Biomedical Engineering

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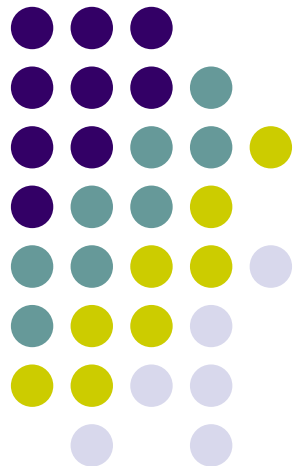
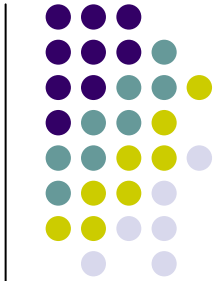


Overview

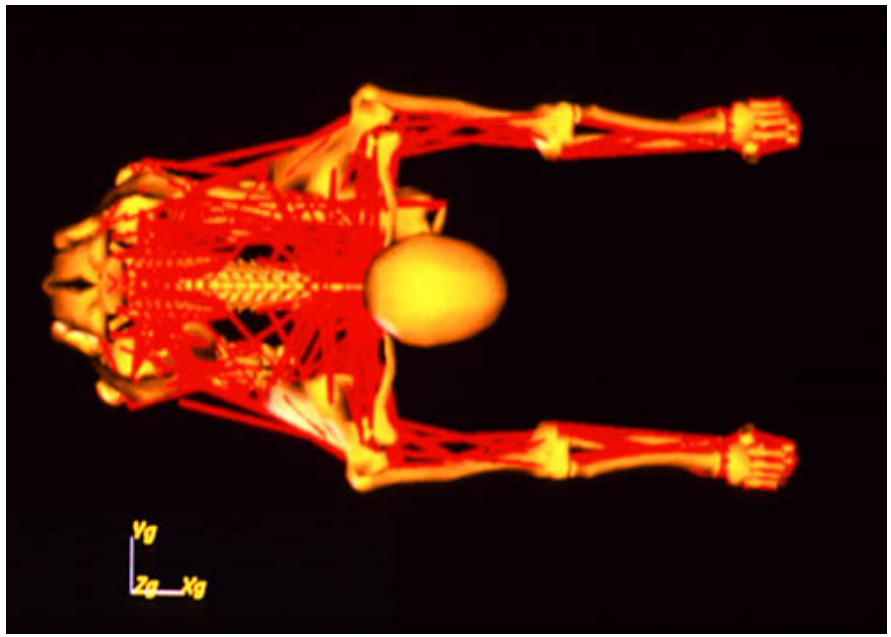


- Intro to group members/BME
- BME @ UW-Madison
- Design Courses
- Current/Past Projects
- Questions
  - UW, BME, Engineering, College, etc.
- EMG Demo

Biomedical Engineering

- What is biomedical engineering?
  - Bio → Life
  - Engineering → Problem solving

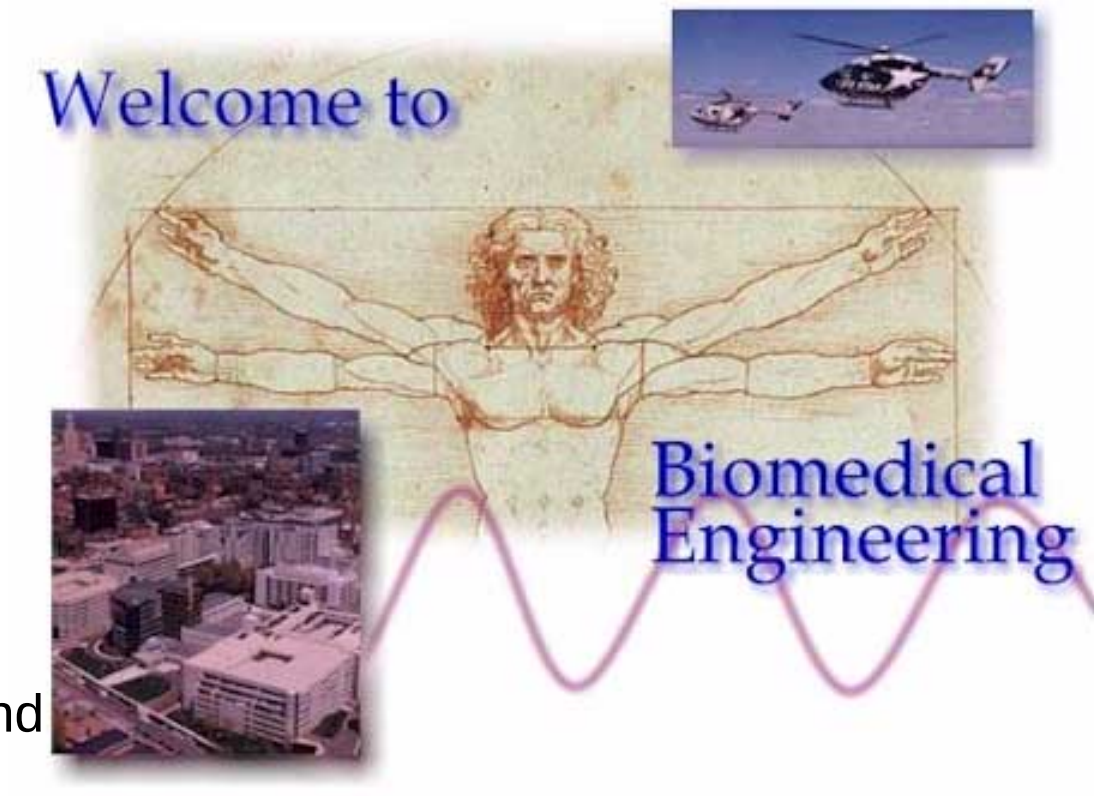
- Involved in:
  - Research
  - Clinical applications
  - Product manufacturing



http://www.engr.wisc.edu/bme/

BME

- Multiple Specialties:
  - Biomechanics
    - ME
  - Medical Instrumentation
    - ECE
  - Biomaterials/ Tissue Engineering
    - MS&E
  - Medical Imaging
    - NEEP
  - Health Care Systems and Medical Informatics
    - IE



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BME @ UW-Madison

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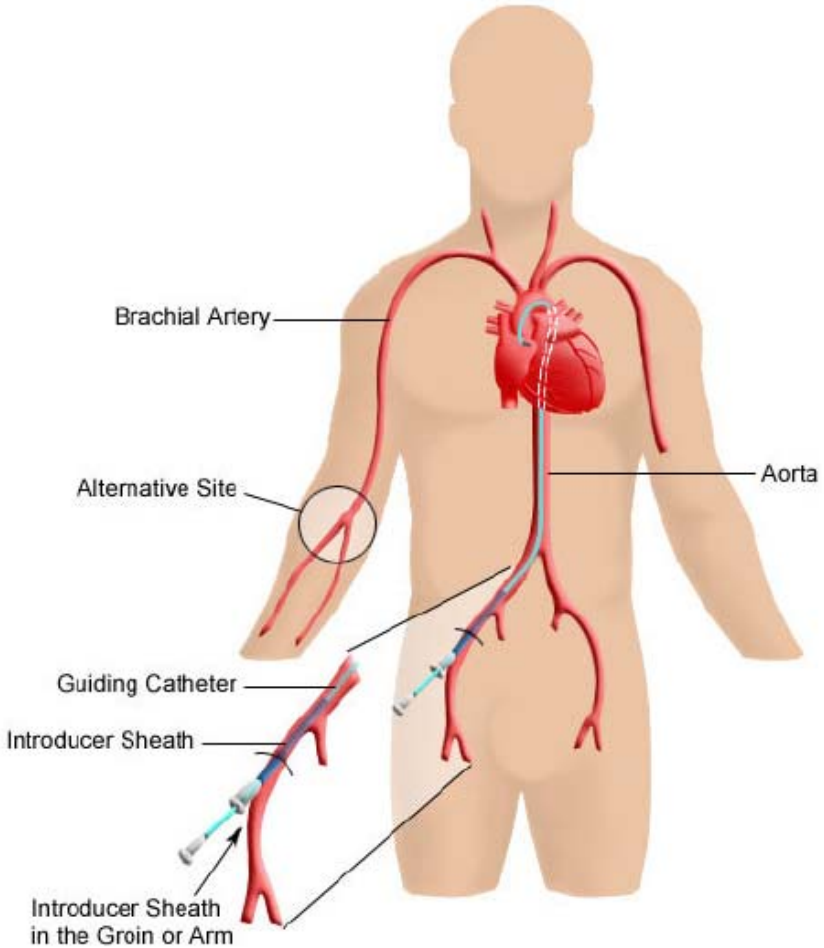
- Challenging coursework
- Selective program
- Small program and classes
- Design classes
- 1-year Masters program
- Great major for pre-med students

Design Courses

- Required every semester
- Work for real-world clients
- Design teams of 4 or 5
- One-on-one relationship with faculty
- Great for internship and co-op interviews
- Select projects from several aspects of BME
- Opportunity for patentable/publishable work

Catheter Calibration



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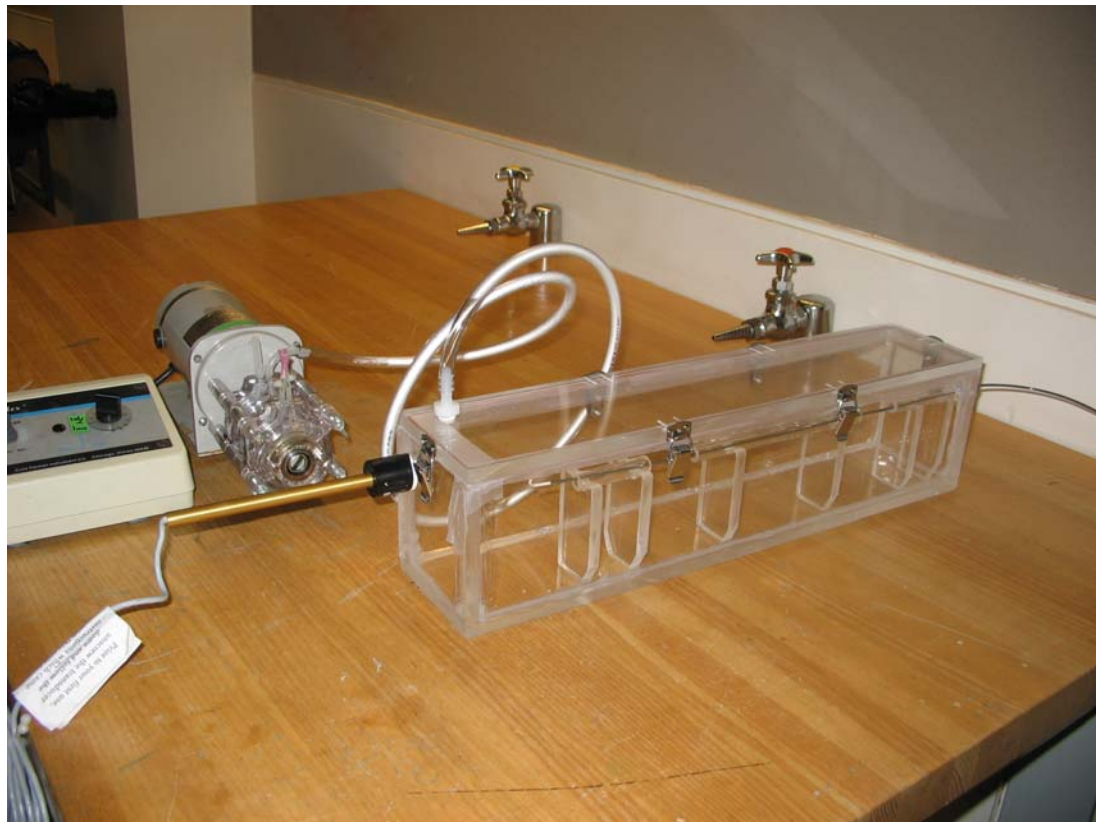
- **Client: Doctor from Cardiovascular Catheter Lab**
- **Uses pressure sensitive cardiovascular catheters to read blood pressure inside the heart**
- **Concern about accuracy of pressure readings**
- **Wants device for verifying accuracy**

Our Solution

- Air/water tight container
- Pressure sensor
- Air pump compresses air in the top of the container
- Operator enters desired pressure
- Compare catheter pressure readings to container pressure



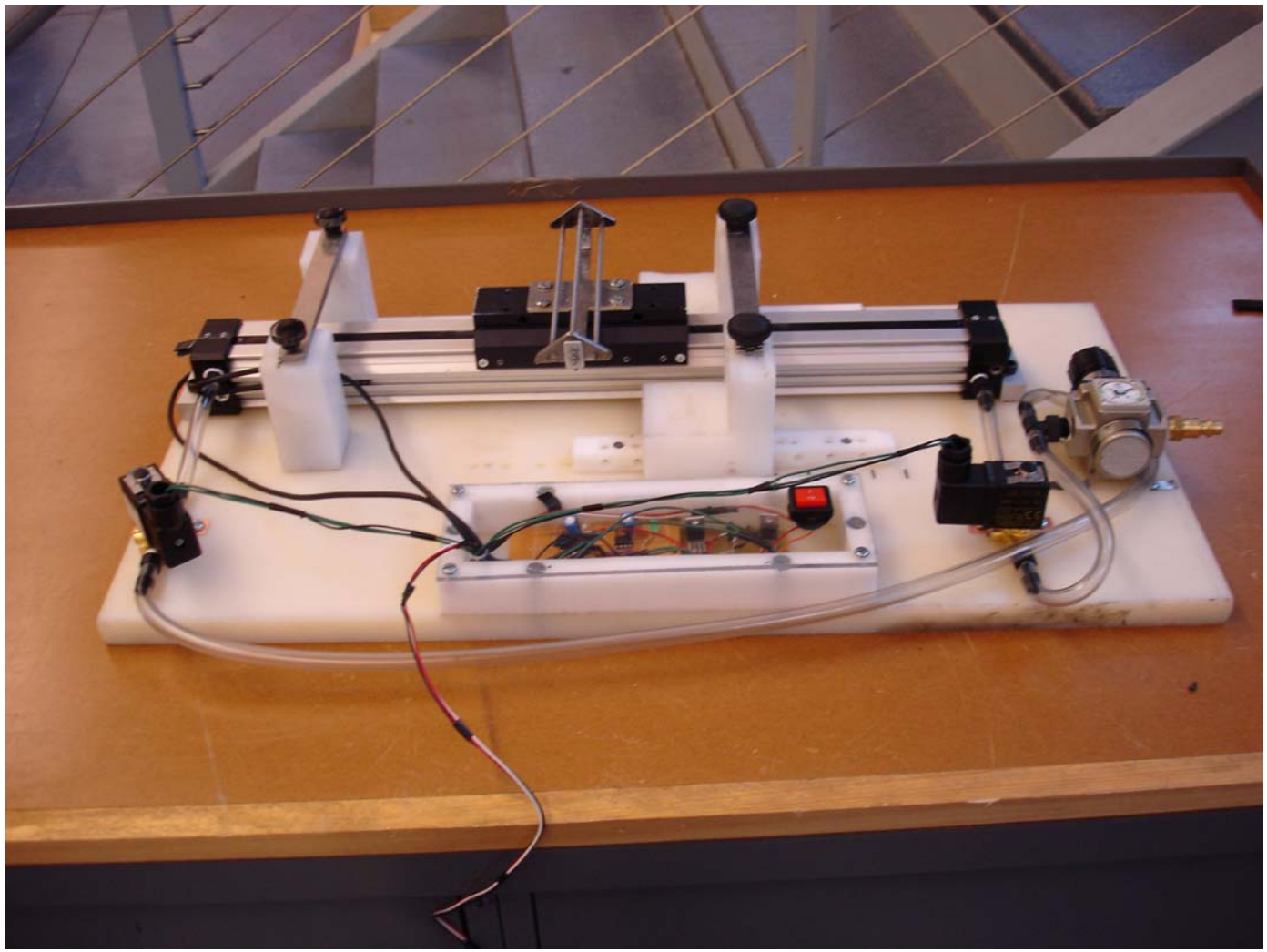
Hair Removal

- Client: Large Medical Device Company
- Uses animal dermis as a sling and tissue in graft in humans
- De-cellularized Tissue; Remnant hair
  - Hair contains DNA; Elicits xenophobic response
- Wants device to remove hair w/ minimal effort

Dermis Hair Removal

- Client: Large Medical Supply Company
- Uses animal dermis as a sling and tissue graft to repair prolapse
  - Prolapse is a weakening or tear in the muscles supporting the pelvic organs.
- De-cellularize tissue and remove hair follicles
  - Hair contains DNA; Elicits xenophobic response

Our Solution



Dermis Hair Removal to Reduce Implant Rejection Risks

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Abstract

Medical conditions such as prolapse and incontinence can be repaired surgically using animal dermis as a tissue graft. A chemical process removes animal DNA and some of the hair in the dermis. If too many hairs remain in the dermis after processing the chance of the body rejecting the tissue increases because humans cannot break down the hair remaining in the graft. This team has developed a functional prototype which not only removes hairs from the dermis, but also limits the amount of labor necessary by the operator. In the future we plan to lengthen the tracks the moveable clamp slides on, and create different rod configurations to test.

Background & Motivation

Prolapse and incontinence are common medical conditions which require strong grafts to repair. Dermis provides a sturdy collagen matrix with high tensile strength, and has proven effective in this type of repair. Biological grafts have multiple factors that can affect the outcome of the graft:

- -Strength of tissue/connection
- -Incorporation with existing tissue
- -Reaction of body to foreign object

Due to the body's severe xenophobic nature, anything deemed non-self is destroyed. DNA found in hair and the hair itself will cause this reaction, and thus hairs have to be sufficiently removed from the dermis.

Problem Statement & Design Criteria

-Develop an ergonomic, efficient device that will remove hair from dermis
-Examine the strengths and weaknesses of the current prototype
-Determine the most efficient method to quantitatively count hairs

Device:	Less than 7 hairs/cm squared Will not denature/weaken dermis -chemically compatible with dermis -no tearing or puncturing Easily implemented in laboratory setting
Hair Counting:	Efficient yet quantitative method of counting

Hair Counting

Experiments were conducted with hematoxylin dye and commercial black hair dye. Hematoxylin is a nuclear stain which only dyes nuclei.
Results:

-Hematoxylin dye
  -ineffective, dyed all pores

-Commercial black hair dye, figure 1
  -dyes dermis purple/blue
  -dyes remaining hairs black

Figure 1, Hair dyed black under a stereomicroscope projected onto a TV

First Prototype

Idea:
-Hair is forced out when pulled around a radius, figure 2
-Smaller radius & dermis contact for greater arc length increases hair removal
-Greater tension increases hair removal

Figure 2. Dermis bent over radius, *r*.

Result: Elliptical prototype, figure 3
-Dermis is pulled over a rod and secured at the foci of elliptical tracks
-The rod rides on the elliptical tracks forcing hairs out
-Removes hairs to less then 6 hairs/cm2 with 99% confidence

Figure 3. First prototype processing dermis. The rod is moved back and forth along the tracks by an operator.

Problem Areas:
-Incapable of processing varying lengths
-Securing the dermis is cumbersome
-Achieving sufficient tension is difficult
-Requires an operator at all times

New Prototype

Three Rod Idea:
-Dermis can be forced to the radius over a greater arc length with a three rod configuration, figure 4
-This allows the dermis to be pulled under tension linearly
-Linear movement is easier to automate

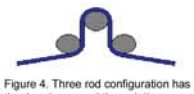


Figure 4. Three rod configuration has the dermis weaved through it.

Result: An automated prototype
-Dermis is passed through a three rod configuration as seen in figure 5
-Dermis is fixed at ends via steel clamps
-Three rod configuration is attached to an air slider
-The air slider has two inlets, pressure at one inlet forces the slider to opposite end
-Inlet pressure is controlled via solenoid valves and a pressure regulator
-Magnetic reed swithces at the clamp positions trigger a circuit to open/close the corresponging solenoid valves such that the slider and the three rod configuration will oscillate between the fixed ends of the dermis
-The tension on the dermis combined with the oscillation of the three rod configuration force hairs out of the dermis

Figure 5. Prototype during recent testing

Testing Results

The new prototype was tested with five dermis strips. The strips were processed on only one side or on both sides. The strips were dyed with black hair dye after processing. Three one cm square pieces were cut from each strip and examined under a microscope. One square was also cut from an unprocessed portion of each dermis strip. See figure 6 for initial test results.

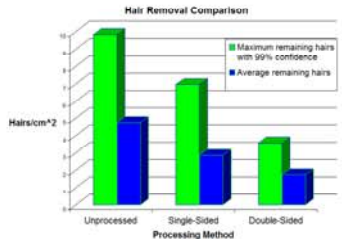


Figure 6. Compares the average remaining hairs for each processing method. Assuming a normal distribution the figure also compares the expected maximum hair level with 99% confidence (mean plus three standard deviation units)

Conclusions

Based on initial testing, hairs in the dermis were removed to levels less than 7 hairs/cm squared (client's specification). The prototype also solves many problems experienced with the previous design, such as difficulty to load dermis, the necessity to process manually and the inability to process varying lengths of dermis. The new device could easily be implemented in a manufacturing setting, and the installation of multiple devices could greatly decrease processing time with no increase in operator labor. In short, the design effectively and efficiently removes hair follicles to desirable levels.

Future Work

-Install start switch to move slider to the reed switches and begin processing cycle
-Modify circuit to include a AC/DC power converter to plug into a normal 115 V 60 Hz AC wall socket
-Experiment with different triangle-rod configurations to determine what configuration leads to the most effective hair removal.
-Complete more testing to develop a standardized protocol including how many runs to make on the dermis, at what air pressure the device should be run and whether to process both sides of the tissue

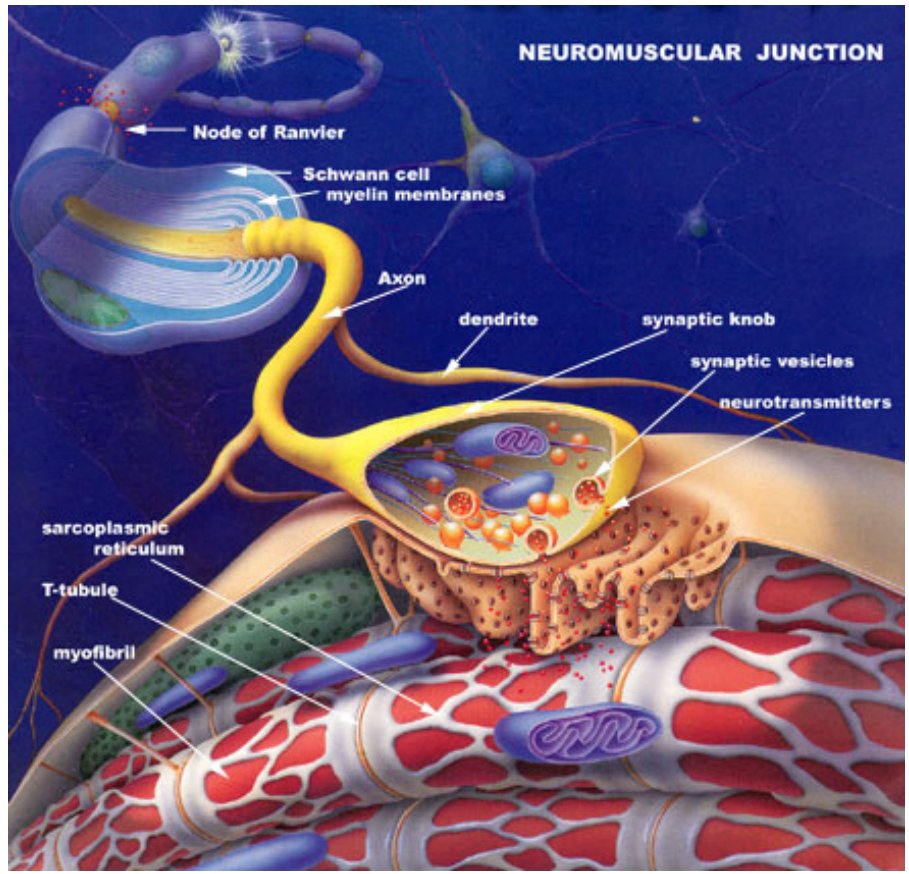
Acknowledgements

1) Professor Masters, advisor
2) Professor Webster, advisor
3) Professor Williams, BME Dept.
4) Peter Jacobs
5) ME shop personnel

Questions??

Electromyograph (EMG) Demonstration

- Contracting muscles create an electrical gradient
- EMG amplifies/filters signal changes to current
- Can be used with amputees to move artificial limbs via a DC input motor



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