Forecast for 2009: Testing and Poking

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Worm Touch Meeting

1/14/2009

Overview

- What Needs to be Done
- Current Status
- Planned Experiments

The MEMS Fairy

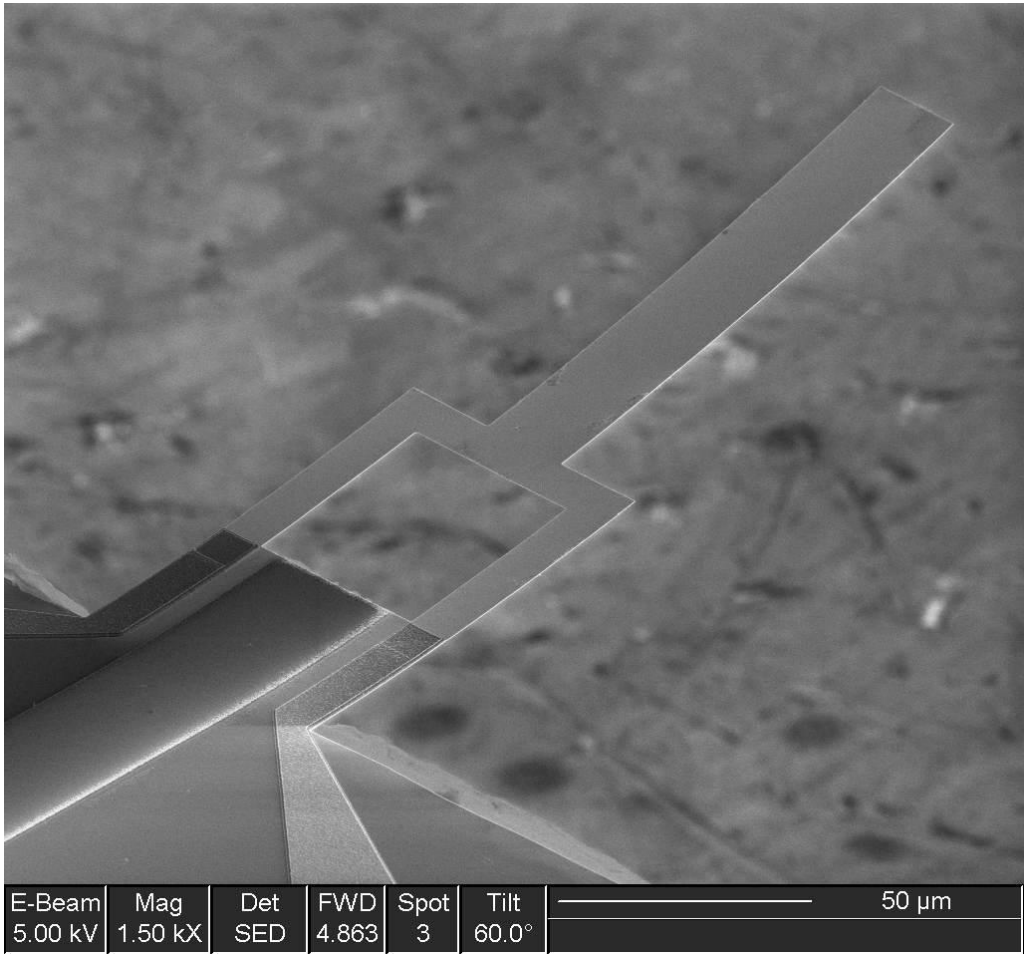
- What would the MEMS fairy do?
  - Piezoresistor noise, sensitivity and frequency response (electrical and mechanical) match design objectives.
  - Parylene passivation negligibly affects sensitivity and noise, allowing stable underwater performance for several hours.
  - Cross-talk between piezoresistor and piezoelectric is negligible or can be compensated.
  - Interface electronics include stable analog feedback control, auto-balancing Wheatstone bridge to compensate for DC noise.

Current Status

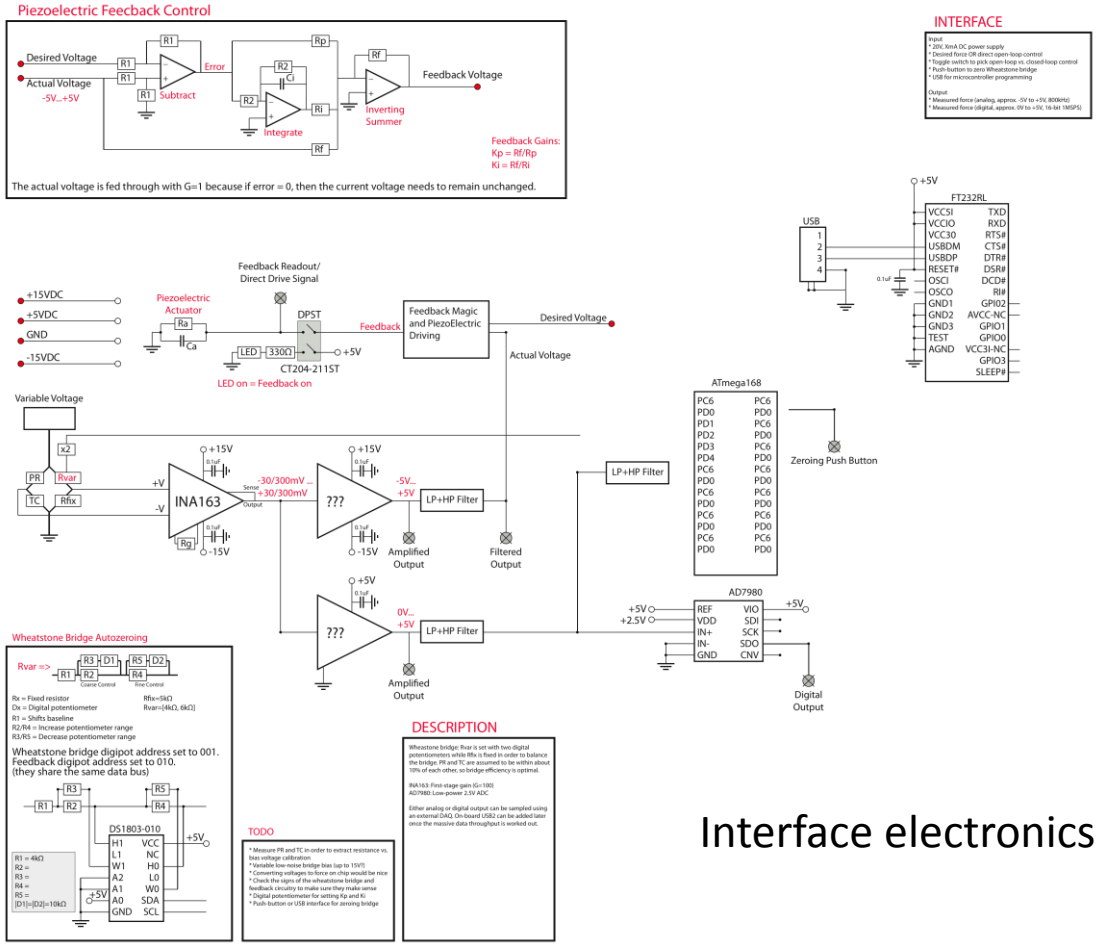
Fabrication is complete. Have verified that PR and PE work separately, still need to test integrated device.

Getting trained on Auger Electron Spectroscopy in order to identify strange etch byproducts.

Working on piezoresistor characterization to look at designed vs. actual performance.



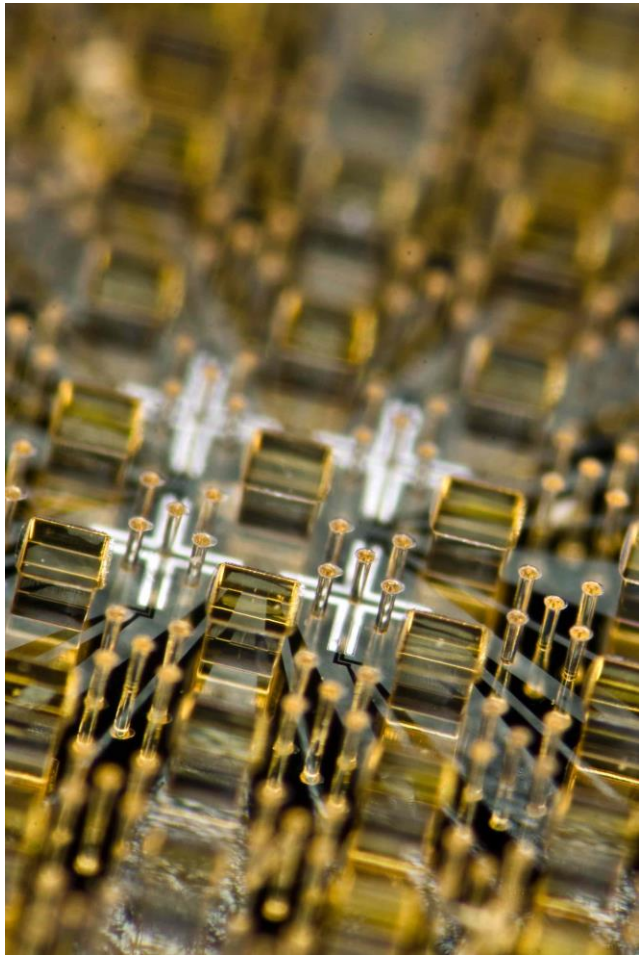
Current Status



Interface electronics are in progress

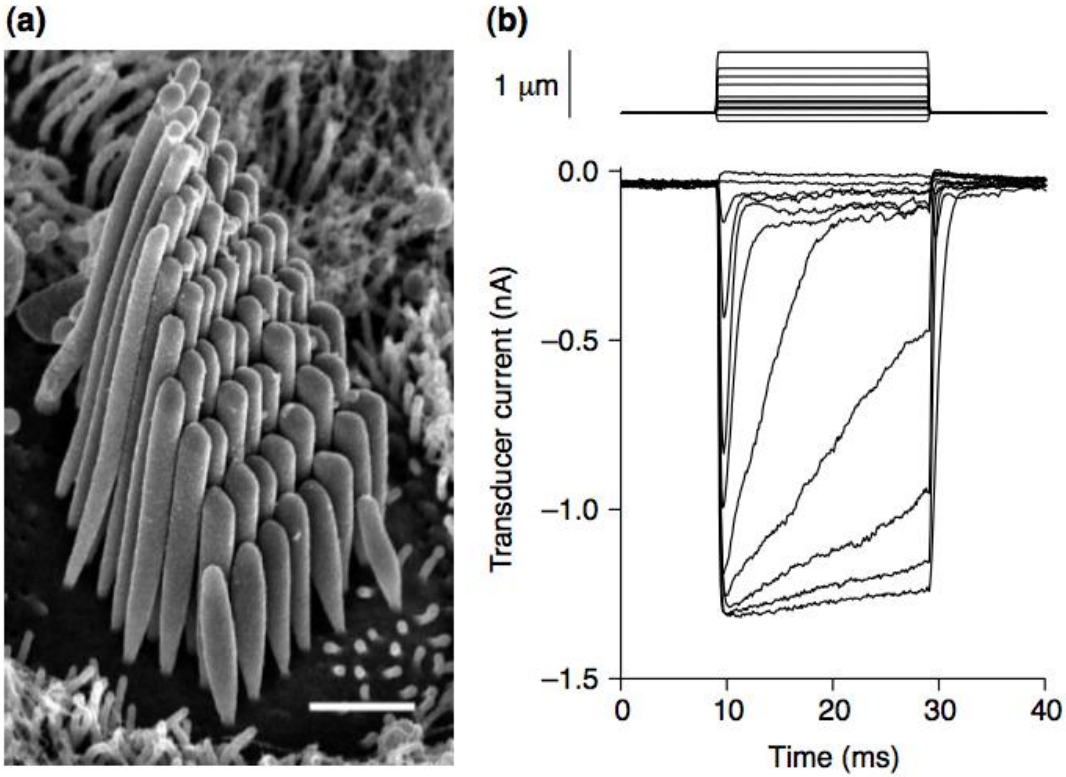
Current Status

Working on conference abstracts, papers (cantilever design, AlN on Ti)



Planned Biological Experiments

- Hair Cells
- TRNs

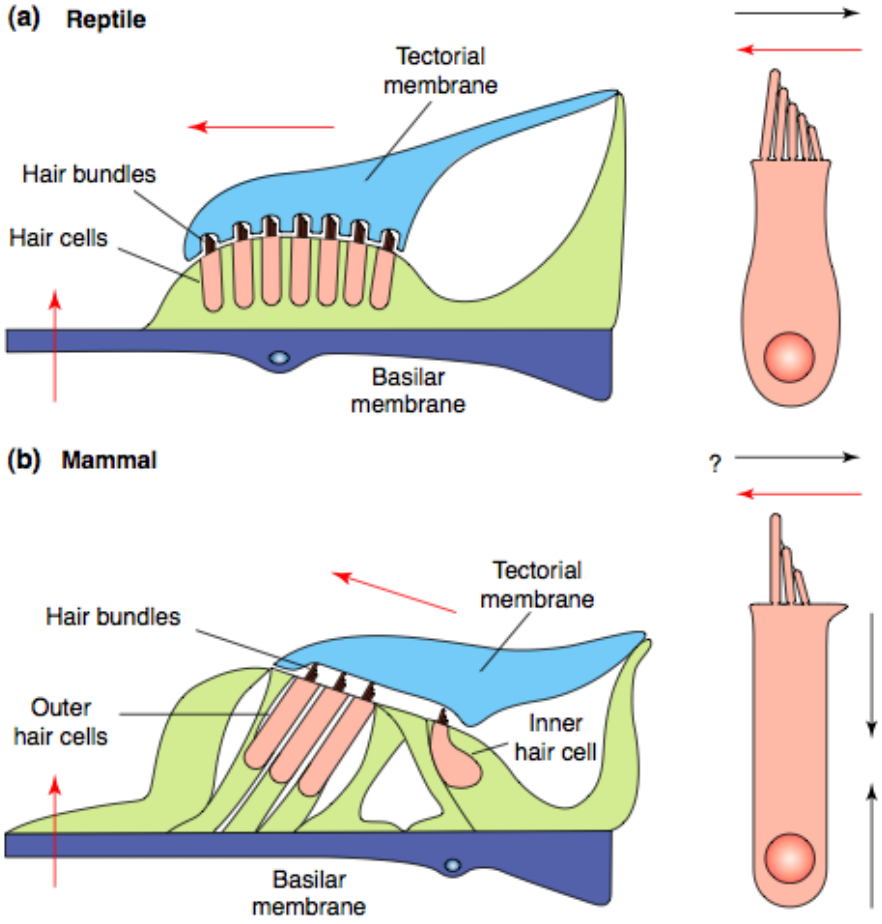


Turtle hair cell

Clues to the cochlear amplifier from the turtle ear, Fettiplace, Ricci and Hackney, 2001

Hair Cells

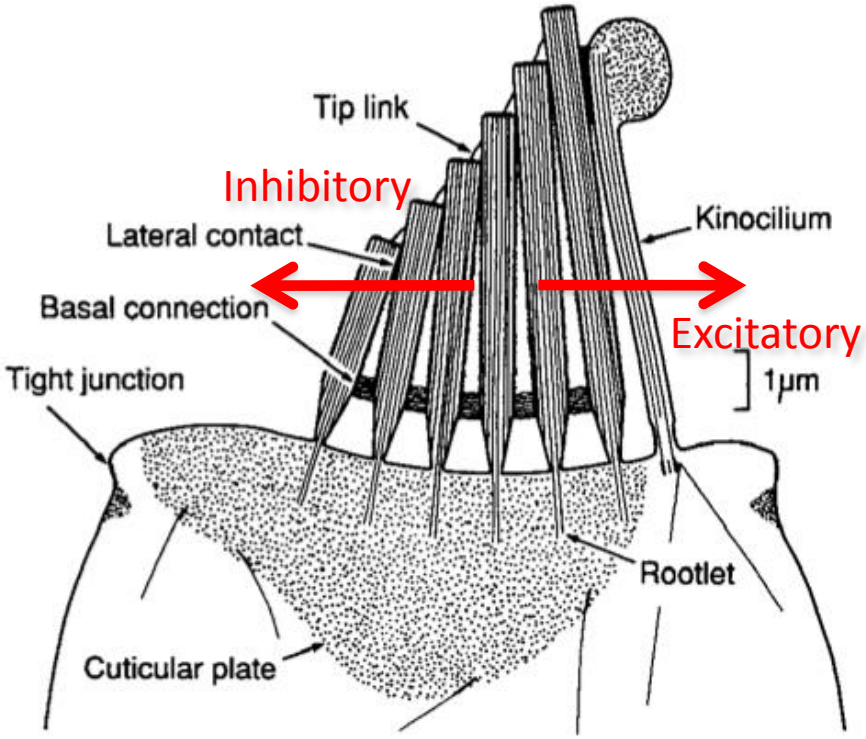
- **Goal**: direct application of force to hair cell stereocilia
- Frequency response of actuators to date ~6kHz (60us rise time)
- Glass probe used, acid cleaned to adhere to hair cells



Clues to the cochlear amplifier from the turtle ear, Fettiplace, Ricci and Hackney, 2001

Hair Cells

- Hearing threshold = 0.1-1nm of tip deflection
- Sensitive over 100nm range
  20kHz in humans, 100kHz in bats and whales
- Small number of channels (5-50) per stereocilium, 100k/ear -> hard to purify
- <25usec delay between deflection and opening
- 0.6pN to directly open channel



Hair Cells: Transduction, Tuning, and Transmission in the Inner Ear, Roberts, Howard and Hudspeth, 1988.

Hair Cells

- Active tuning and hair cell actuation, another force measurement?
- k ~ 1mN/m
- Adaptation mediated by Ca^{2+}
- Both electrical and mechanical tuning mechanisms

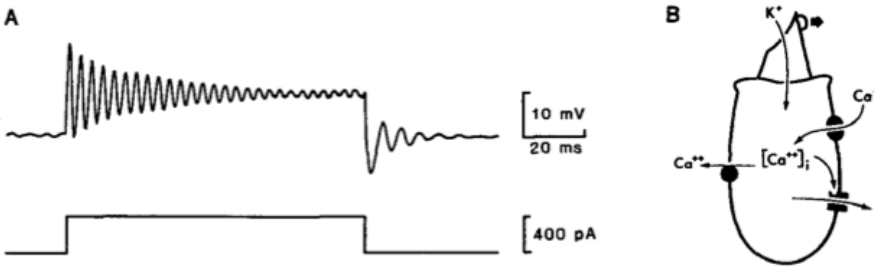
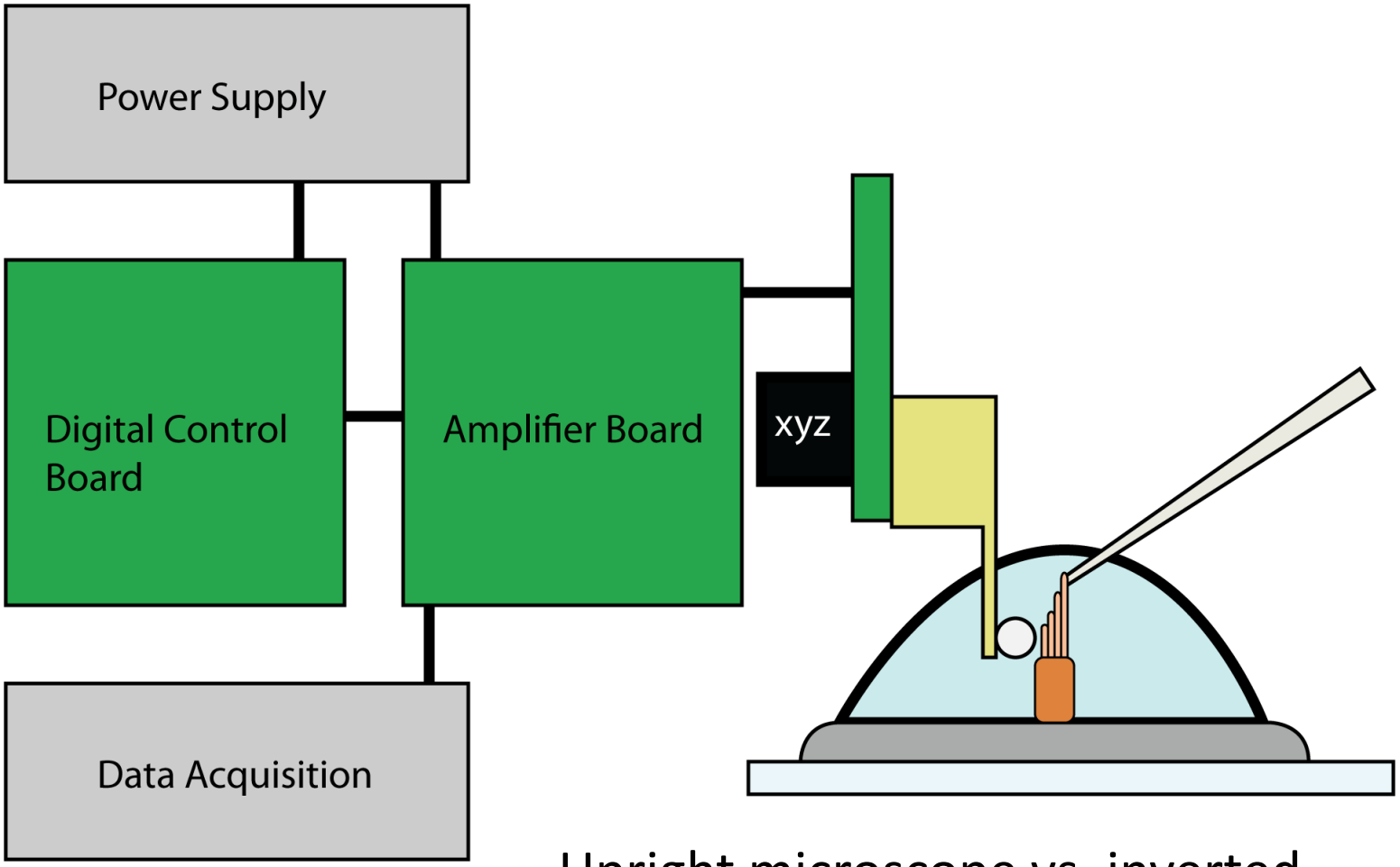


Figure 5 Electrical resonance and its ionic basis. (*A*) When a hair cell of the bullfrog's sacculus was depolarized by a square current pulse, the membrane potential exhibited damped, sinusoidal oscillation at a frequency of 270 Hz. Oscillation at a lower frequency also occurred at the termination of the pulse. (*B*) Positive deflection of a hair bundle allows K^+, the principal cation in the endolymph that bathes the bundles, to enter through transduction channels and to depolarize the cell; the injection of current through a microelectrode has a similar effect. As depolarization activates voltage-sensitive Ca^{2+} channels, the influx of Ca^{2+} further depolarizes the cell. As Ca^{2+} accumulates in the cytoplasm near the plasma membrane, however, it opens Ca^{2+}-sensitive K^+ channels; the efflux of K^+ through these channels repolarizes the membrane and the next cycle of oscillation commences.

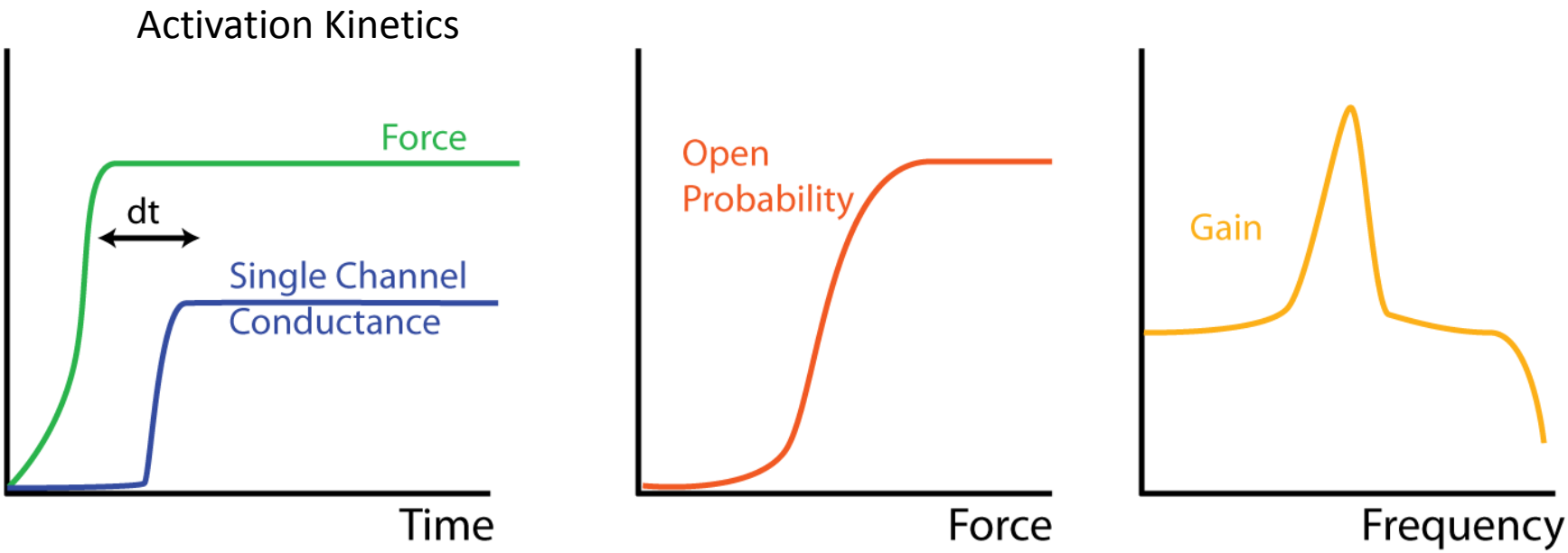
Hair Cells: Transduction, Tuning, and Transmission in the Inner Ear, Roberts, Howard and Hudspeth, 1988.

Experimental Setup



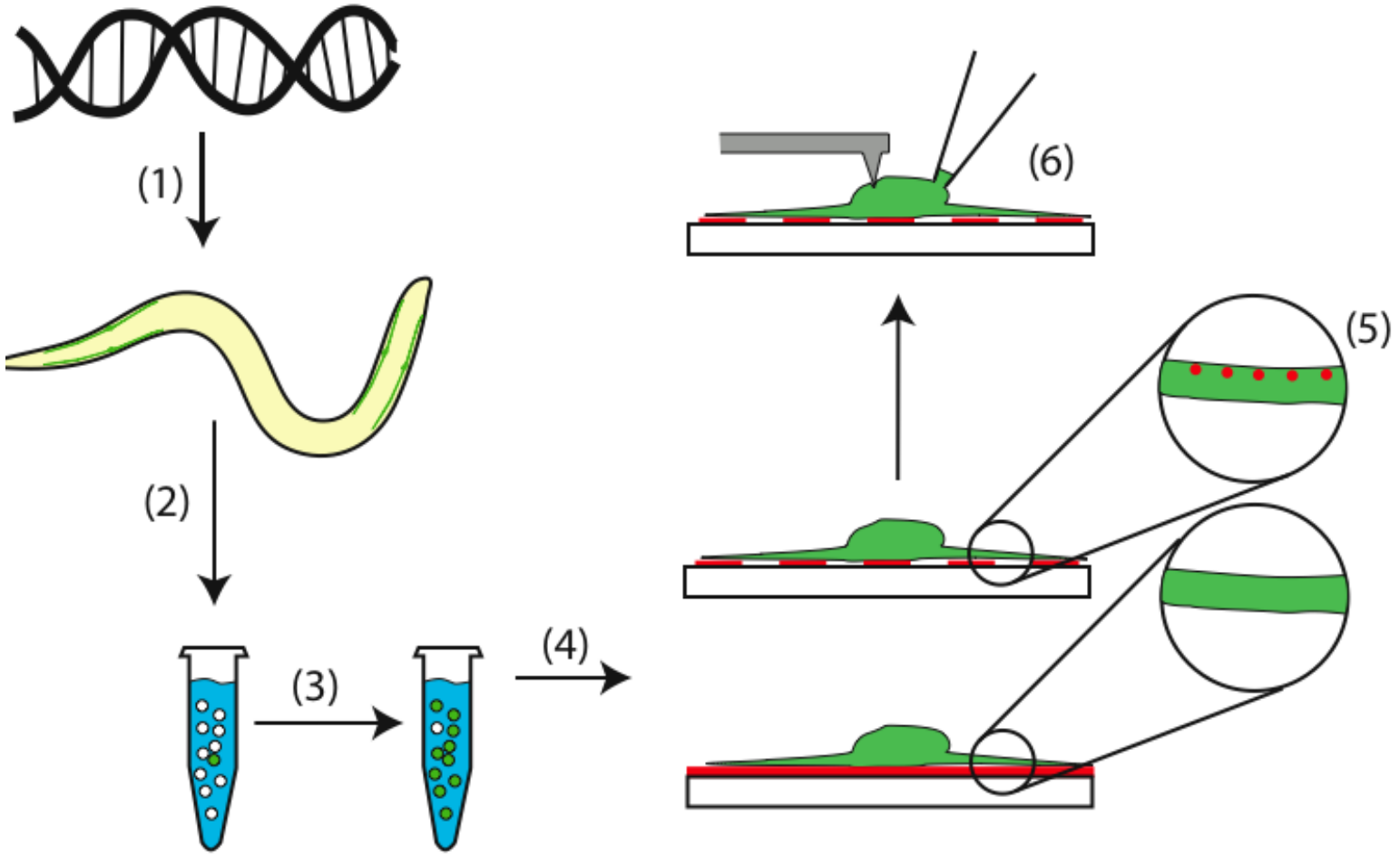
Upright microscope vs. inverted….

Things to Measure?



Need to learn more about what is unknown, where limitations of current force application systems limit the experiments

Touch Receptor Neurons



Timeline

- **Jan-Feb:** Device characterization
- **Feb-Mar:** System integration
- **Apr-May:** System characterization
- **June:** Start experiments