Biomedical Engineering, Medicine and Optimizing the Human Body

*a brief glance*

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VCHS Class of 99
Biomedical Engineering

- Encompasses all main fields of Science
- Extremely non homogeneous field
- Room for Expansion
- Opportunity to push the boundaries
Classic Science Pyramid

- Physics
- Chemistry
- Biology
Real Science Pyramid

- Physics
- Chemistry
- Biology
Medical Development

- Only 3-5% of biomedical startups make it
- Proven or assumed benefit
- Good profit margin
Medical Development

- FDA Clearance: Class I, II, III
- Quality Control
- Intellectual Protection
- Buy-in by medical providers
- Buy-in by medical reimbursers
Biomedical Jobs

- Basic Science Researcher
- Inventor
- Research and Development
- Manufacturing
- Quality control
- Regulations
- Representative to health care professionals
- Patent Law
My Personal Dissertation Research
Chemical Cytometry

Migration Rate \( \approx \alpha \frac{\text{Charge}}{\text{Mass}} \)

++Capillary Electrophoresis

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Chemical Cytometry

- The separation of the contents of a single cell by micro-electrophoreoretic techniques.

- Dovichi and Krylov- analyzed 30 proteins
- Allbritton and collaborators- kinase activity
- Monica Palcic’s- carbohydrate synthesizing enzyme
- Edgar Arriaga’s- analyze mitochondria
- Robert Kennedy’s- peptide-protein interactions
Current Biomedical Significance

• 210 types of cells in the human body
• 500 genes encode for protein kinase in human genome
• Epigenetic and cell cycle diversity in cells results in a large variation of protein kinase expressed.
• Genetic mutations alter the function of protein kinases example: BRC-ABL
PKA Activation through the β-Adrenergic Receptor

G-protein Coupled Receptors

Adherent Cells & Kinase Activation

- Slow lysis can trigger cell stress responses
- Removal of adherent cells from their substrate can trigger cell stress responses

Reliable analysis of kinase activity by chemical cytometry requires fast lysis of attached cells
Overview

- Most cells are adherent
- Cells are heterogeneous
- Prior throughput was 5-10 cells a day
- 600s-1,000s of cells are required
- A high throughput method is needed
1st Generation Chemical Cytometry

Fluorescently labeled substrates for protein kinases
2nd Generation Chemical Cytometry

Gold Plated Capillary
NEW Generation
20 Cells Analyzed

Oregon Green  Fluorescein

Seconds
Part 2: Fast Lysis Cell Traps and Chemical Cytometry
Two Cell Trap Electrode

DC Advantages

- Less patterned electrodes
- Easier fabrication
- Simple lysis set up
- Robust lysis
- Focused electric field
- Electro kinetic injection

AC Design

Gold / Titanium Electrodes

DC Design

Polymer Cell Trap

Indium Tin Oxide Electrode

Glass
Focused DC Field

Ground Electrode

B

10 kV/cm
10 μm

0.1 mm

100 V Lysis Electrode
4th Generation Detector Design

- Capillary
- Objective
- Laser Fiber
- Optic input
- PMT Collection
- Optic Output
- Filter Set
4th Generation Detector
Short Capillary Enabled

Polyethylene Tubing

2-3 cm capillary after detection window

Epoxy

detection window

Total Length
10-15 cm
Vs. 50-60 cm
Micro Buffer Flow Control

a Heat Transfer Affair
Pu 238 oxide Ball Bearings Prevent Bearings Grease from Freezing
Buffer Delivery System

- Fan & Heat Sink
- Sheath Valve
- Heat Sink
- Flow Regulators
- Cross Flow Valve
Cross Buffer Delivery System

Cell Buffer

Flow Regulator

Valve

Heat Sink

Spiral Heat Exchanger

RTD (Temperature Measurement)

Cross Flow
Buffer Delivery System

- RTD (Temperature Measurement)
- Spiral Heat Exchanger
- Cross Flow
- Sheath Flow
- Vacuum
- Heater Cartages
Buffer Delivery System

Cross Flow Heater Controller
Stage Heater Controller
Sheath Flow Valve
Cross Flow Valve
Current Electrode Interface
Space Race and Robustness
Thank you

Machinists
 Lee Moritz, Chris Peters, Ron Hulme

Committee Chair
 William Tang

Staff Scientist
 Yuli Wang

Post Doctorates
 Lavanya Rau & Simon Mwongela
Thanks to the Primary Investigators
Other BME Research
Cells Compact the Collagen Network in Gel Culture but Reduce Structural Stiffness Dependence on Collagen Content
Collagen Remodeling and Elastin Disruption Occurs Following Scrape-Injury in a Rabbit Model of Airways Fibrosis

[Images of histological sections and fluorescence micrographs showing changes in tissue structure over time with different treatments.]
Bioartificial Lung


http://phys.org/news198390175.html
Physician and Medical School Overview
Medicine

- is an uneven agreement between individuals
- an Art of Science
- is pattern recognition
- becoming more and more controlled by politicians, insurance companies, lobbyists, lawyers, and unions
Key Medical School Factors

- Clinical Exposure!!!!!!
- Research
- Community Service
- Leadership
- MCAT
- GPA
Road through Medical School

- 2 years didactic, 2 years clinical
- Board exams: step 1, step 2 ck, step 2 cs
- Main 3rd year rotations
- 4th year electives
- Application and the match
Different Fields Different Personalities

The 12 Medical Specialty Stereotypes

Orthopedics: The meatheads
- Cash New Knee no fit!
- Why no hammer harder, you?
- Hammer hard already! Need me bigger mallet!
- (Dude! Dude!)

Neurology: The armchair intellectual
- For you, with the onset of dysthria, an intellectual manner's syndrome, and diminished sensation to the contralateral body, we can isolate this sense to the posterior circulation specifically a lateral medullary infarct. What can you do about it now?

Emergency Medicine: The Cowards
- Patient's leg is bleeding! No time to call surgery! Tourniquet and amputate! Quick, throw me a scalpel!

Neurosurgery: Workaholic Egomaniacs
- Come on people! Let's get the patient in the room! Am I the only person who does work around here?

Family Medicine: Hippy Dippy Country Doctor
- Now, I could give you some vitamins for that skin infection, or I could make you a poultice of horseradish.

Psychiatry: The Face Doctor
- Can't you see that all of the patient's depression stems from his latest sexual attraction to his childhood pal?

Dermatology: Glamazons
- Dry hands, itchy hands, dry mouth, sore throat...

Pediatrics: If Patch Adams and Mutter Rogers mated.
- Hey kids! Who's ready for their shots?

Radiology: Rich in the dark
- Sound of counting reads. X-ray.

Pulmonology: If Patch Adams and Mutter Rogers mated.
- Hey kids! Who's ready for their shots?

internal Medicine: Works
- Not quite sure that I'm going to do today. My head is in a fog. My mind is in the gutter. My stomac

Anesthesiology: Lazy Burns
- Gotta get out of here. I'm tired. My mind is in the gutter. What else could I do today?
Optimizing the Human Body
Health Basics

• Smoking cessation
• Calorie control
• Daily exercise
• Healthy Diet
• Supplementation
Slides for Health and the Human Machine
Thank you

Now go and change the world! 😊