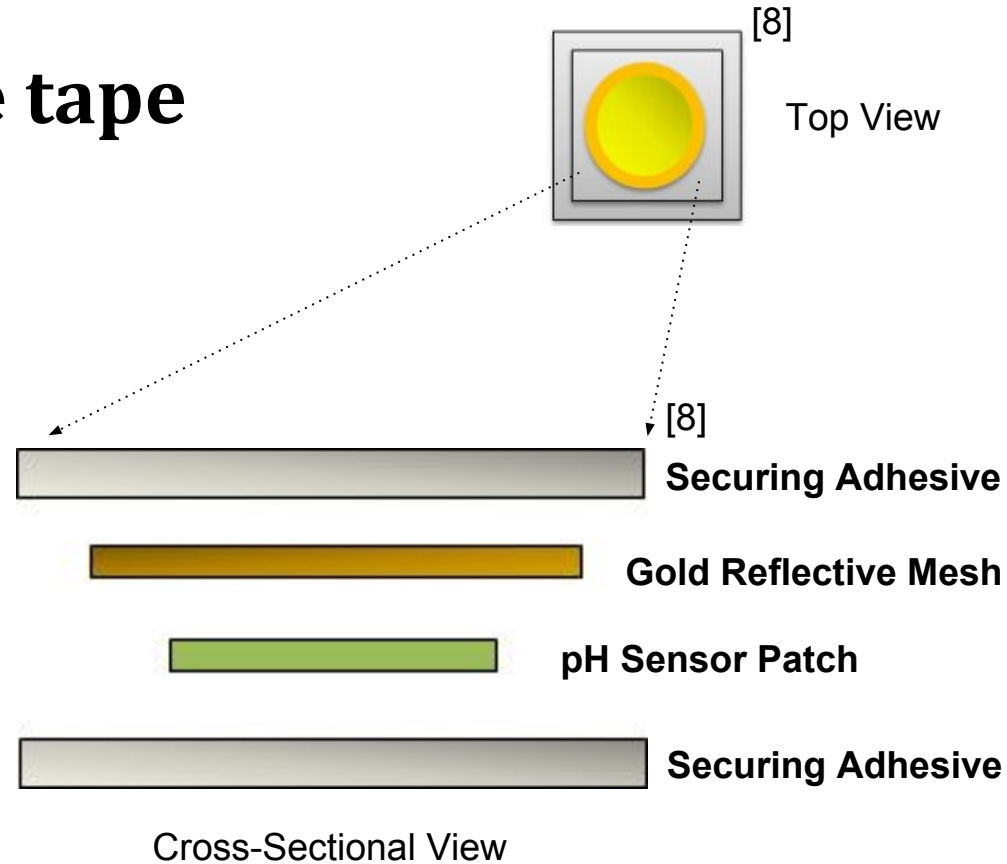
- pH indicator dye is immobilized on a hydrogel.
- Selectively permeable membrane adhered between indicator dye and hydrogel.
- Optical fibers held in place with epoxy glue.
- Intensity of light reflected off indicator dye correlates to pH.



Reflective pH-reactive tape

Configuration

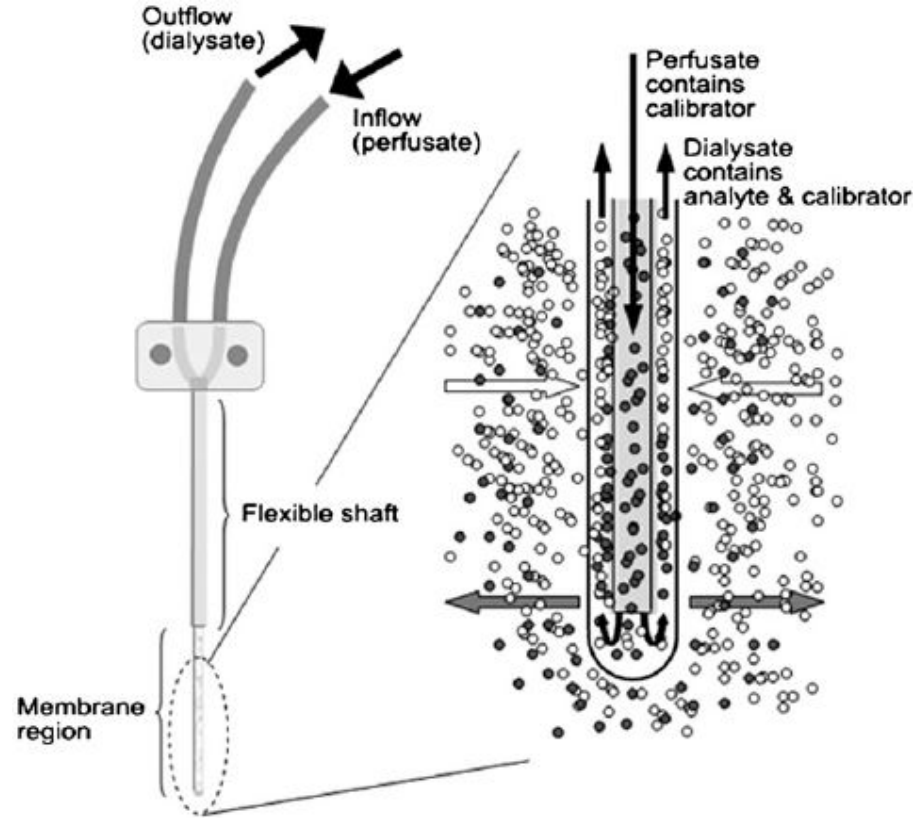
- Composed of four layers
 - Two securing adhesive layers
 - One Gold Mesh layer
 - One pH indicator dye layer
- Tape adhered to commercially available transmissive pH probe.
- Transmissivity of light emitted from probe is measured and correlated to pH.



Microdialysis Chamber

Configuration

- Microdialysis probe continuously perfused via inlet tube.
- Semipermeable membrane allows analyte to diffuse into probe.
- Dialysate containing analyte sent to analysis chamber via outlet tube.
- Spectrometry performed on outlet tube to determine pH



Depiction of Microdialysis process [10]

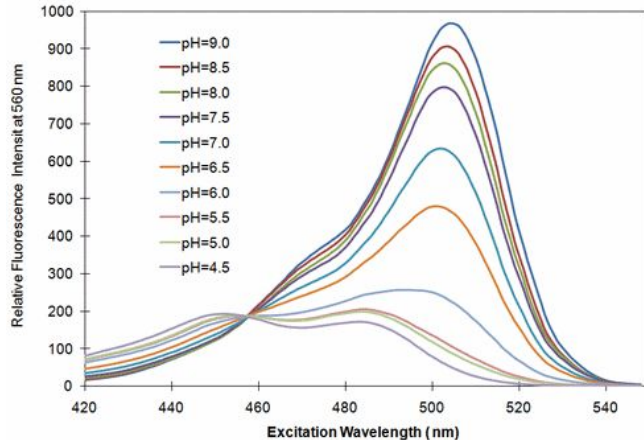
Design Matrix

Criteria (Weight)	Hydrogel Microenvironment		Reflective pH Tape		Microdialysis chamber	
	Accuracy and precision (35)	5	35	4	28	3
Biocompatibility (25)	4	20	4	20	5	25
Invasiveness (15)	3	9	3	9	3	9
Ease of Reuse(10)	2	6	4	8	4	8
Measurement Continuity (10)	5	10	5	10	3	6
Cost (5)	3	3	4	4	3	3
Total	83/100		79/100		72/100	

Future Work: Phase 1 (Fall Semester)

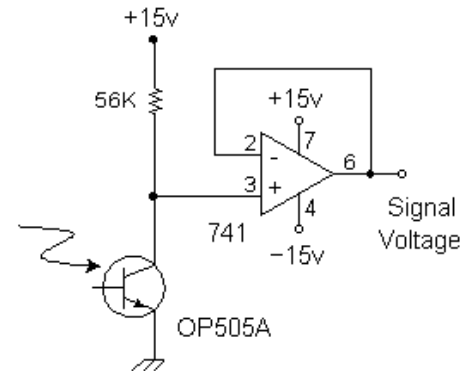
Chemistry

- pH indicator
 - BCECF
- Immobilization/encapsulation



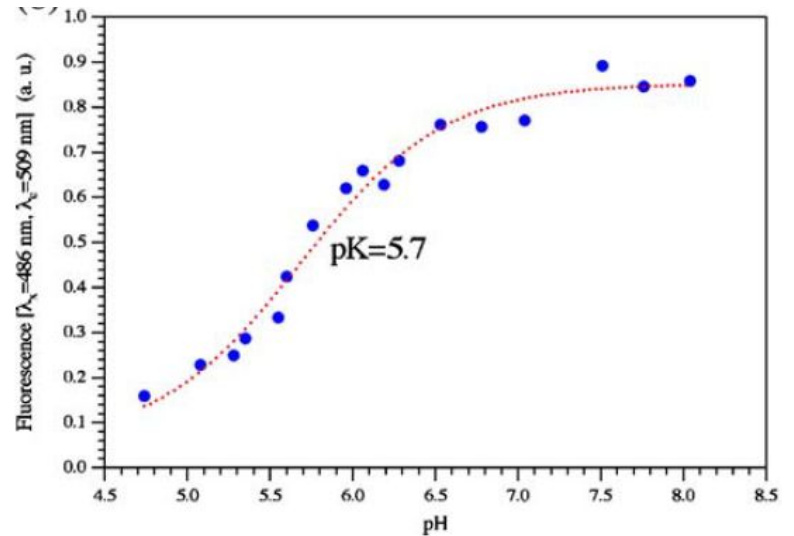
Instrumentation

- Dichromatic excitation
- Optimizing optical feedback
- Developing analytical circuit
 - Correlate response, pH



Future Work: Phase 2 (Spring Semester)

- Integrating 'cuvette', instrumentation
- Testing
 - Stability of connection
 - Signal collection
 - Calibration against other probes



References and Acknowledgements

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