Interface between life and physical sciences

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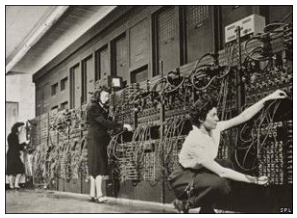
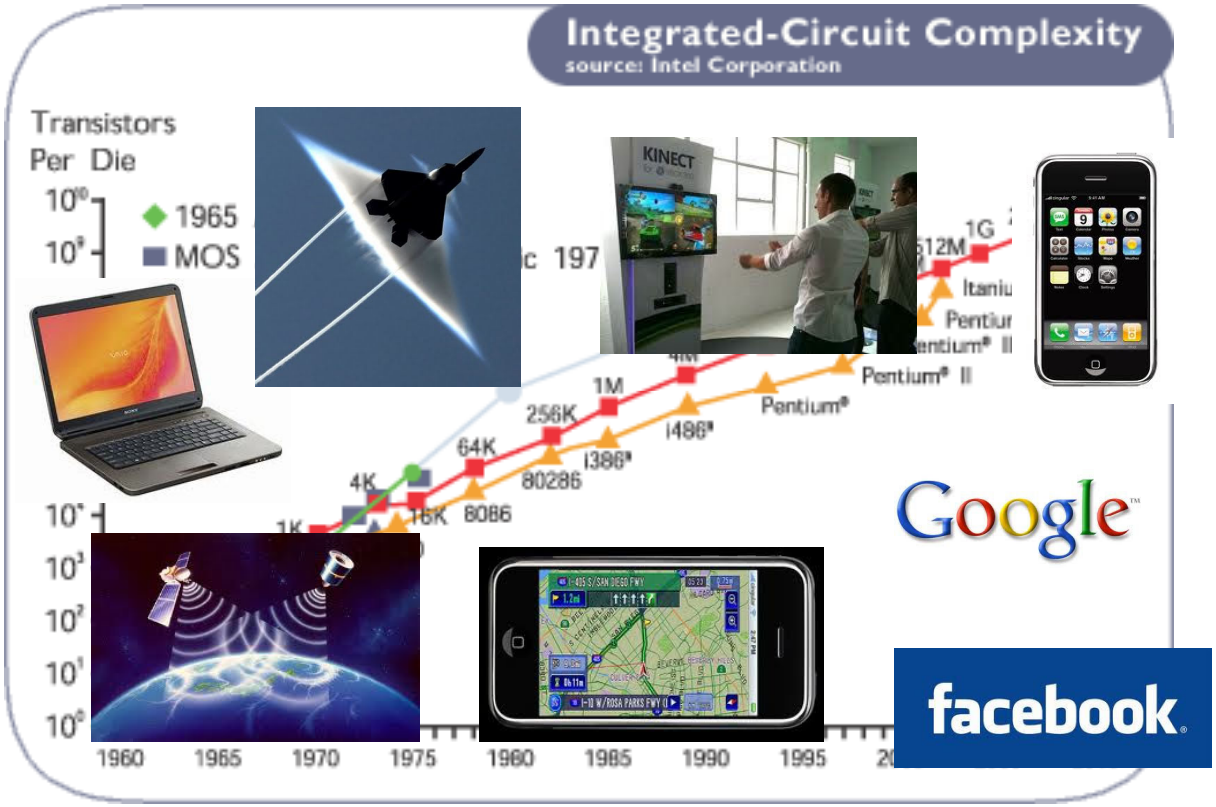
The CURIE project team

Semiconductor revolution



1946
Eniac

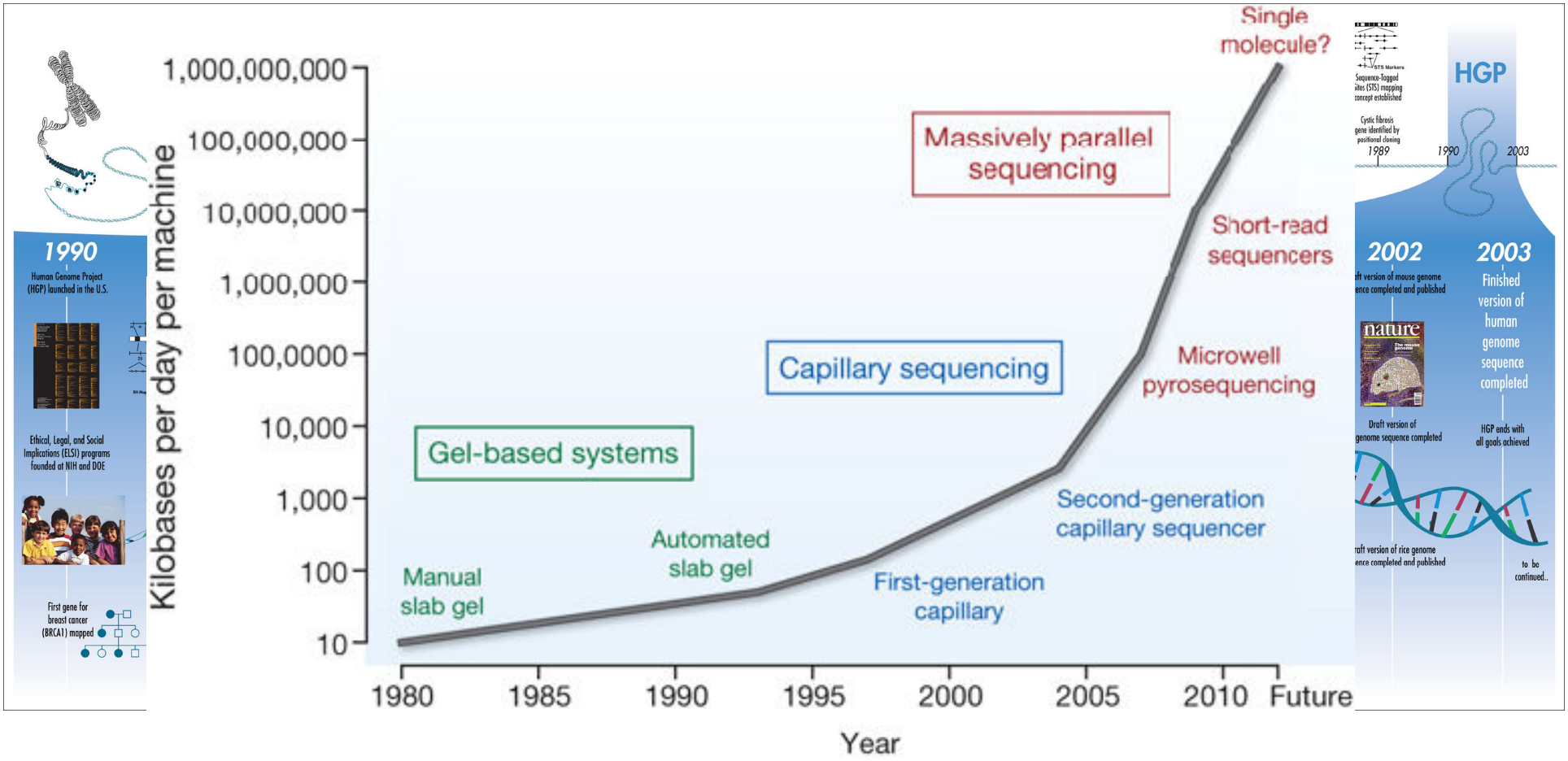
1948
First transistor



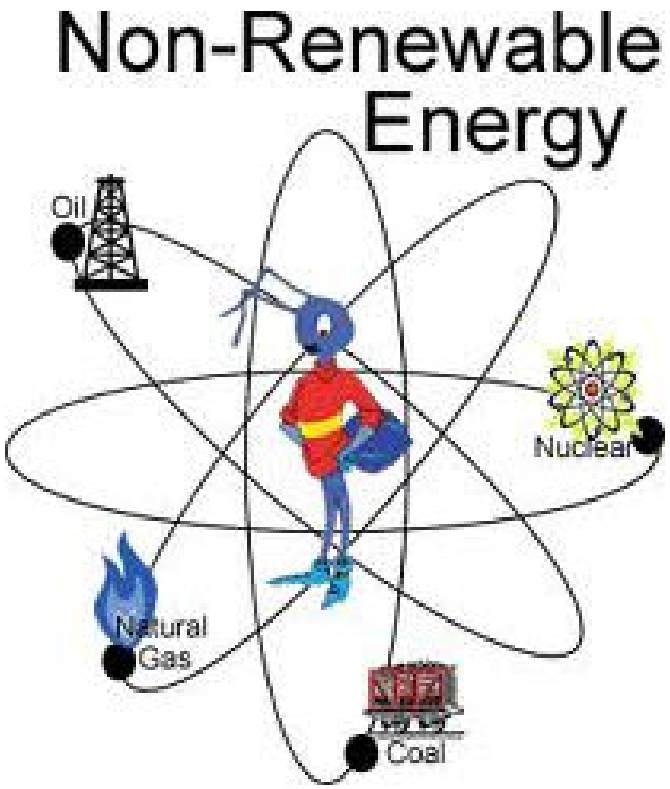
1946

2011

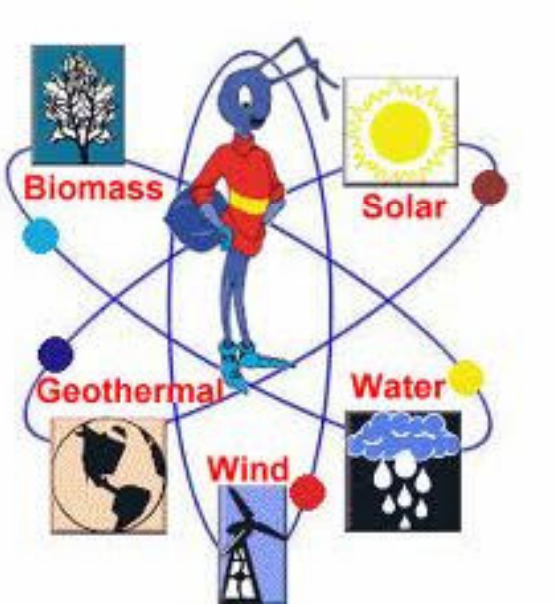
Genome revolution



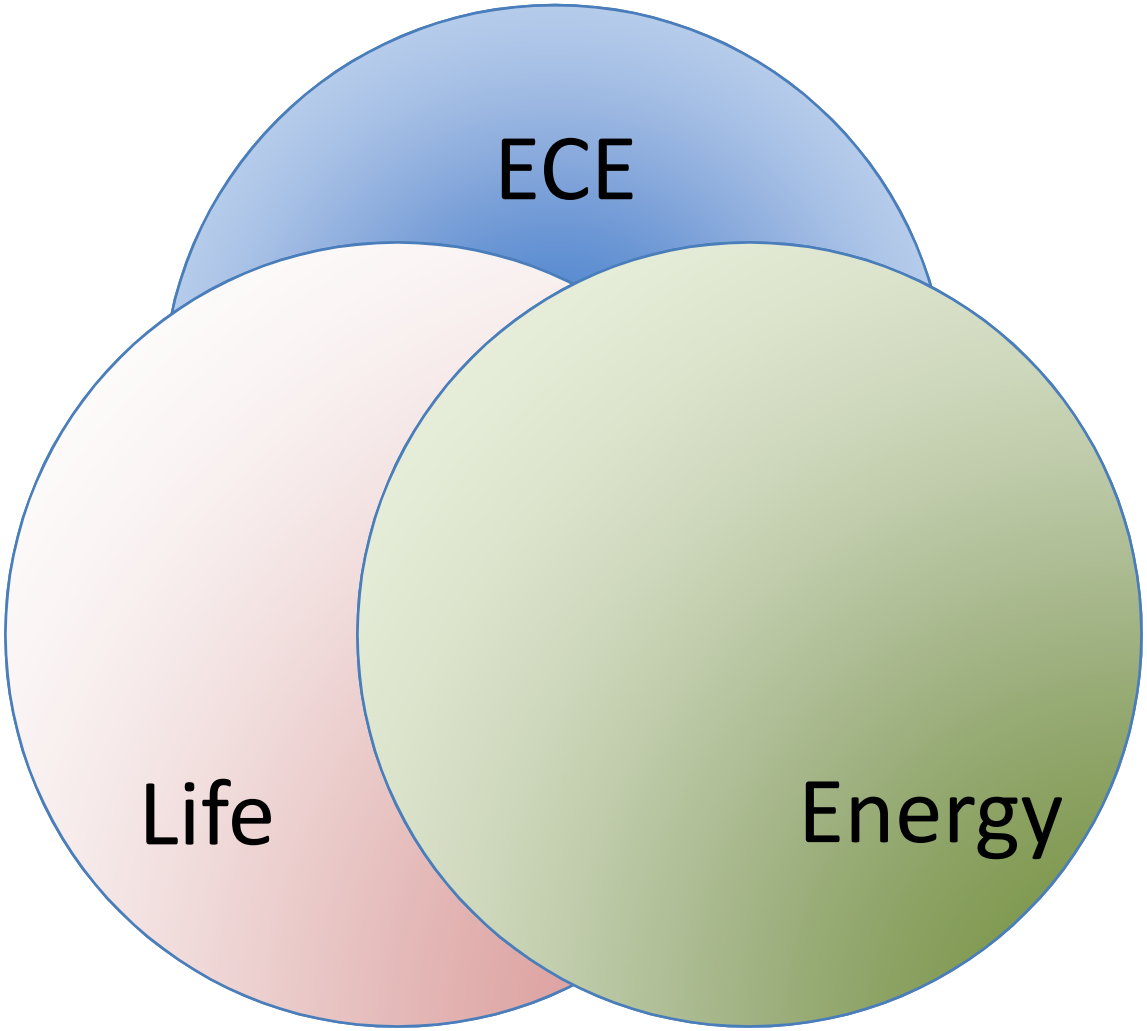
Energy revolution?



Renewable Energy



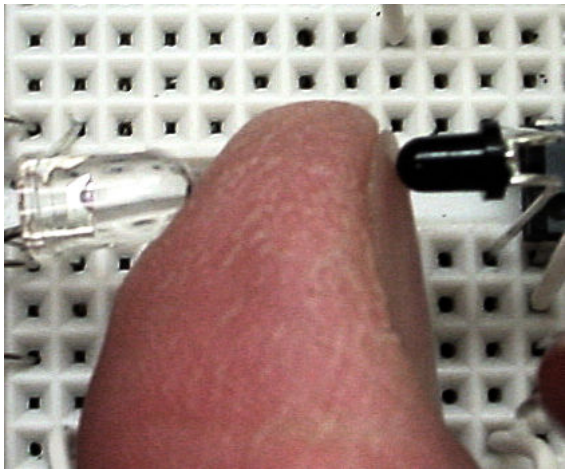
Breakthrough is at the interface



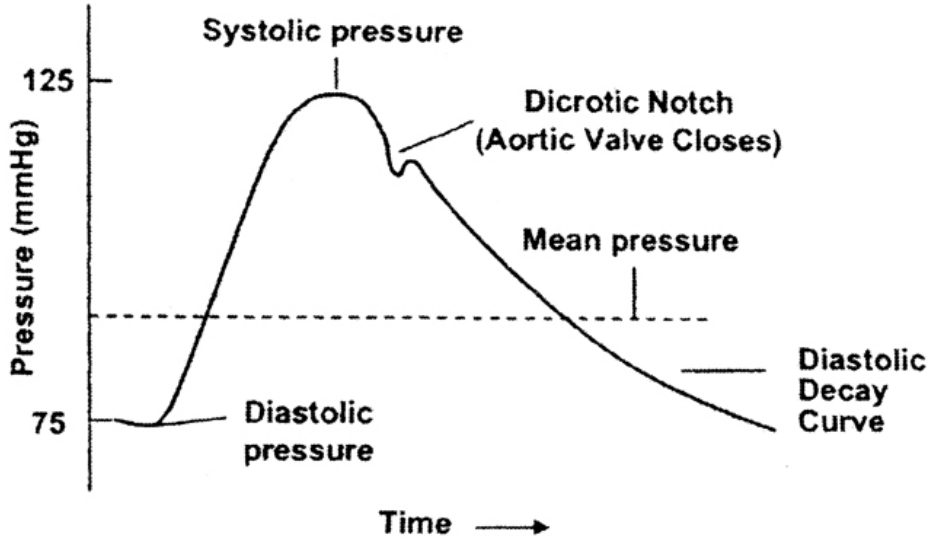
Projects for CURIE 2011

- Infrared pulse meter (biomedical)
- Sleep apnea feedback device (biomedical)
- Microvascular on chip (biomedical)
- Protein localization in mammalian cell (bio)
- Electronic cricket (bio-inspired design)
- Electrical vs. genetic oscillators (systems & synthetic biology)
- Sun tracker (energy)
- Wireless combination lock (electronics)

Project 1: Infrared Pulse Meter

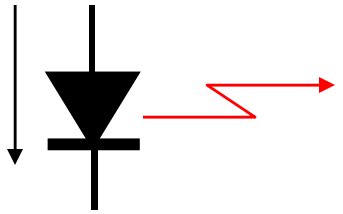


- Idea: Use noninvasive infrared light to probe blood pressure and pulse rate in a finger tip.
- Uses: A variant of this device is used routinely in hospitals and is called a pulse-oximeter.
- Components:
  - Comparator
  - Amplifiers and filters
  - Light emitting diodes and photosensors



Project 1: Infrared Pulse Meter

The clear device to the left is an infrared emitting LED.

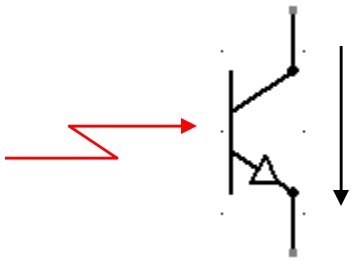


- amount of light → amount of current L = k*I
- Wavelength (color) sets voltage.
  For IR, V is around 1.2 volts
- Only works one direction
- Use your cell phone camera to see if it operates.

The black device to the right is an IR sensor (phototransistor)

Current flows when light is absorbed:

I = k*L



Your finger absorbs more IR if there is more blood.
Each heart beat sends more blood into your finger and changes the IR absorption, but the change is *small*.

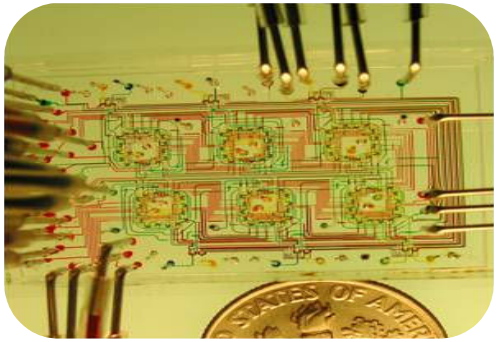
Project 2: Sleep Apnea Feedback Device

- The most common treatment is an assisted breathing device called a continuous positive airway pressure (CPAP) mask, designed to keep the upper airway open during sleep.

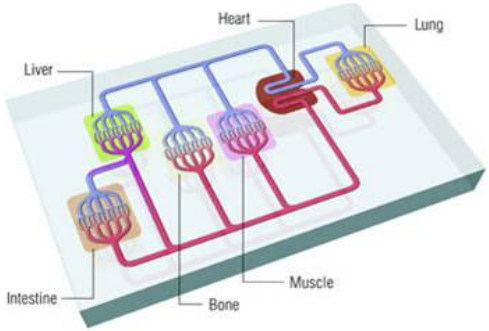
Project 2: Sleep Apnea Feedback Device

- Idea:
  - Create auditory and visual feedback systems to relate the amount of force back to the person exerting the force
- Potential uses:
  - Biomedical training device
  - Superior to existing treatment?
- Components:
  - Microcontroller
  - Resistor
  - Light emitting diodes (LEDs)
  - Transistor
  - Peizo Buzzer
  - Analog-to-digital converter (ADC)
  - Digital potentiometer
  - Force sensor (load cell)

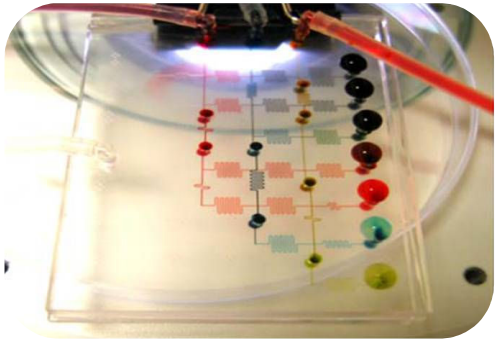
Project 3: Microvascular on Chip



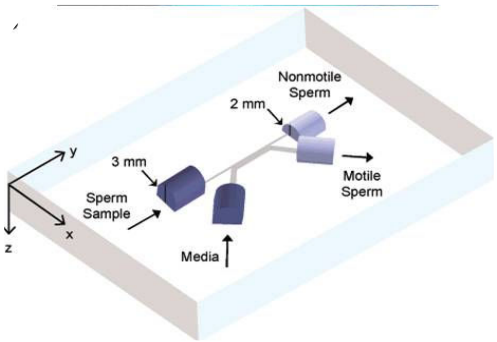
LSI



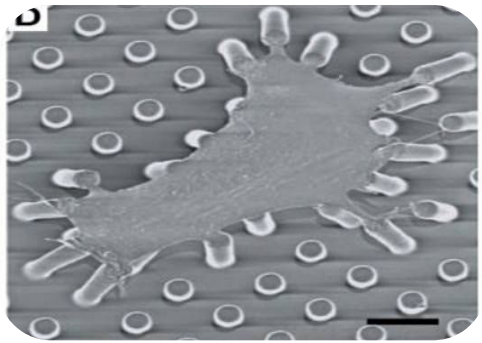
Body on chip



Concentration gradient



Sperm sorter for IVF

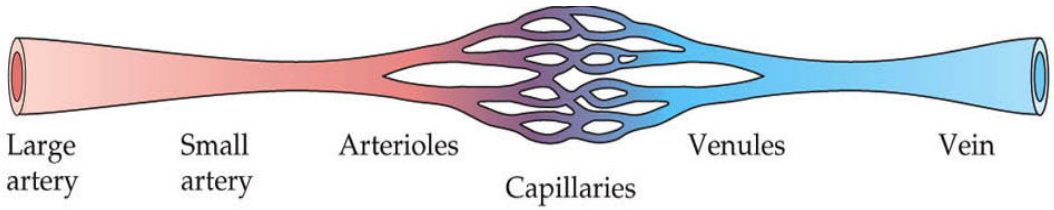


Traction force microscopy

Portable medical diagnostics

Project 3: Microvascular on Chip

- Idea: To characterize a simple model of the microvascular system using a microfluidic device
- Potential Uses:
  - Simulate clot, stroke, plaque buildup in arteries
  - Discern effect of vessel blockage or occlusion on blood pressure
- Components:
  - PDMS microdevice
  - Tubing
  - Syringe pump
  - Silicone sealant
  - Beads for visualization
  - Microscope
  - Image capture software
  - Image analysis software



Project 4: Protein Localization in Mammalian Cells

- Cystic fibrosis (CF)
- Familial hypercholesterolaemia (FH)
- Congenital sucrase-isomaltase deficiency (CSID)

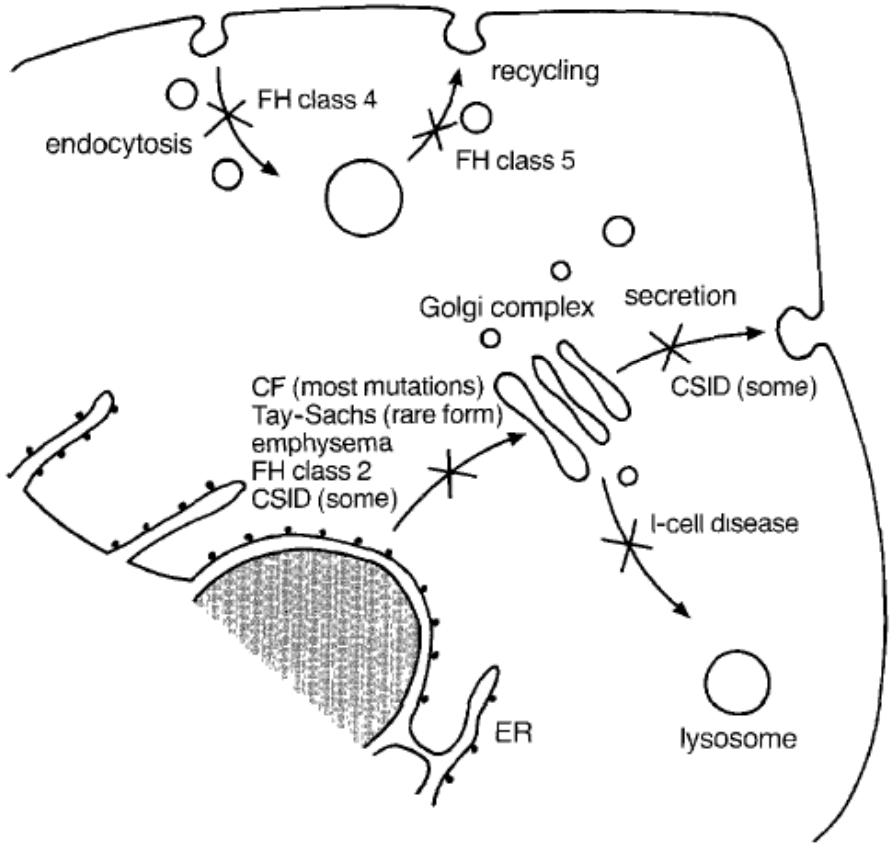
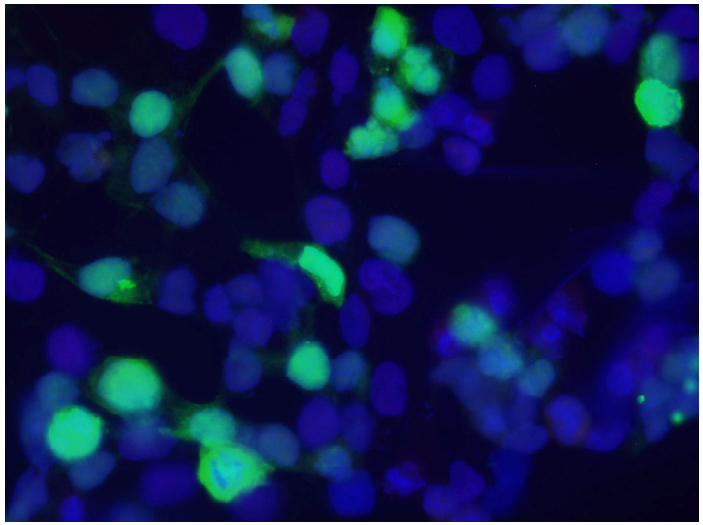


FIGURE 1

Protein trafficking events disrupted in some genetic diseases. CF, cystic fibrosis; FH, familial hypercholesterolaemia; CSID, congenital sucrase–isomaltase deficiency.

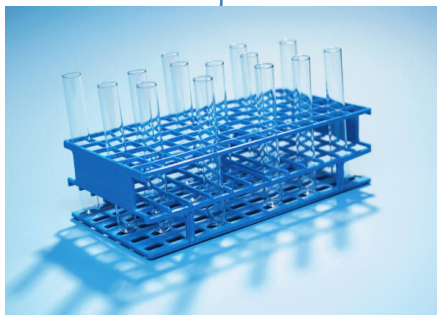
Project 4: Protein Localization in Mammalian Cells

- Idea: Compare localization of proteins (ZFP568 & GALT) in two types of mammalian cells
- Significance: Protein location is essential for proper function, mislocalization is associated with disease
- Biological Techniques:
  - DNA extraction & purification
  - Transfection of DNA into HEK293T (human embryonic kidney) & NIH3T3 (mouse embryonic fibroblast) cells
  - Cell staining & fluorescence microscopy to visualize protein location with GFP

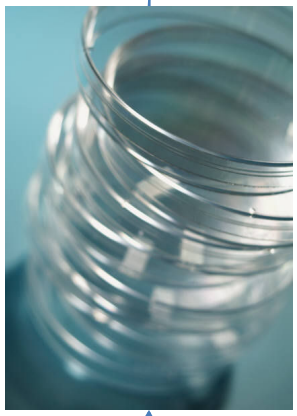


Project 4: Protein Localization in Mammalian Cells

Miniprep to extract DNA from bacteria (Tues)



Transfect to put our DNA in mammalian cells (Wed)



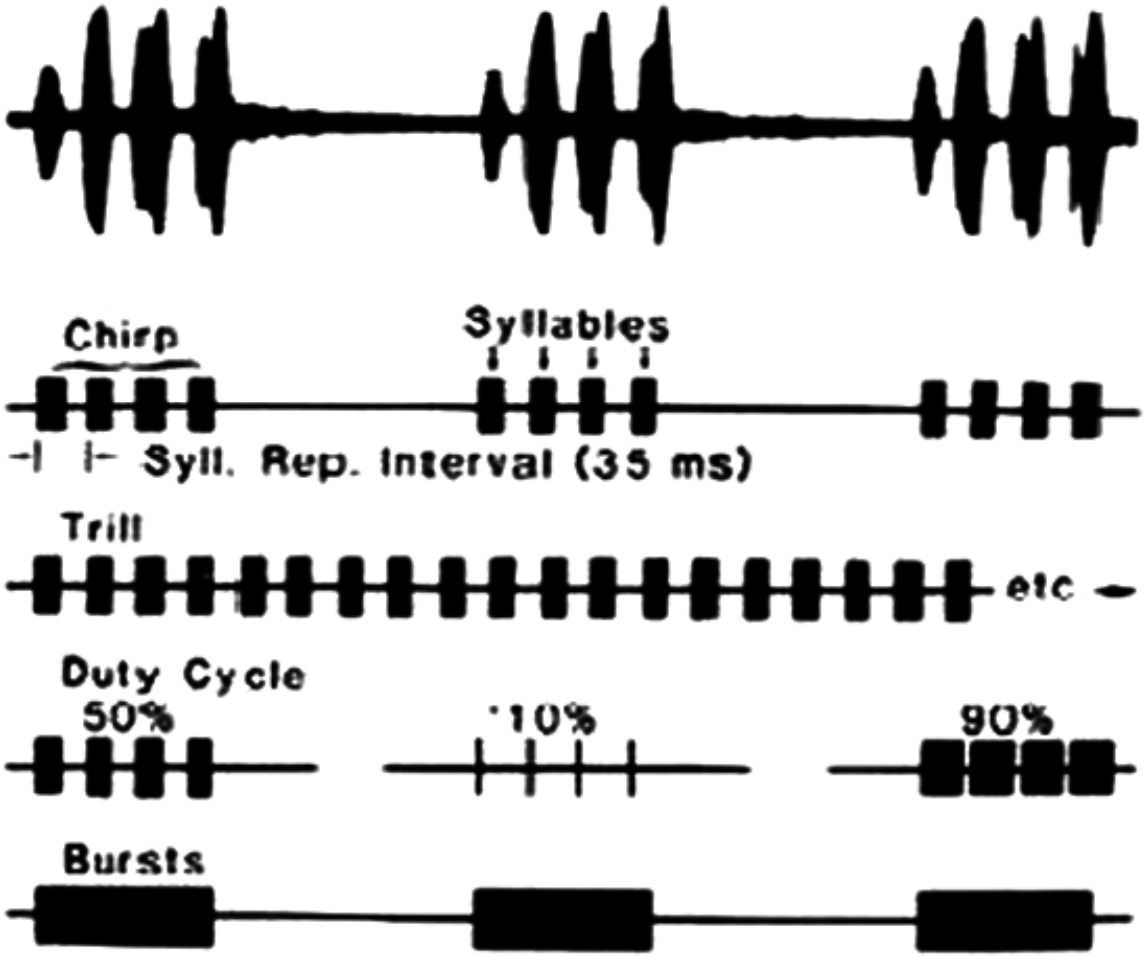
Stain & look at our cells to see where the protein is (Thurs/Fri)

Project 5: Electronic Cricket

- Idea:
  - Use photoresistor to detect light, only chirp when dark
  - Create sort-of-realistic cricket noise using several oscillators
  - Match to real cricket calls: google “cricket chirping”
- Potential uses: annoy people; investigate cricket social interactions (see Genetic Control of Acoustic Behavior in Crickets – Ron Hoy)
- Components:
  - Photoresistor
  - Oscillators
  - Speaker

Project 5: Electronic Cricket

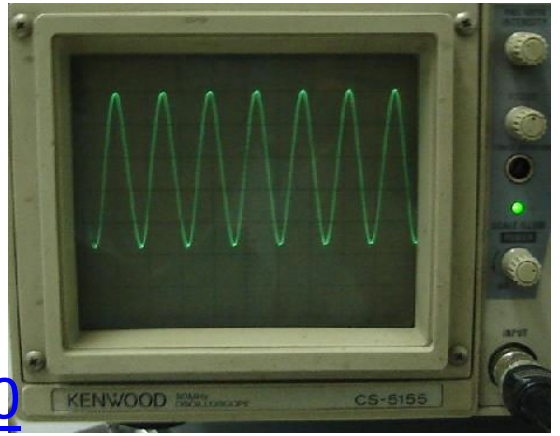
- Field cricket:
- Syll. frequency 4-5 kHz.
- Syll. Repeat 35 mSec
- Duty Cycle ~50%
- Chirp repeat rate ~2-4/sec



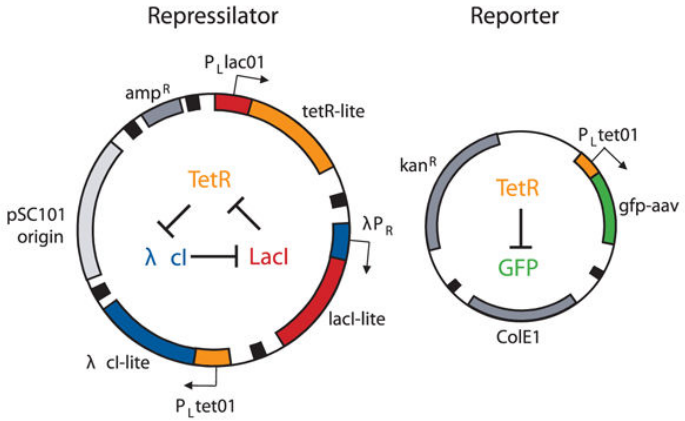
From http://www.uni-graz.at/~hartbaue/introduction.html

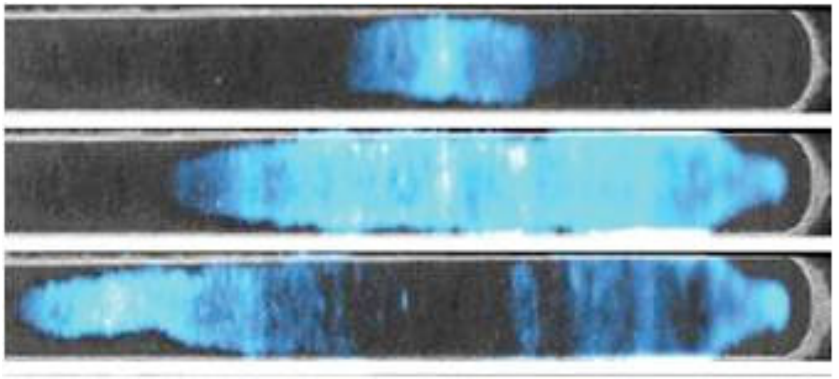
Project 6: Electrical vs. Genetic Oscillators

- Oscillator is ubiquitous in electrical systems
  - cell phone, computer, TV, PDAs, satellite …
- Clock in living organisms
  - circadian rhythm
  - synthetic genetic clock



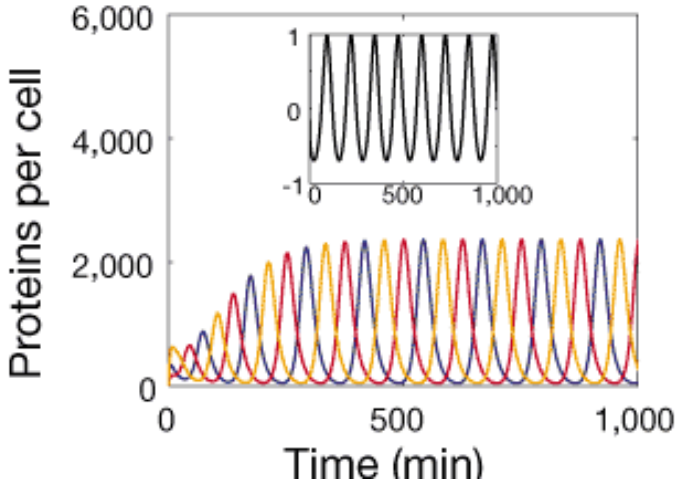
http://www.youtube.com/watch?v=pnjdAr4EjI0





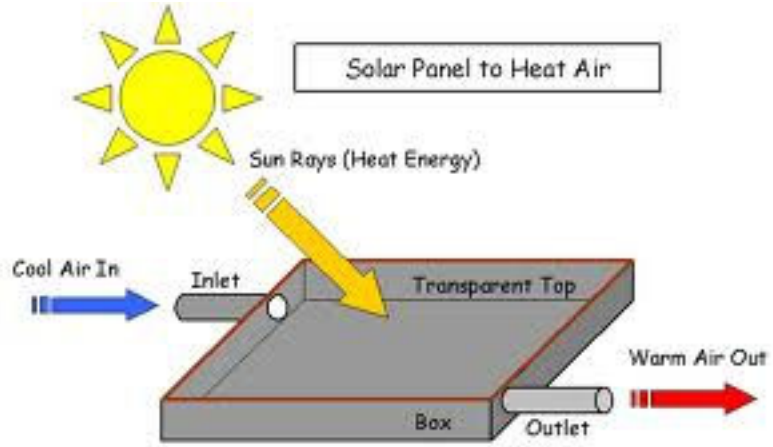
Project 6: Electrical vs. Genetic Oscillator

- Idea:
  - Use electronic circuits to understand the operation of a genetic oscillator.
  - Genetic oscillators must be involved in circadian rhythms and other periodic protein expression.
  - Similar math can be used to understand both electronics and gene circuits.
- Potential uses: Help with understanding feedback effects in biology.
- Components:
  - Timing circuits
  - Amplifiers
  - Light emitting diodes

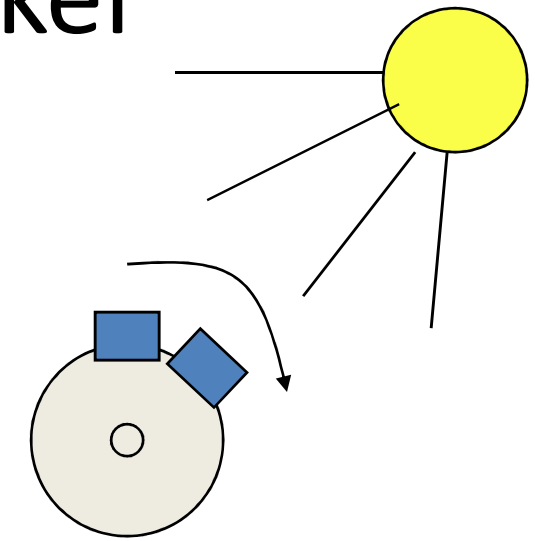


Project 7: Sun Tracker

- Challenges for Harvesting solar energy
  - Efficiency
  - Cost
    - Manufacturing
    - Maintainence



Project 7: Sun Tracker

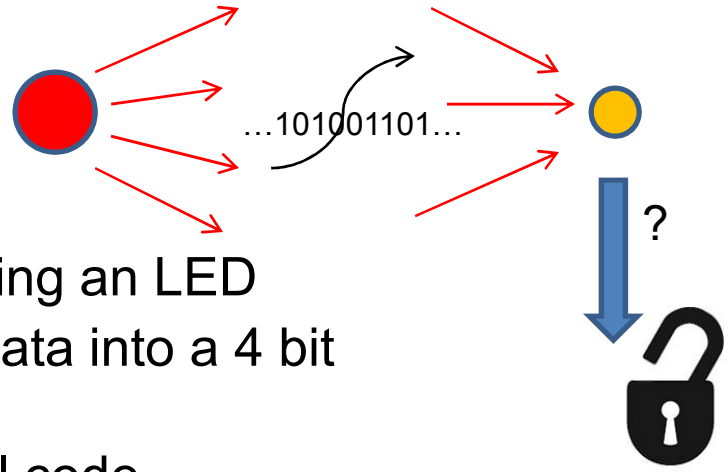


- Idea:
  - Use two photodiodes to detect where the sun is
  - Control a motor to turn toward the sun
  - When sun is “half-way” between PD, stop.
- Potential uses: solar cell tracking
- Components:
  - Stepper motor
  - Shift register
  - Photodiodes
  - Comparators
- Optional: build clock circuit and power with batteries to take outside

Project 8: Remote Sensing Security lock

- Cyber security - Privacy is under attack:
  - Personal information
  - Banking
  - Network loophole
  - Medical records
    - Your DNA sequence?

Project 8: Remote Sensing Security lock



- Idea:
  - Create a 4bit password using switches
  - Send data serially (one bit at a time) using an LED
  - Receive the code serially and convert data into a 4 bit number
  - Compare the received data with original code
  - Unlock the key if it matches!
- Potential uses: TV/ DVD/Car unlock … remote control
- Components:
  - Timer -- Switch
  - Shift Register -- Comparators
  - Amplifier
- Optional: extending the system into 8-bit

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