

מתגלית להמצאה, ומהמצאה לחידוש

טכנולוגי:

מה ניתן ללמוד מהמצאות העבר ותגליות

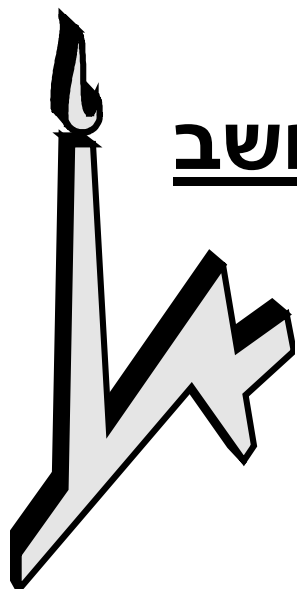
ההווה על טכנולוגיות המחר

אהרון אגרנט

המחלקה לפיסיקה יישומית,

ומרכז ברוידא לחדשנות בהנדסה ומדעי המחשב

האוניברסיטה העברית בירושלים



# מושגי יסוד:

- תגלית
- המצאה
- חידוש טכנולוגי



# Reebok Pumps



# Design Continuum

## IV equipment



## Air Cast

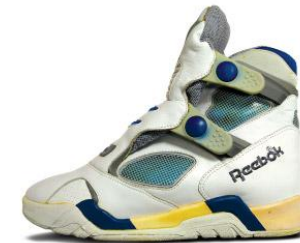


## Reebok Pump Technology



### **INTERNAL PUMP BLADDER**

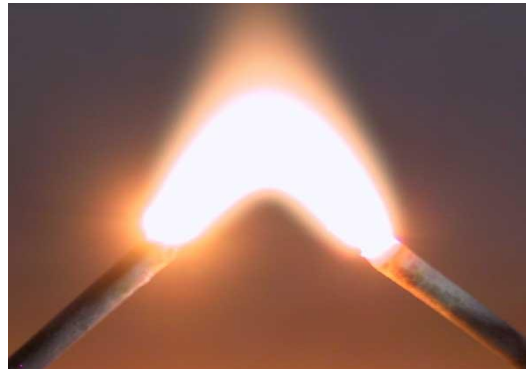
EVER WONDERED WHAT THE PUMP INSIDE YOUR SHOES ACTUALLY LOOKS LIKE? WELL NOW YOU KNOW...



UNRELEASED PROTOTYPE (1992)

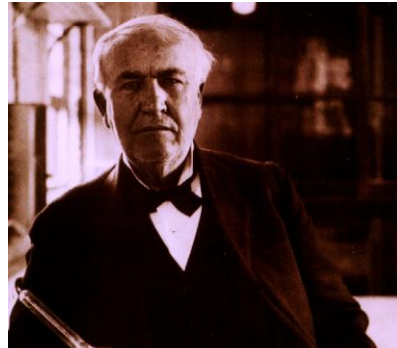
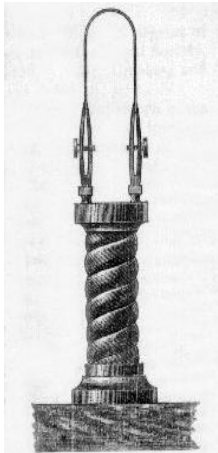
# Inventing the Electrical Lighting

Sir Humphrey Davy  
1801



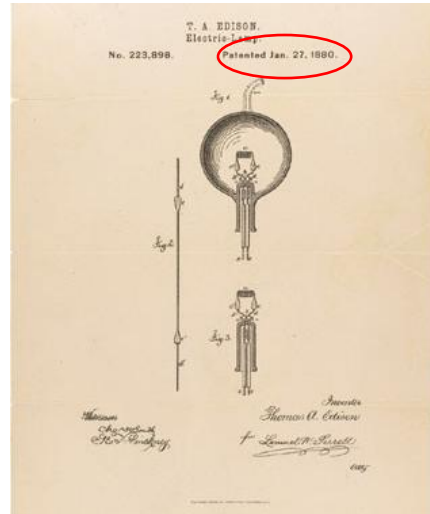
# Inventing the Electrical Lighting

Moses Farmer  
1858 - 1859

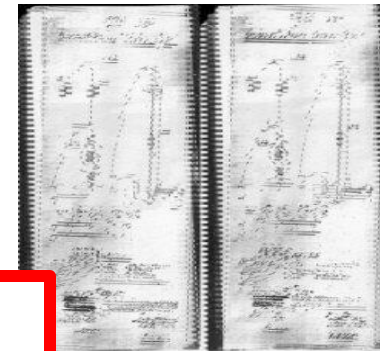


**Total: 22 Inventors**

Thomas Alva  
Edison



Henry Woodward



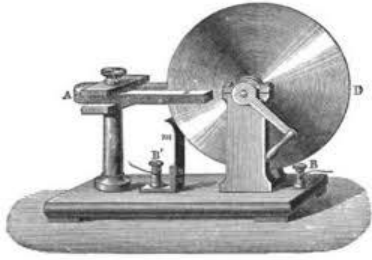
Joseph Swan



Demonstrated:  
December 18<sup>th</sup>, 1878  
Patent No. 4933:  
November 27<sup>th</sup>, 1880

# ממה נובעת המוסכמה שאדיסון הוא ממציא הנורה החשמלית

Michael Faraday 1831



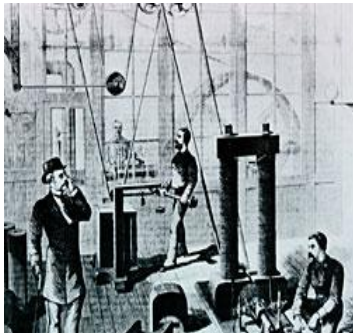
- נורת חוט הלהט:
- טמפרטורה גבוהה:
- ✓ אור חזק
- ✓ זמן חיים קצר
- תהליך ייצור – ואקום
- נורה ניתנת לשינוע

עיקרון הפעולה והמכשיר ליישומו:  
הנורה החשמלית

תחנת הכוח החשמלית  
ה- Dynamo

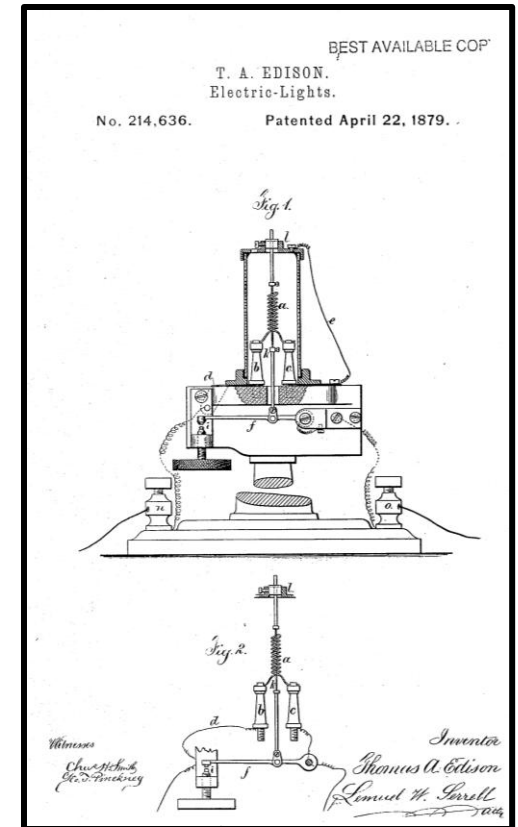
טכנולוגיית  
התאורה החשמלית

Long Legged Mary Ann  
1882



טכנולוגיית הפצת הכוח החשמלי

- הטכנולוגיה פותחה עבור תעשיית הטלגרף.
- המודל העסקי נלקח מתעשיית הגז.



# מ-"המצאה" ל-"חידוש טכנולוגי"

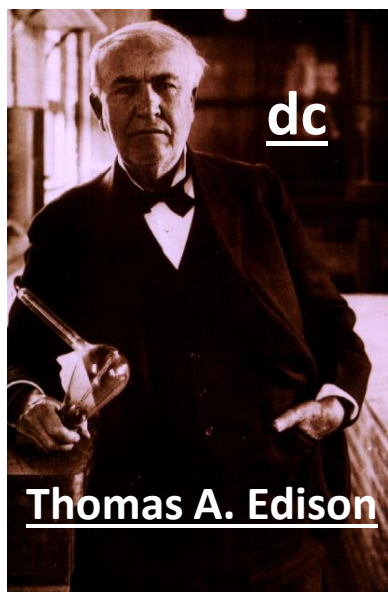
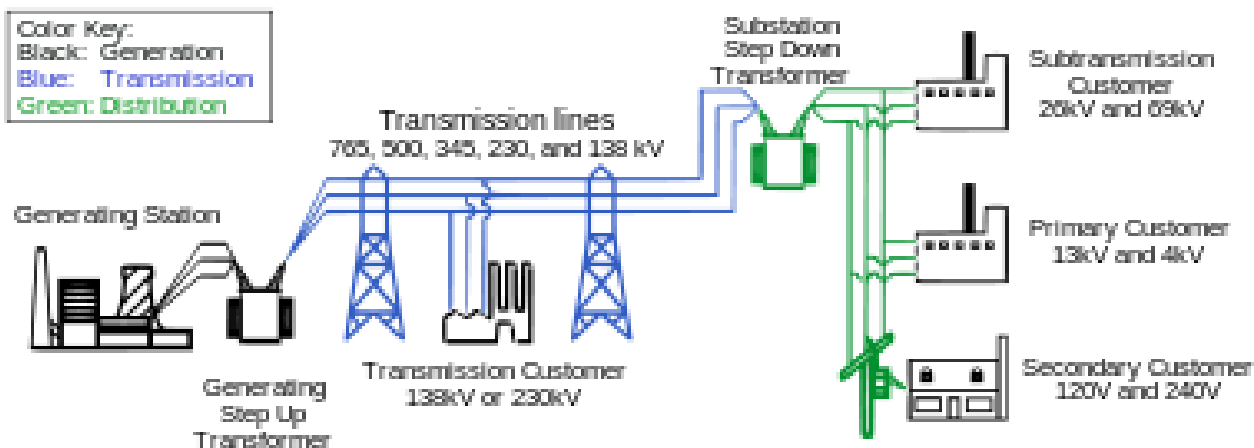
## או: מה בכל זאת עשה אדיסון

- פיתח שיטת ייצור של נורות אמינות יעילות וזולות.
- פיתח מקור כוח חשמלי יעיל.
- הביא את החשמל הביתה בהתבסס על טכנולוגית הטלגרף.
- אימץ את המודל העסקי של תעשיית הגז: "מכור אנרגיה ולא נורות".

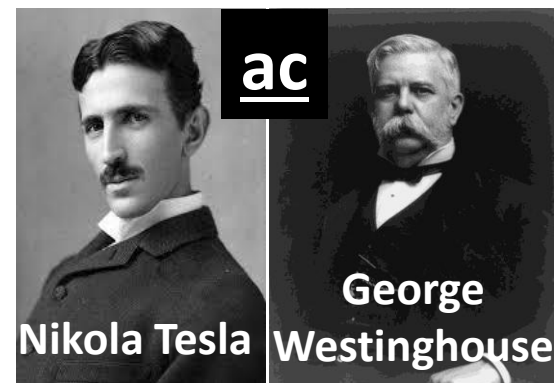




# עוברים מ- dc ל- ac

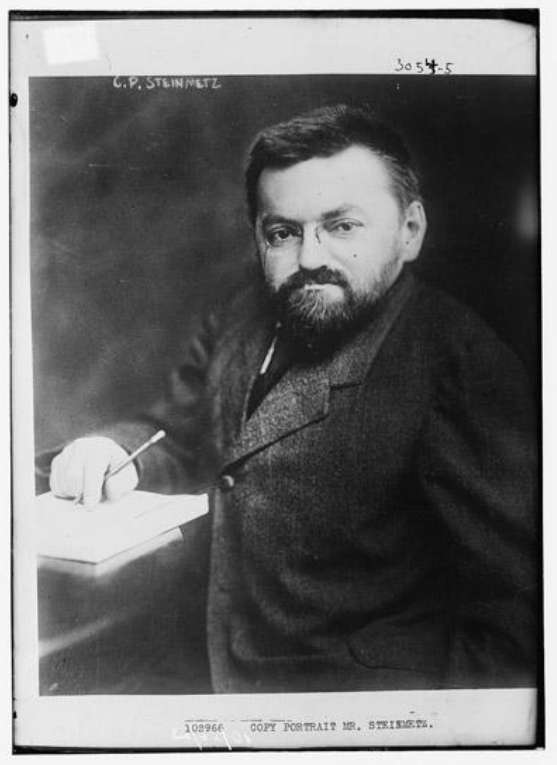


## The War of the Currents



# עוברים מ- dc ל- ac

## Charles Proteus Steinmetz The Wizard of Schenectady



To: Mr. Henri Ford  
River Rouge Electric Plant  
Dearborn.  
From: Charles P. Steinmetz

### INVOICE

Making chalk mark on generator	\$1.
Knowing where to make mark	\$9,999.

Total: \$ 10,000



# האם הטכנולוגיה צריכה מדע?

## חוקי האלקטרומגנטיות

### משוואות מכסוול

1864

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0} \quad \bullet \text{חוק קולומב}$$

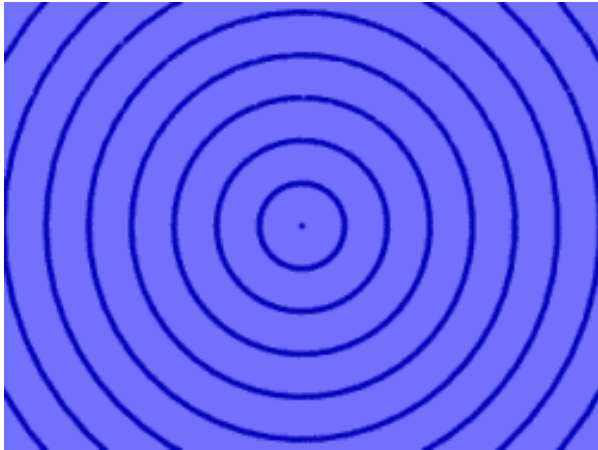
$$\nabla \cdot \mathbf{B} = 0 \quad \bullet \text{המגנט הוא דו קוטב}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \quad \bullet \text{חוק פאראדי}$$

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} \quad \bullet \text{חוק אמפר}$$



# האם הטכנולוגיה צריכה מדע?



## משוואות מכסוול

1864

$$\nabla \times \mathbf{B} = \mu_o \left( \mathbf{J} + \epsilon_o \frac{\partial \mathbf{E}}{\partial t} \right)$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_o \mathbf{J}$$

$$\nabla \times \mathbf{B} = 0$$

$$\nabla \times \mathbf{B} = \mu_o \epsilon_o \frac{\partial \mathbf{E}}{\partial t}$$

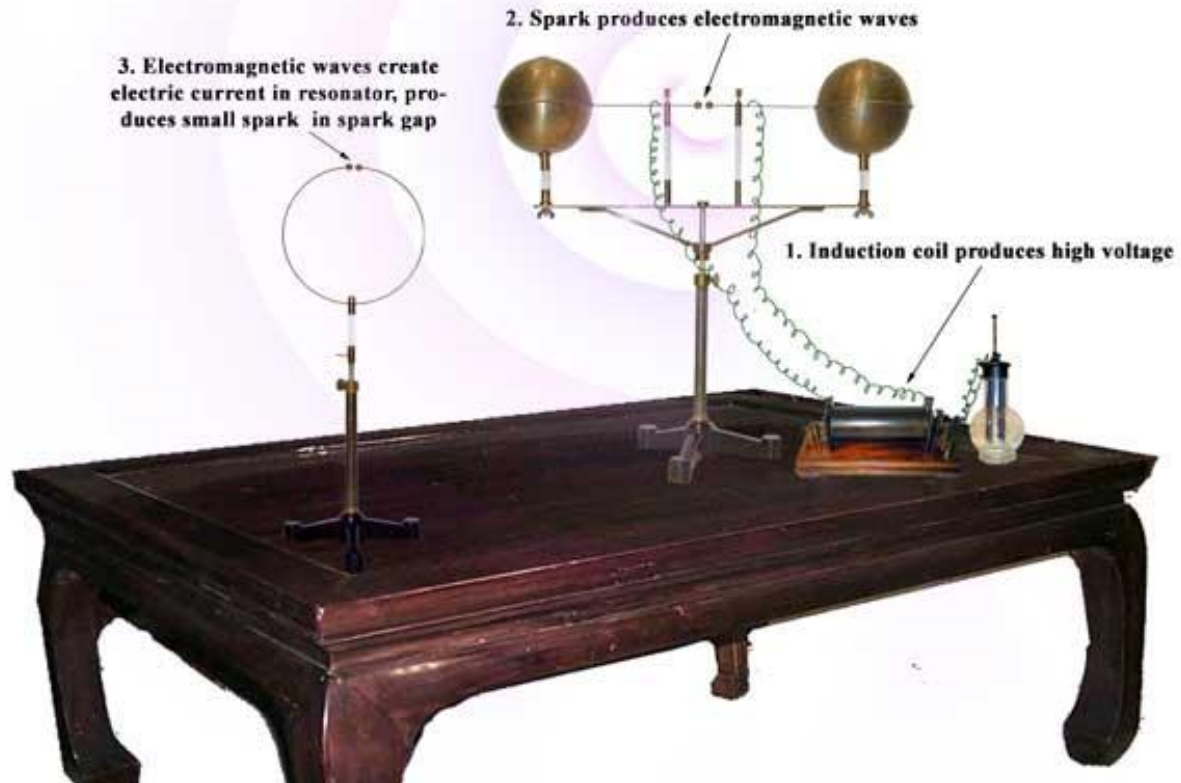
$$\nabla \times \nabla \times \mathbf{E} = -\mu_o \epsilon_o \frac{\partial^2 \mathbf{E}}{\partial t^2}$$

## משוואת הגלים

# Heinrich Hertz and the **Experimental Proof of** Concept of Electromagnetic Waves



1885 - 1890



# And the rest is history . . .

Guglielmo Marconi

1894



Alexander Stepanovich

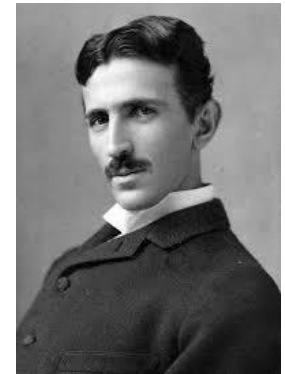
Popov

1895



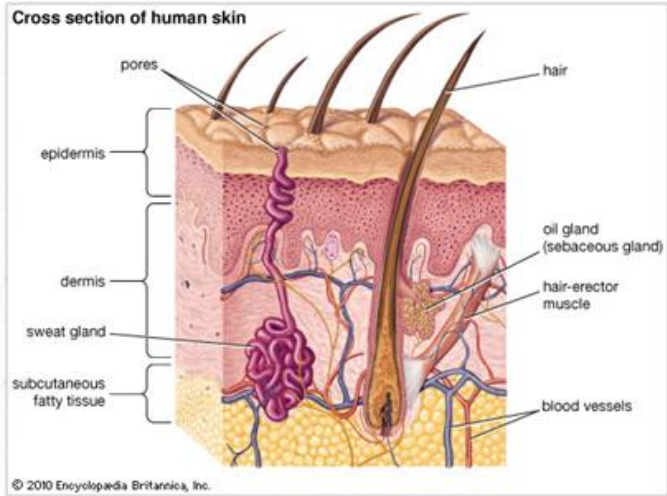
Nikola Tesla

1893

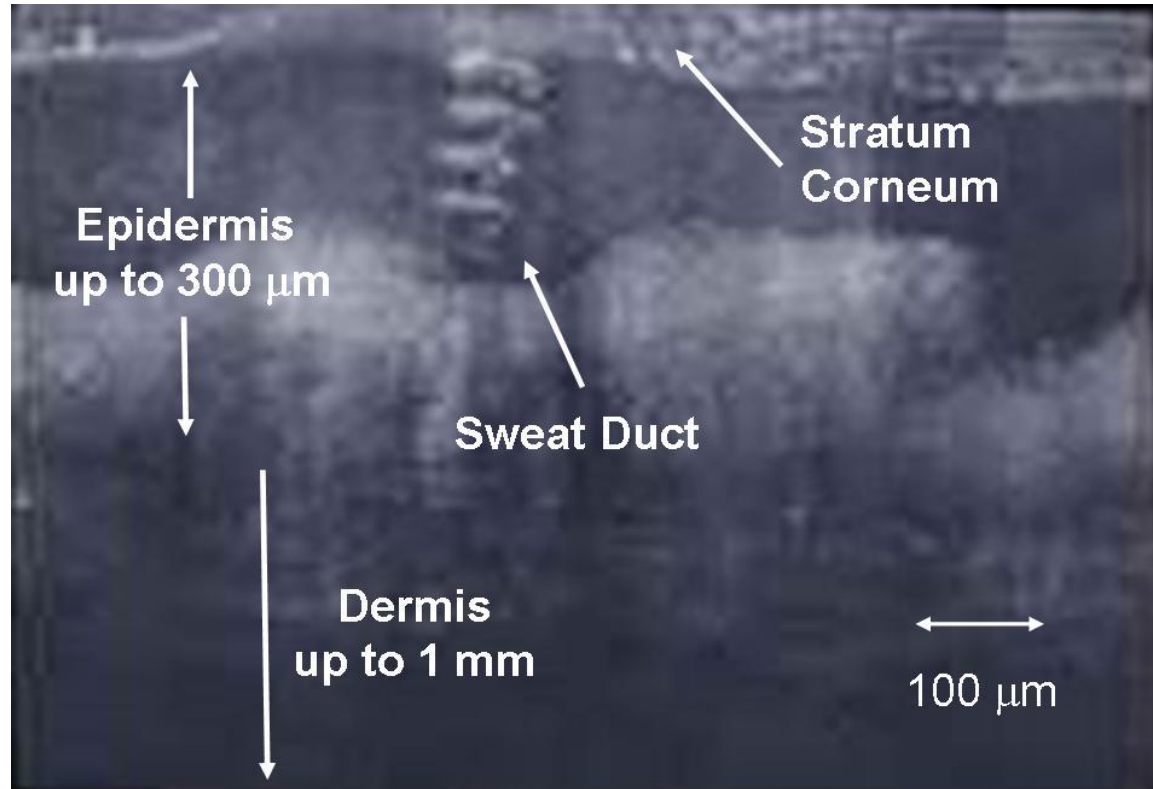


# 125 Years later

## SKINRAD

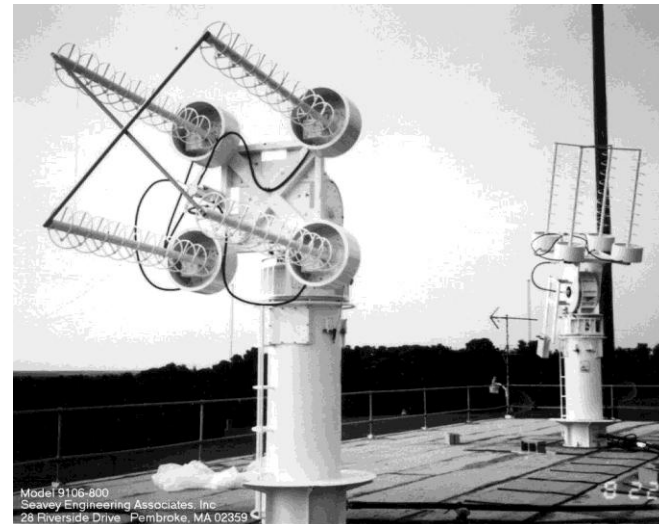
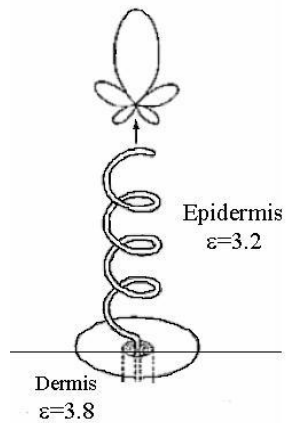
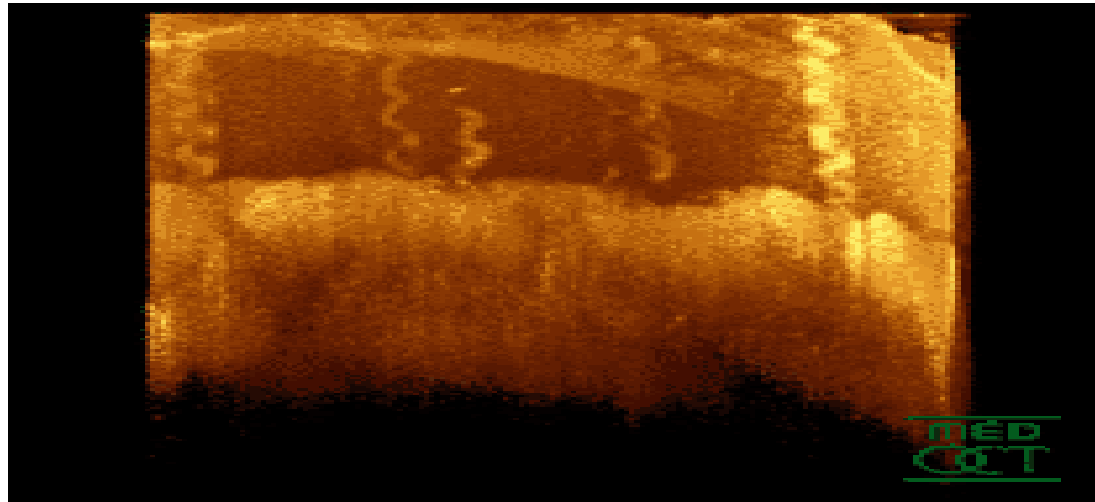


פרופ' יורי פלדמן  
ד"ר פול בן ישי  
ד"ר אלכסנדר פוז'נקו  
פרופ' אהרון אגרונט



# 125 Years later

## SKINRAD





# Far field Measurements (FFM)



The skin reflectance is presented in terms of its **frequency average relative signal intensity** given by

$$\langle W_{rel} \rangle_f = \frac{1}{f_2 - f_1} \int_{f_1}^{f_2} \frac{|U_{subject}(f)|^2}{|U_{reference}(f)|^2} df$$

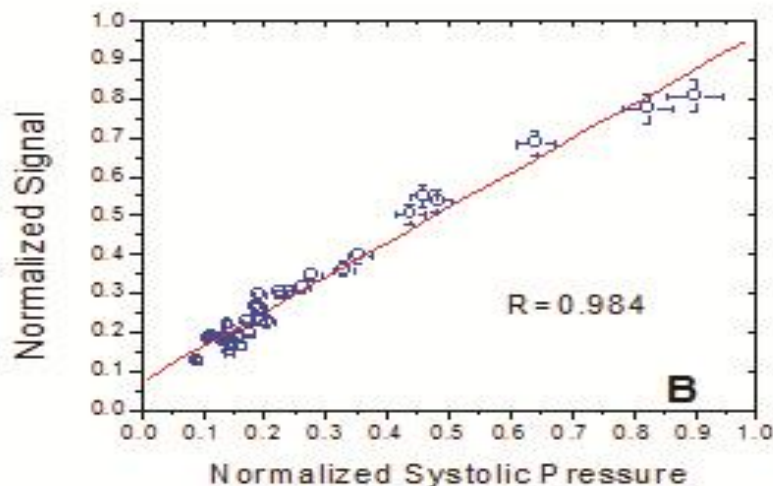
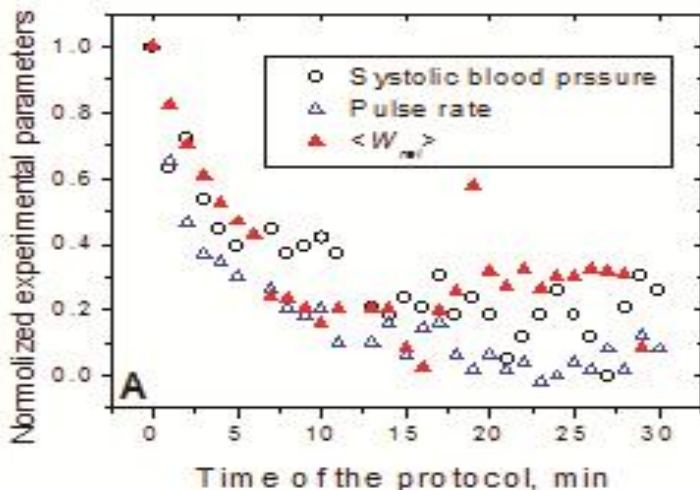
where  $U_{subject}(f)$  is the reflected signal from the subject,  $U_{reference}(f)$  is the reflected signal measured in the open ended setup,  $f_1=75\text{GHz}$ , and  $f_2=110\text{GHz}$ .

# Ensemble Averages of a Group of 13 Subjects

The intensities and blood pressures were normalized over their amplitudes to allow averaging and the correlation coefficient

$$r = \left( \sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y}) \right) / \left( \sqrt{\sum_{i=1}^n (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^n (y_i - \bar{y})^2} \right)$$

was calculated from linear regression. The value  $r=0.984$ , close to unity, demonstrates a strong correlation between them. Essentially they exhibit similar temporal behaviour. The correlation of  $\langle W_{rel} \rangle$  with the pulse rate is  $r = 0.85$ .



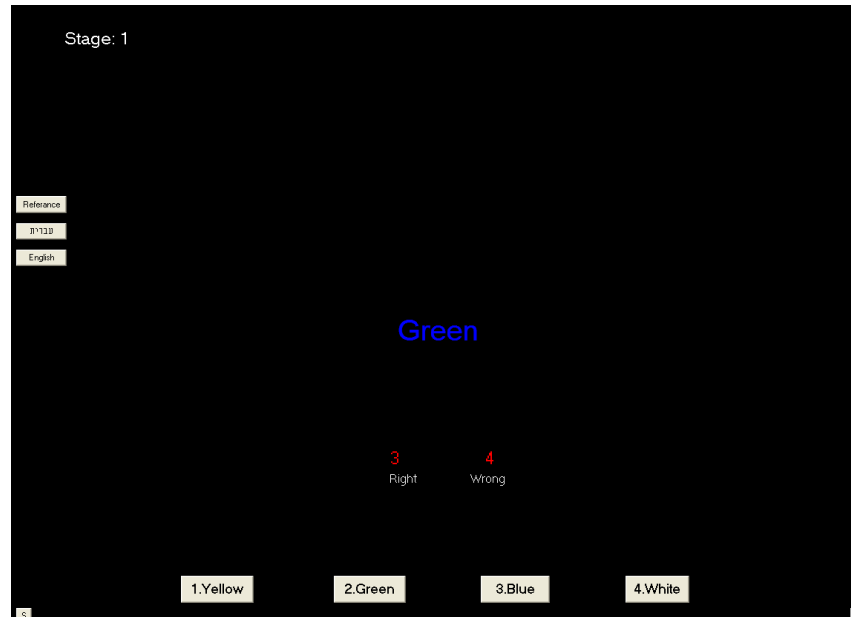
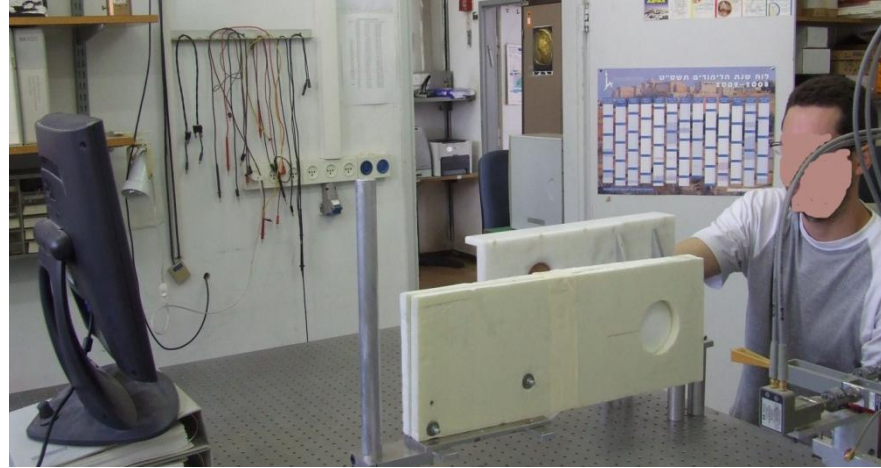
# Color Word Test

Yellow

red	green	yellow	blue
1	2	3	4

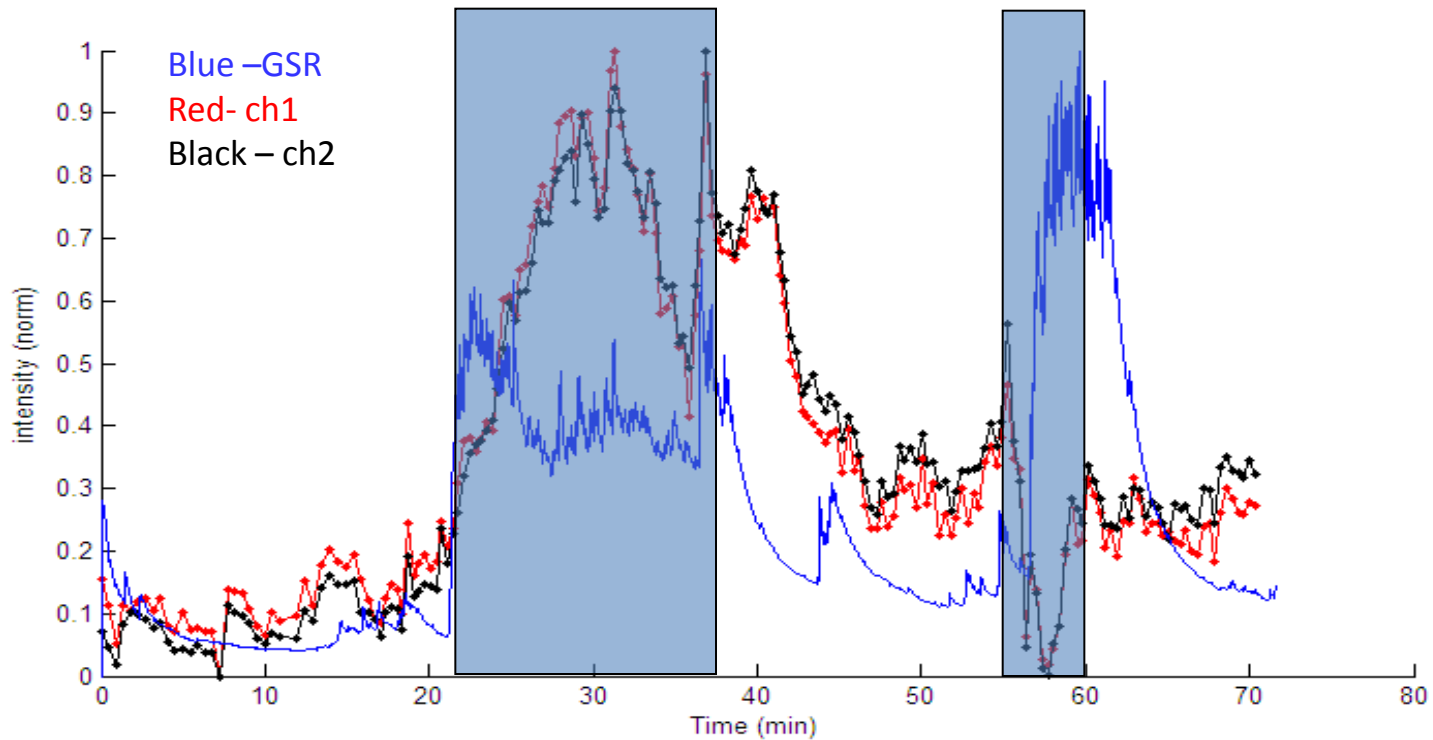
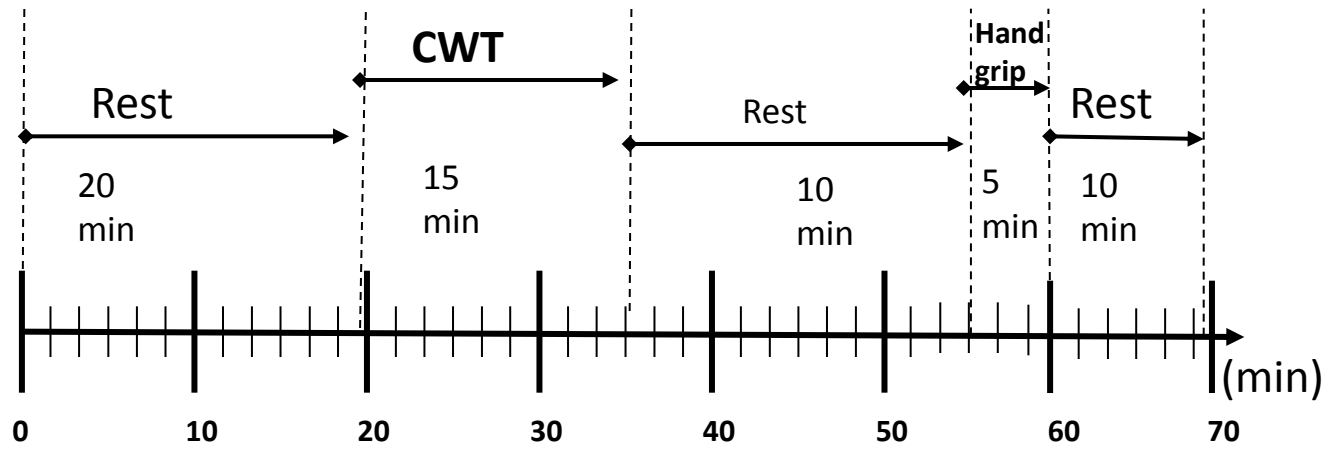


# מדידת לחץ נפשי



D Band  
6.7.09 a

Subject 3



**“The decades-old friendship of computer technology and physics has been an honorable one, and has produced benevolent results”.**



**Joel Birnbaum**

***Joel Birnbaum  
Former HP Chief Scientist***

***In a speech delivered at the American  
Physical Society's 1999 Centennial  
Conference.***



# Chance Favors the Prepared Mind! (Louis Pasteur)

## Alexander Fleming and the discovery of Penicillin

"When I woke up just after dawn on September 28, **1928**, I certainly didn't plan to revolutionize all medicine by discovering the world's first antibiotic, or bacteria killer, But I suppose that was exactly what I did."



### Mass Production

**1940:** Howard Florey and Ernst Boris Chain in Oxford

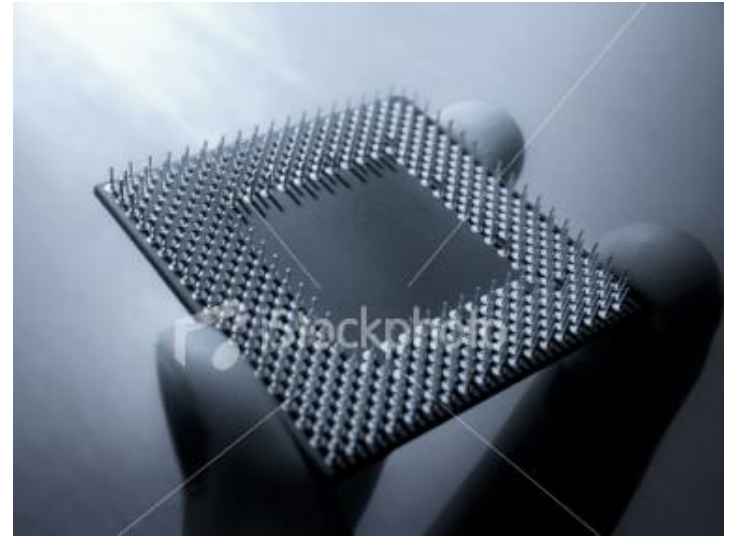
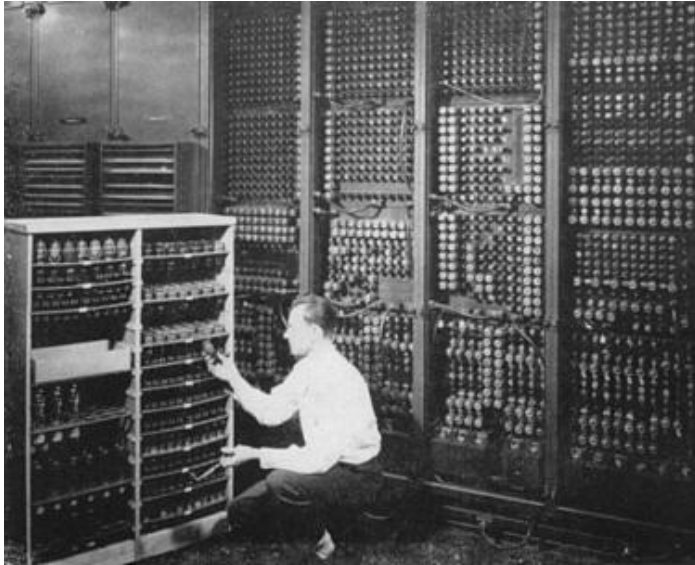
Enough Penicillin to treat 1-5 patients.

**1944:** 1.5 Million units ready to be used by Allied Forces in Europe.

# המיקרוואלקטרוניקה: תהליך הייצור האולטימטיבי





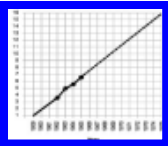
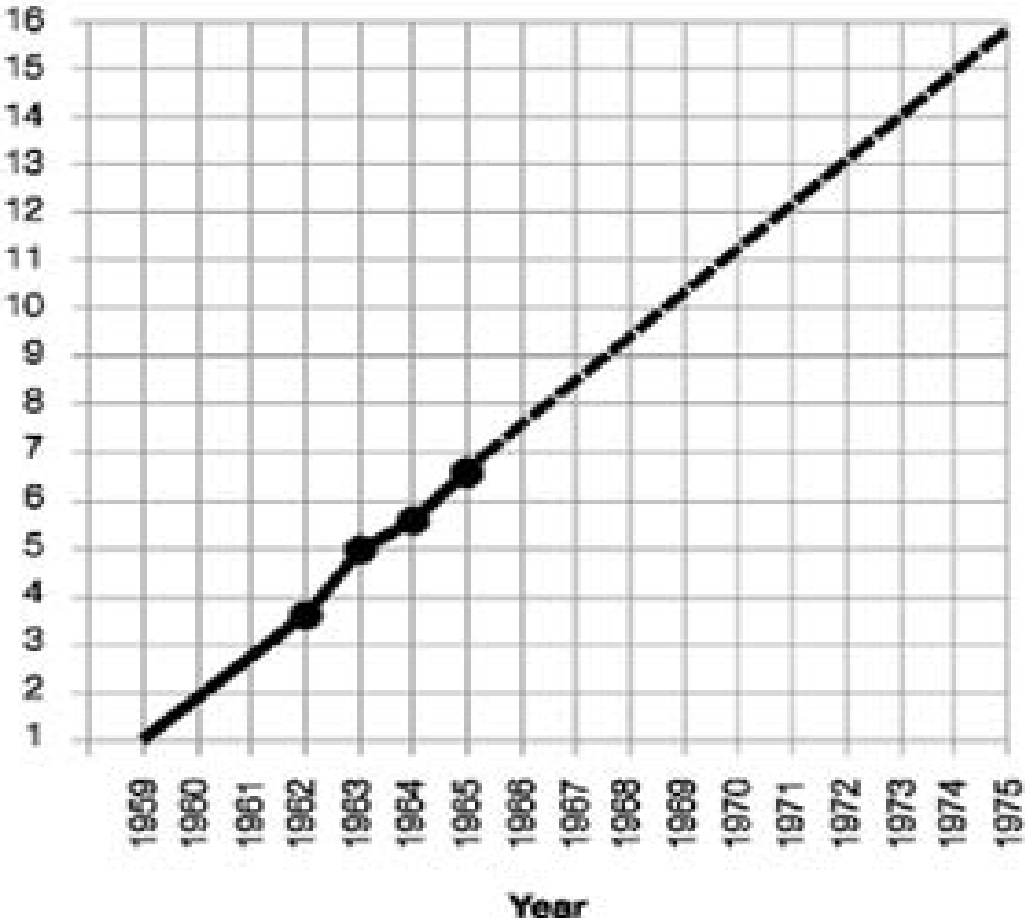


**ENIAC: The first Digital  
Computer**  
**(Electronic Numerical  
Integrator and Computer)**

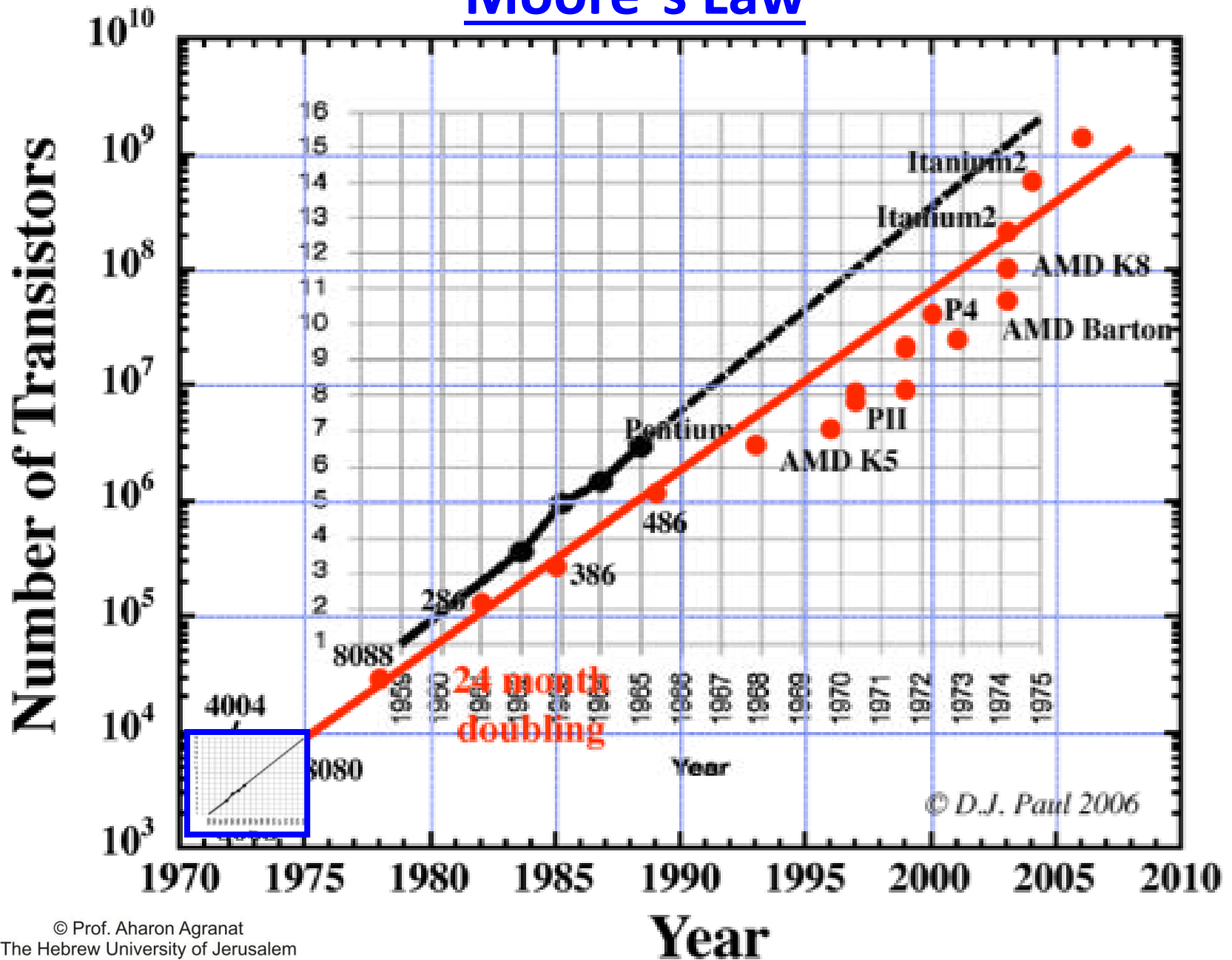
**The Pentium Processor**



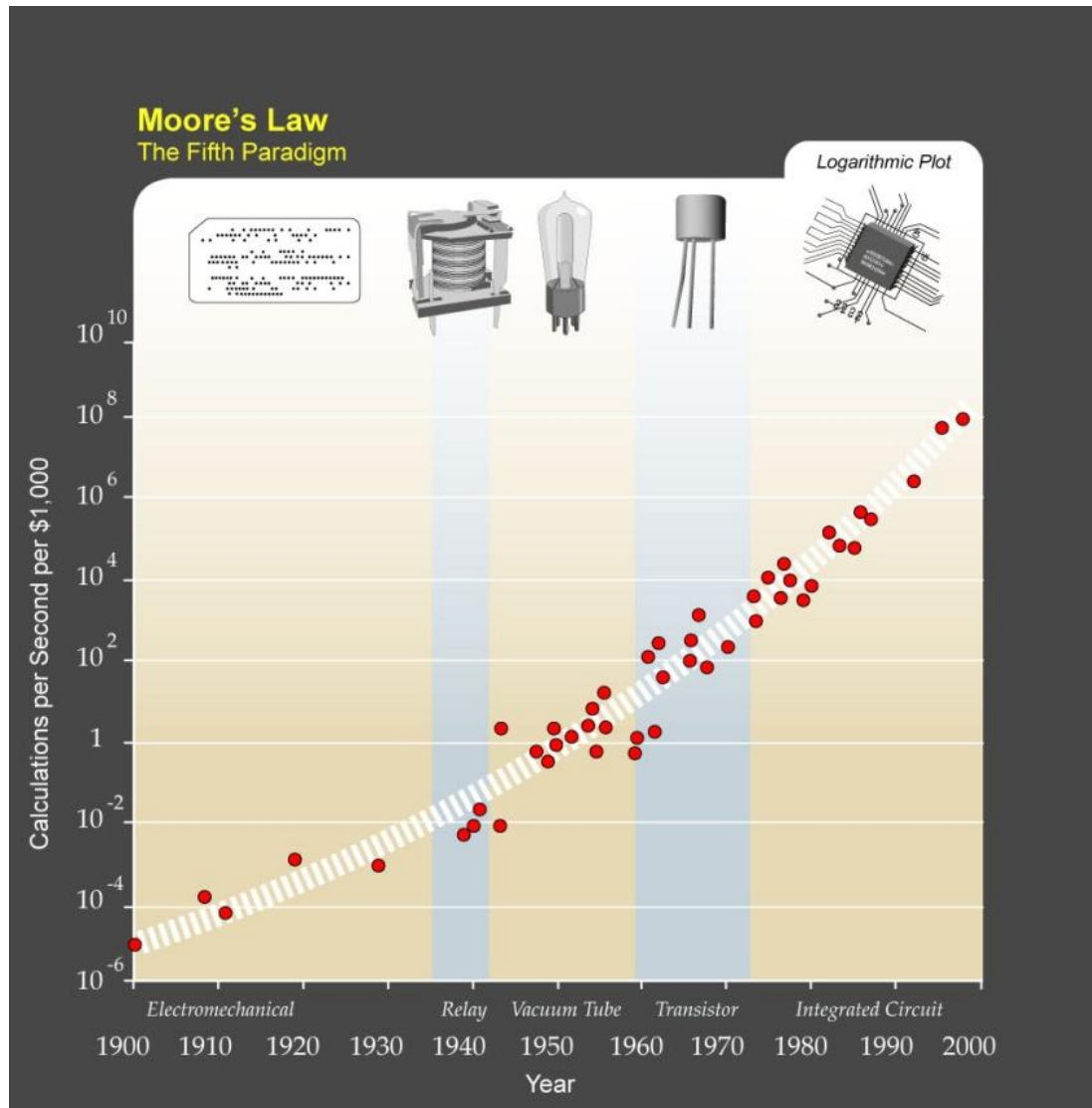
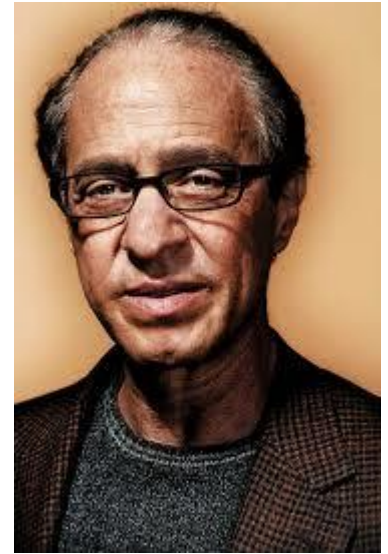
# Moore's Law



# Moore's Law



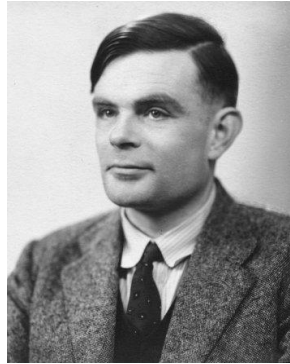
# Moore's Law: Ray Kurzweil Version



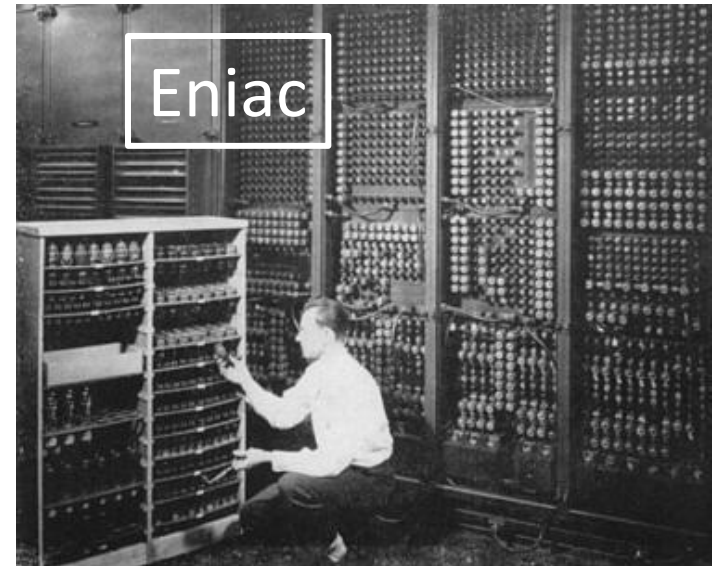
# How it was done?



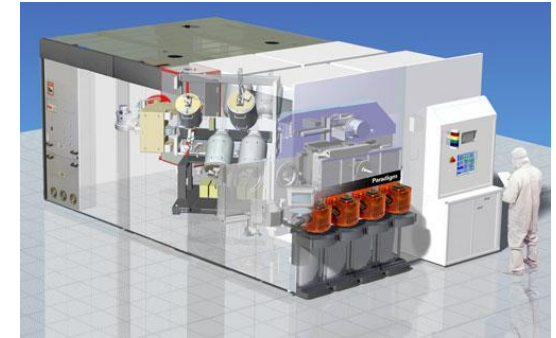
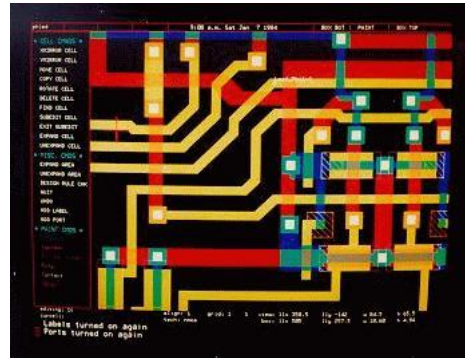
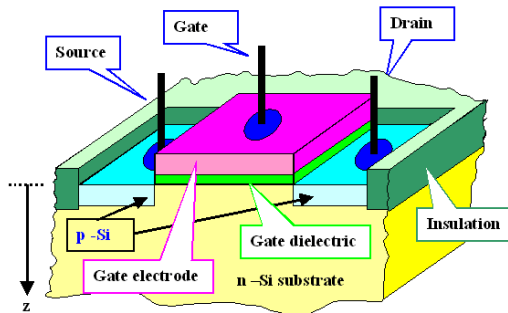
## Why Computers where not developed in England? After all they had Alan Turing . . .



Alan Turing “Baby” Computer 1949



# The Essential Elements for Silicon Based VLSI Circuits



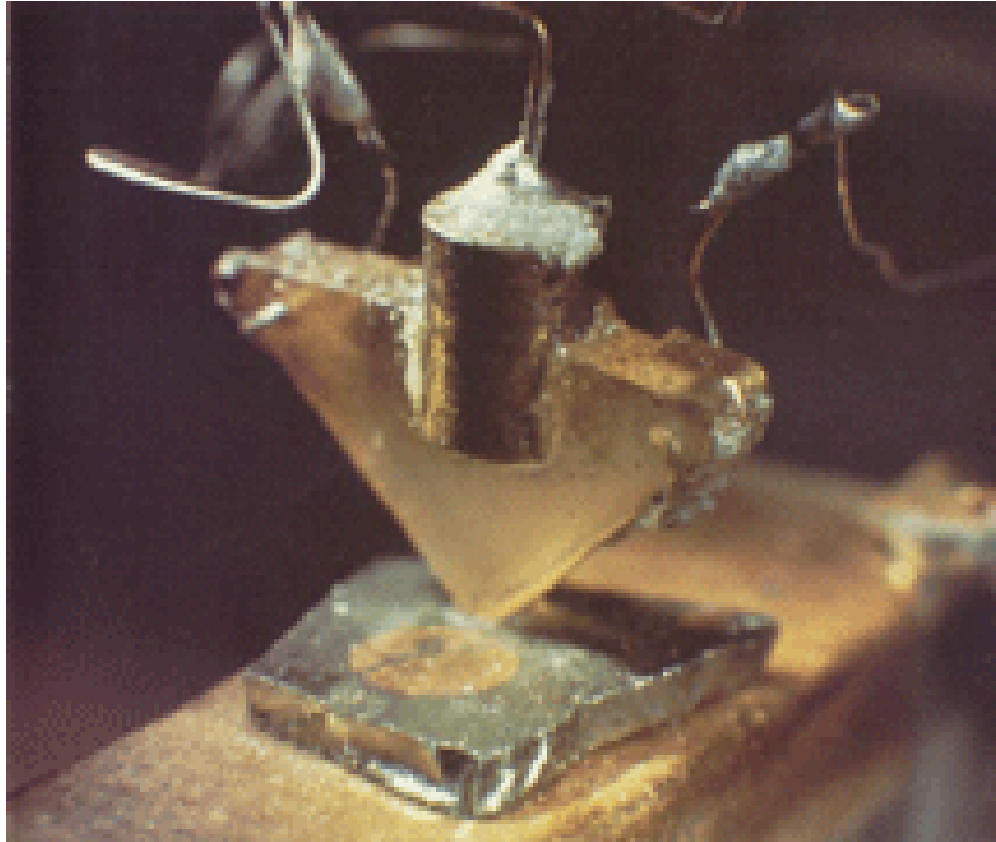
Constructing the entire set of the building blocks by a unified **device physics methodology.**

Designing the entire circuit by **CAD** tools that implement the electronic engineering while complying with device physics constraints of the fabrication process.

Importing the fabrication methodology of **chemical engineering.**

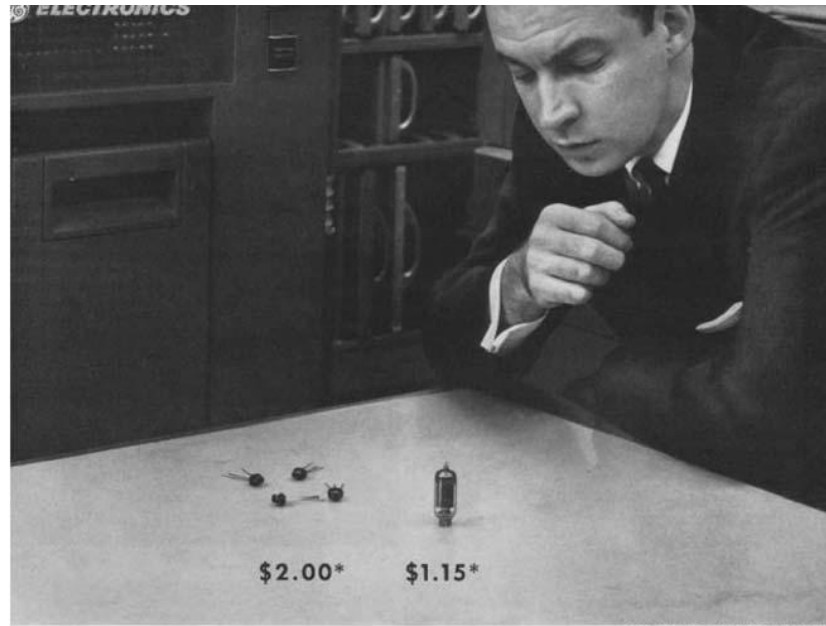


## The First Transistor





# Vacuum Tube vs. the Transistor



\$2.00\*

\$1.15\*

TYPICAL COST TO EQUIPMENT MANUFACTURER

## Must you pay the high price of miniaturization?

**If you're in the market for an electronic computer or other electronic equipment, ask yourself this question: "Do I really need portability and ultimate compactness?" If you don't, why pay for them? A small reduction in computer size can boost your initial cost as much as 100%.**

In a typical computer application, one electron tube, costing \$1.15, performs the same functions as 3-5 solid-state devices priced at \$2.00 or more. When you realize the number of components contained in an office-type computer, the high cost of excessive miniaturization is readily apparent. These savings are a direct multiple of the computer size and complexity.

**Electron-tube equipment offers you even more significant savings** from simpler circuitry, proven design, highest overload protection, and uniform operating characteristics over a wide range of temperatures. Field tests show that the over-all reliability of computers powered by electron tubes consistently exceeds the reliability of computers using solid-state devices. This means longer operation between shutdowns, and reduced maintenance costs.

**When maintenance is necessary,** standardized tube characteristics assure that equipment will meet original performance specifications without costly hand selection of replacement components. Down time is held to a minimum by the many convenient electron-tube sources of supply and by the ease of plug-in replacement.

**Before you buy your next electronic equipment,** investigate and compare all the advantages of electron-tube circuitry.

To help you in your evaluation, send for your free copy of the 62-page comparative study, "Electronic Devices and Their Capabilities."

To: General Electric Company, Room 7115A, Receiving Tube Department, Owensboro, Kentucky



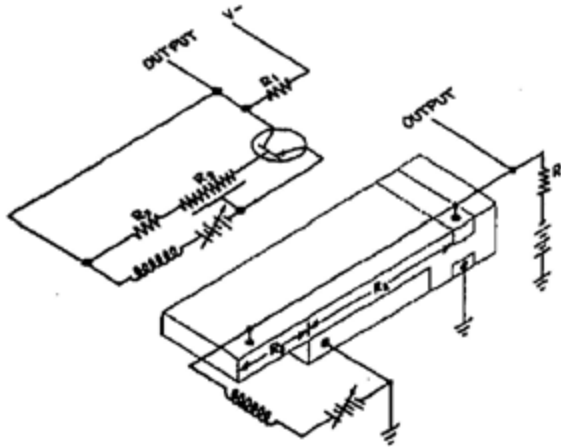
*Progress Is Our Most Important Product*

**GENERAL  ELECTRIC**

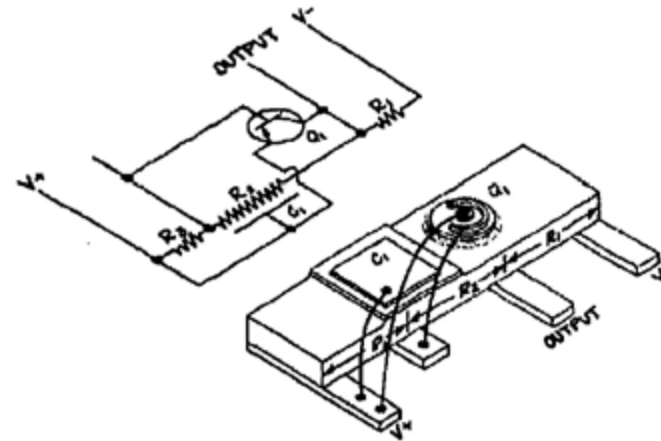


# Integrated Circuits

1953 H. Johnson

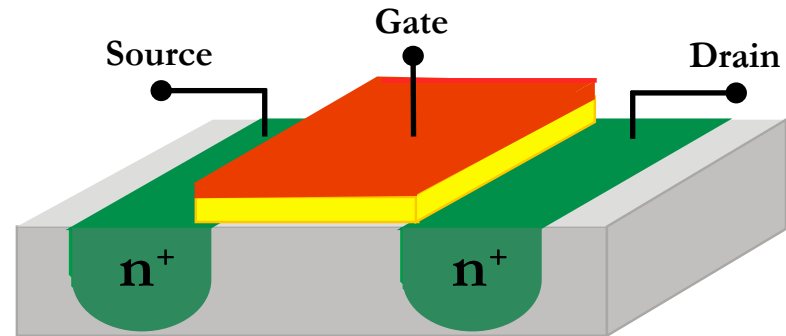
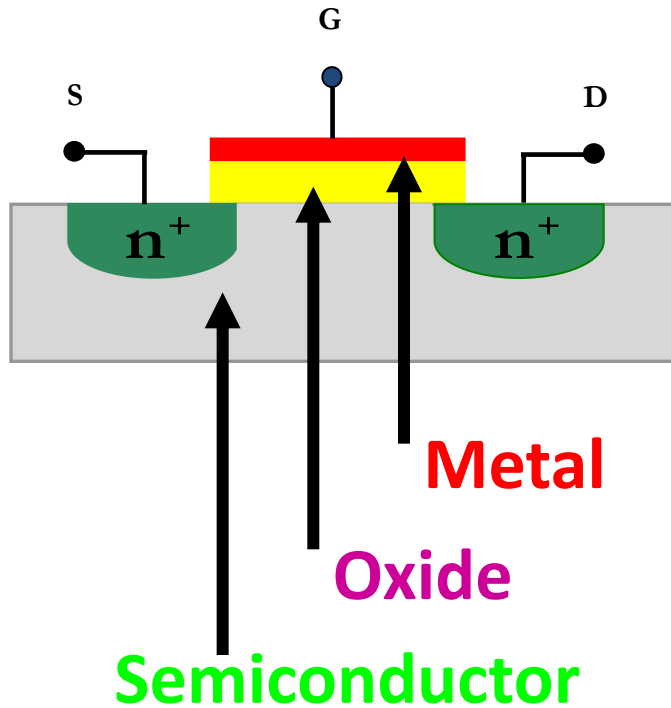
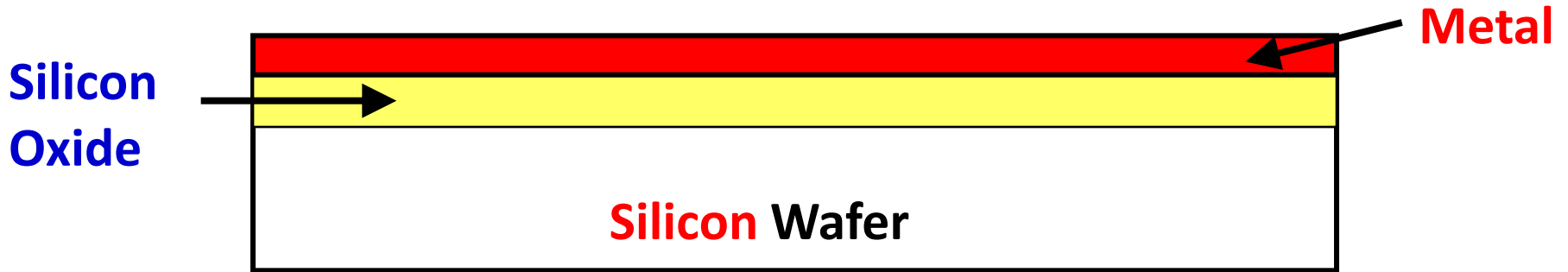


1959 J. Kilby

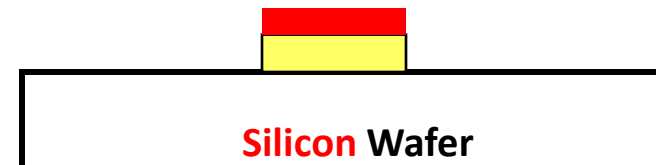
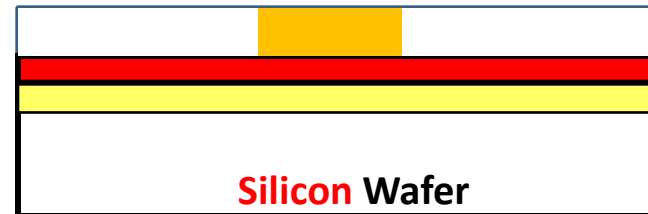
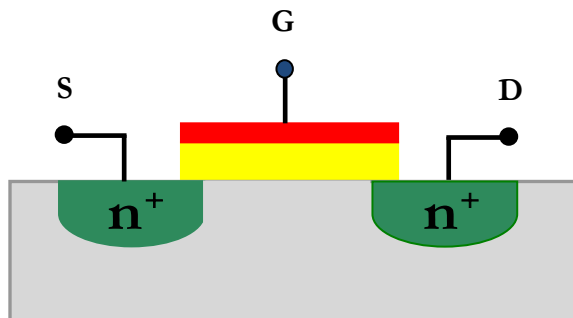
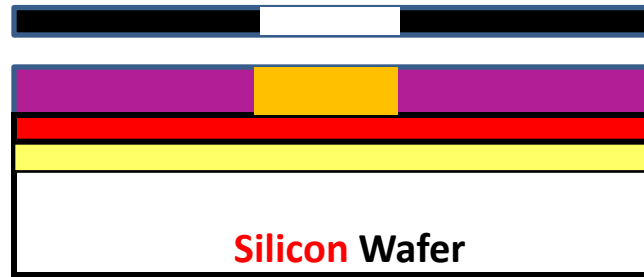
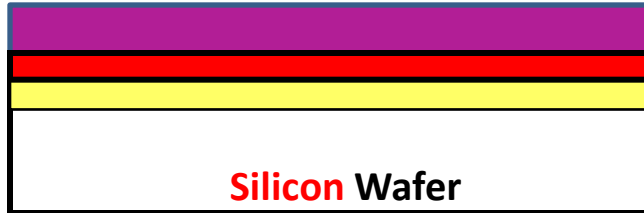


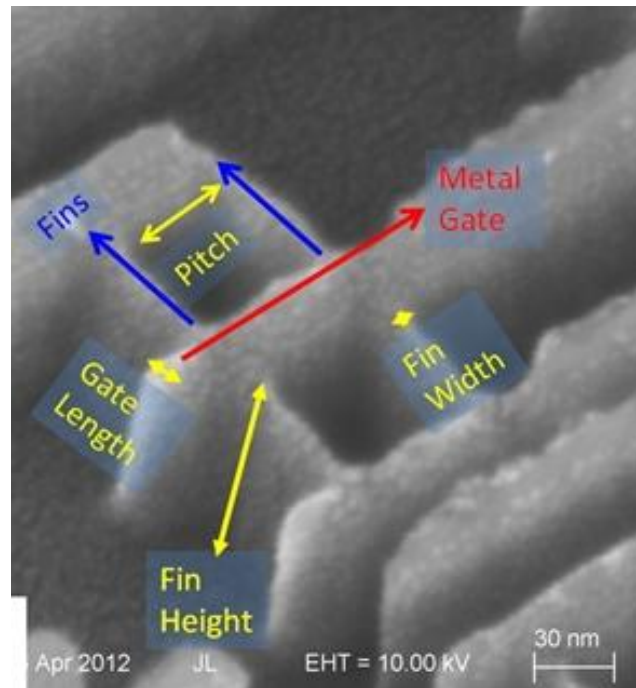
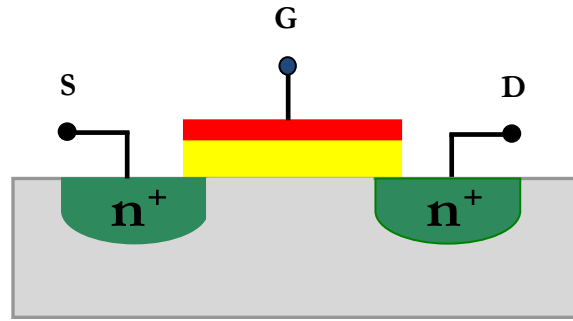
1958-1959  
Robert Noyce, Jean  
Hoerni, Jack Kilby  
and Kurt Lehovec  
all took part in de-  
veloping the inte-  
grated circuit.

# MOS Technology

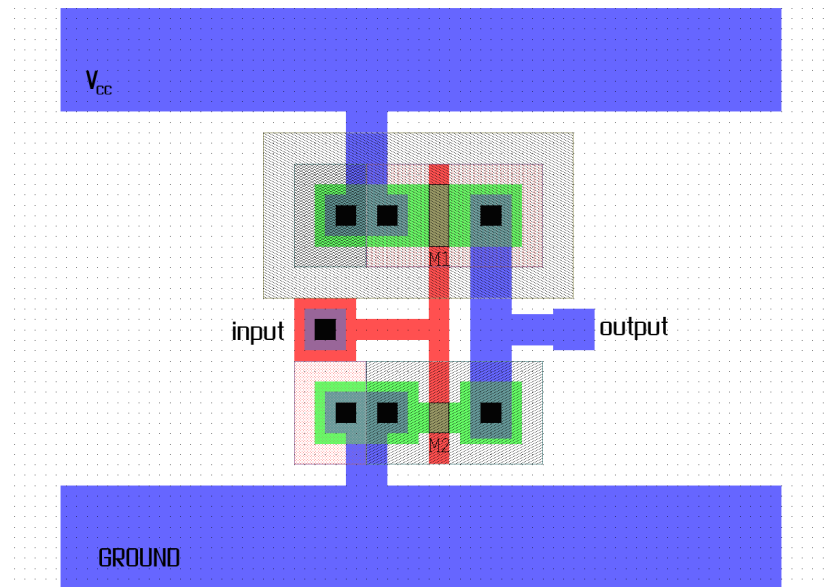
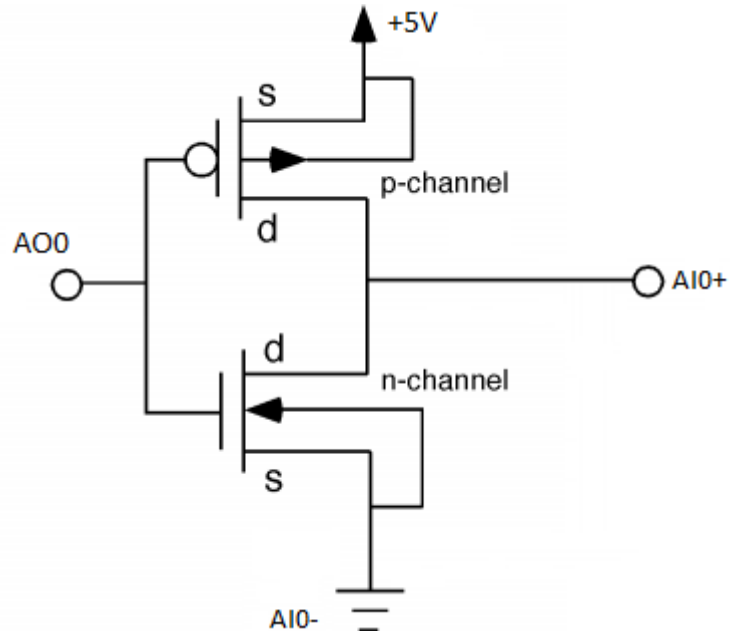
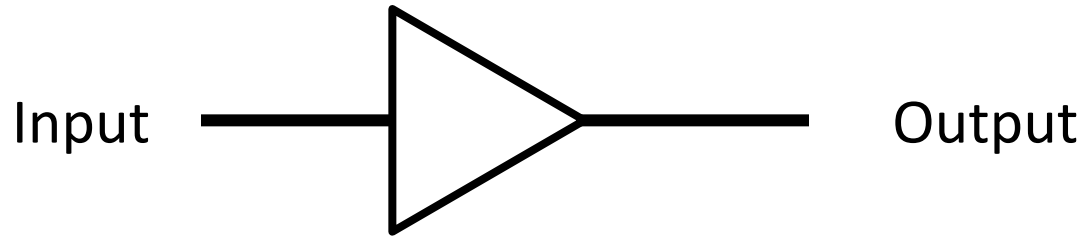


# From Silicon Wafer to Transistor

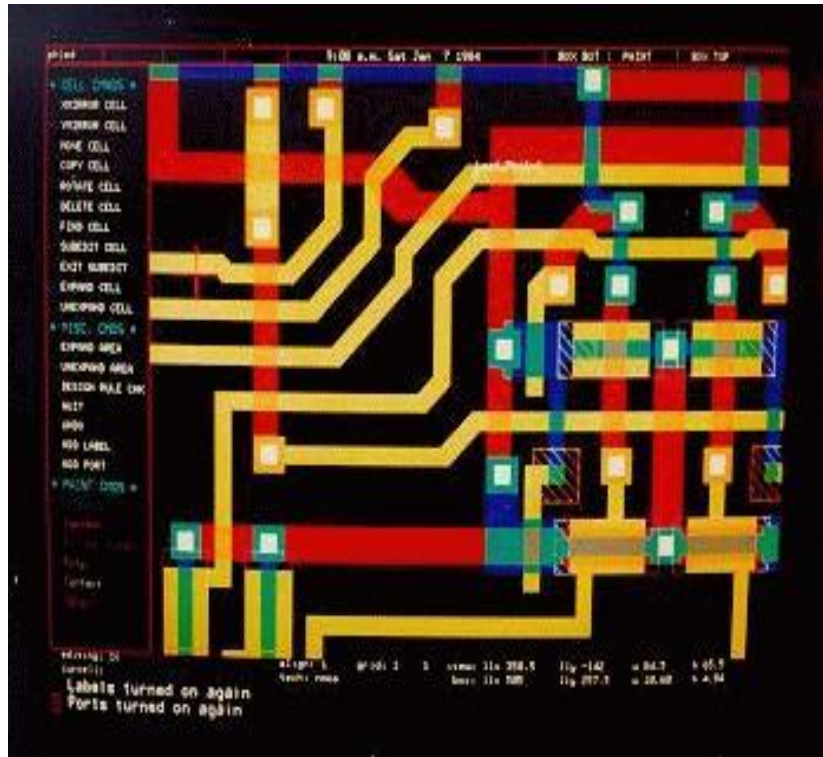




# Inverter



# Very Large Scale Integration (VLSI) Design Methodology



Carver Mead  
CALTECH

Designing the entire circuit by CAD tools  
that implement the electronic engineering  
while complying with device physics  
constraints of the fabrication process.

# Fabrication Methodology



Importing the fabrication methodology of chemical engineering.





# הנדסה במאה ה-21



# "תחנת" האינטרנט בעבר בהווה ובעתיד

כיצד נראית התחנת האינטרנט בעתיד?



# כבר לתחנות האינטרנט היום יש יכולות חישה

•מצלמה

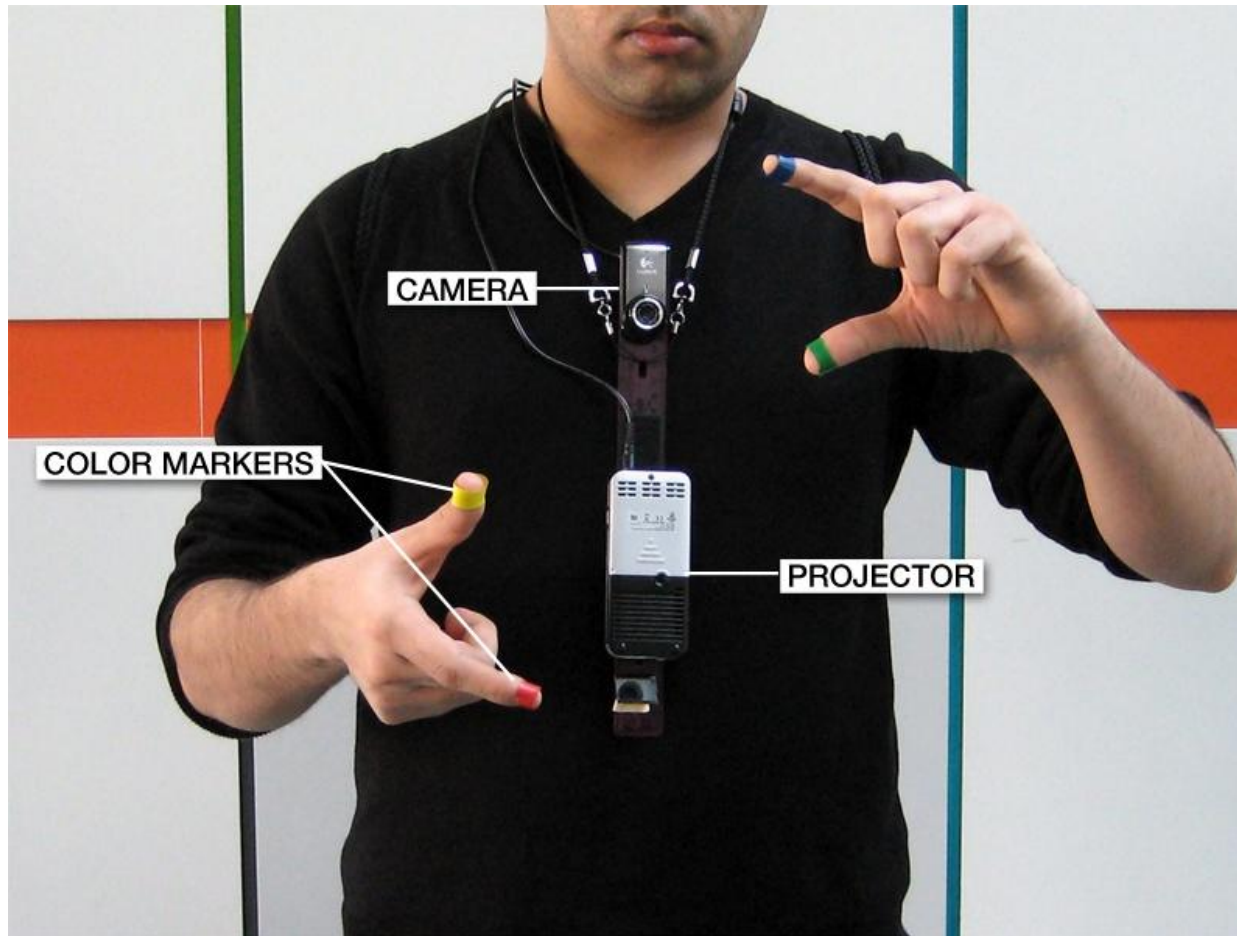
•GPS

כיצד תראה תחנת האינטרנט בעתיד  
הקרוב?



# The SixthSense Project

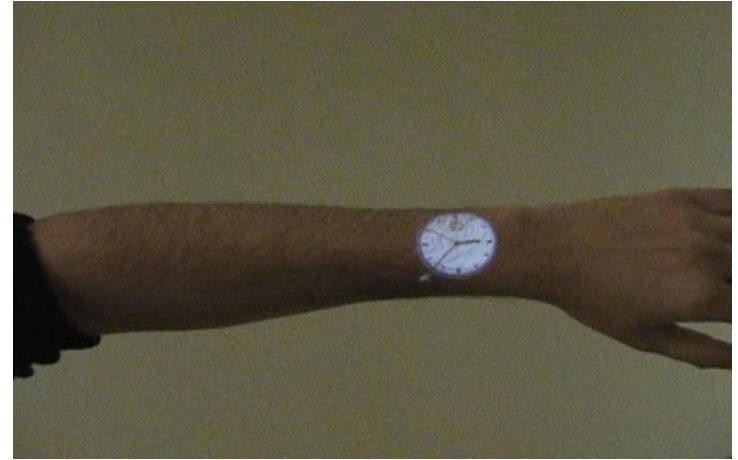
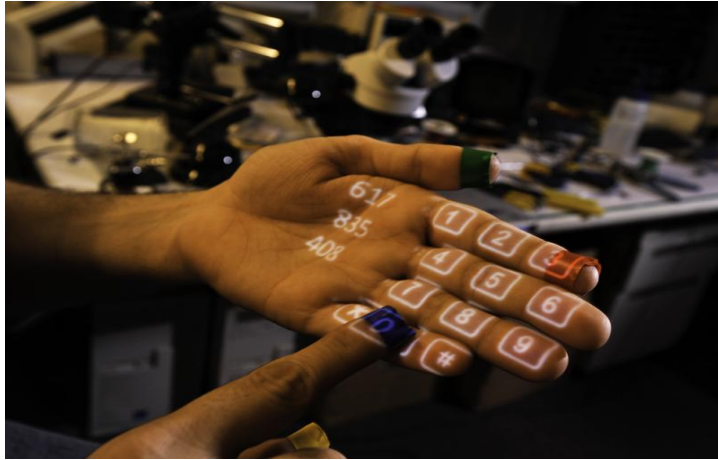
pranav mistry MIT



+ Cellphone + Computer + GPS



# Examples of what this combination can do



# למה בחרו לזה את השם "החוש הששי" ?



# ומה בעתיד היותר רחוק?



# היסודות הבסיסיים של המרחב הקיברנטי

Our Mission Today:  
Merging the  
Cyberspace with the  
Physical World

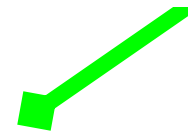
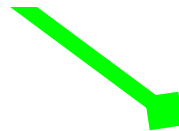
קשורת



מחשבו



חישה





# ומה בעתיד היותר רחוק?

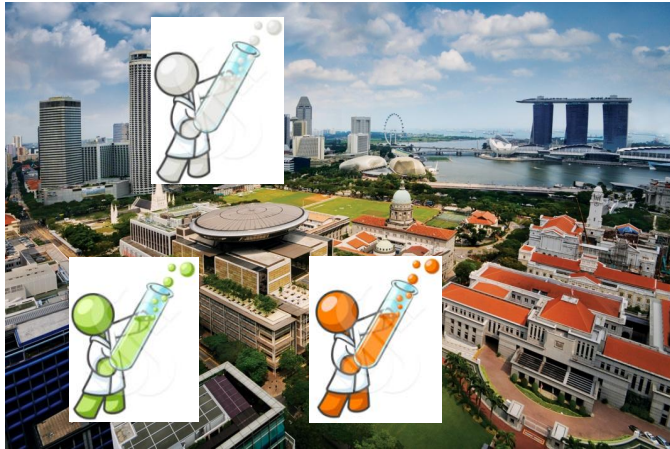
שדרוג יכולות החישה  
(תוך שמירת השילוב עם תקשורת  
וכושר חישוב)



# Urban water systems monitoring

## The way it is done today

Samples are collected from different locations and brought to central analytical lab



### central analytical lab



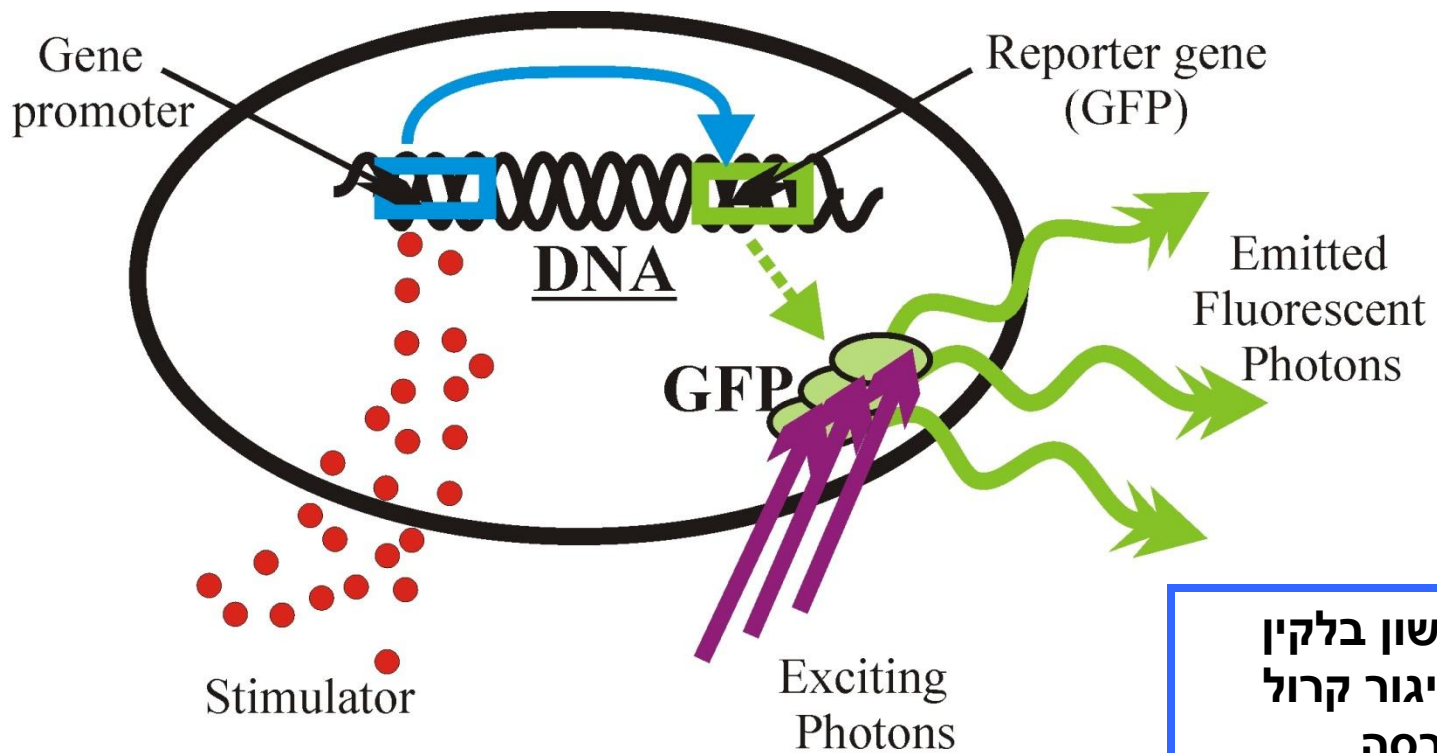
- Expensive.
- Time costly.
- Manpower consuming.

## Why?

Different classes of pollutants are identified by different analytical systems and techniques

# חישה של חומרים כימיים וביולוגיים ע"י שילוב של Hardware ו- "Wetware":

## או: החיידק כחיישן

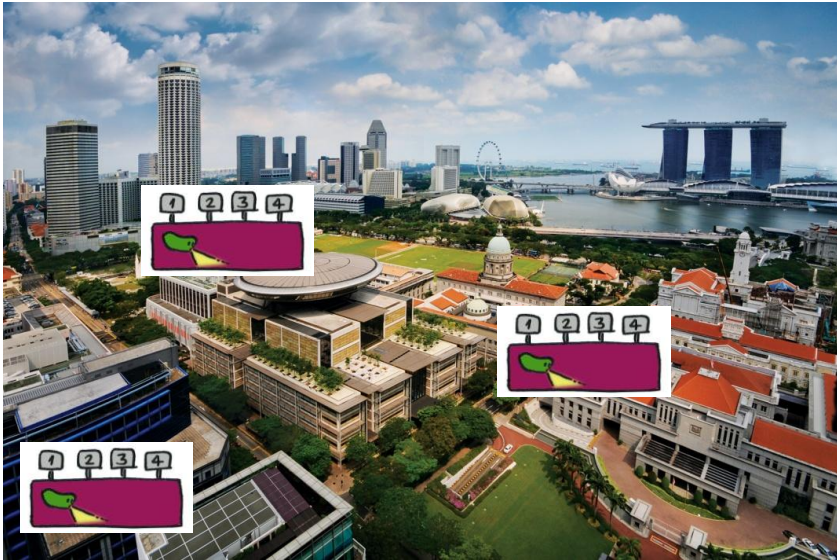


פרופ' שמשון בלקין  
ד"ר שרון יגור קרול  
מר יוסי קבסה  
פרופ' אהרון אגראנט



# Urban water systems monitoring

**Our proposal:** One analytical tool for all potential pollutants is installed at the required locations



## Monitoring & Control center



**How?** The same analytical tool can be used for all different classes of materials.

- **No manpower.**
- **Cost-effective.**
- **Real-time continuous monitoring.**

# System configurations

## Agent in place



Real-time routine monitoring by a grid of bacterial sensors array in pre-selected locations

## Fast deployment force



Mobile deployable ensembles of sensors enabling focused reaction to developing contamination events

## Eyes in the sky



Airborne standoff detection apparatus for large area scanning in water reservoirs or inaccessible locations

## Summary

- Generic concept for cost-effective and comprehensive monitoring of hazardous materials in urban water supply systems
- Various configurations for routine monitoring as well as fast and efficient response to evolving event





US008198606B2

(12) **United States Patent**  
**Agranat et al.**

(10) **Patent No.:** **US 8,198,606 B2**

(45) **Date of Patent:** **Jun. 12, 2012**

(54) **CONCURRENT MONITORING OF A  
PLURALITY OF SAMPLES BY AN ARRAY OF  
BIOSENSING ELEMENTS**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(75) Inventors: **Aharon Agranat**, Mevasseret Zion (IL);  
**Shimshon Belkin**, Kiryat Ono (IL)

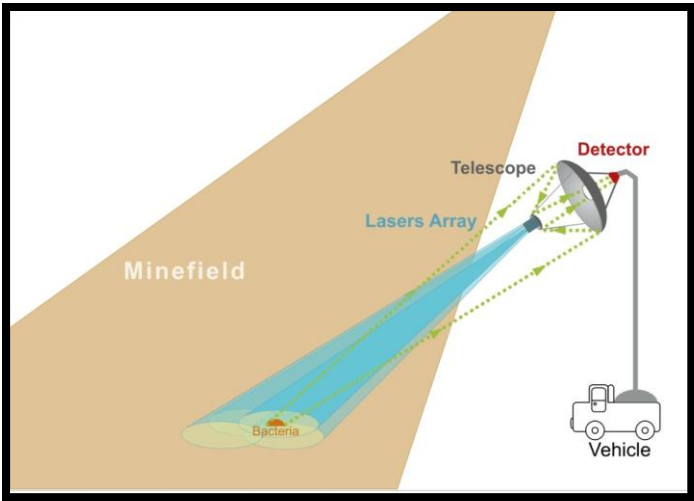
6,304,771 B1	10/2001	Yodh et al.	
6,485,703 B1 *	11/2002	Cote et al. ....	424/9.1
6,485,905 B2 *	11/2002	Hefi .....	435/6.11

## Global Young Scientists Summit Singapore, January 2014

Yossi Kabessa – A Ph.D student in Applied Physics receives 1<sup>st</sup> prize in the GYSS 2014 from the president of Singapore Dr. Tony Tan Keng Yam

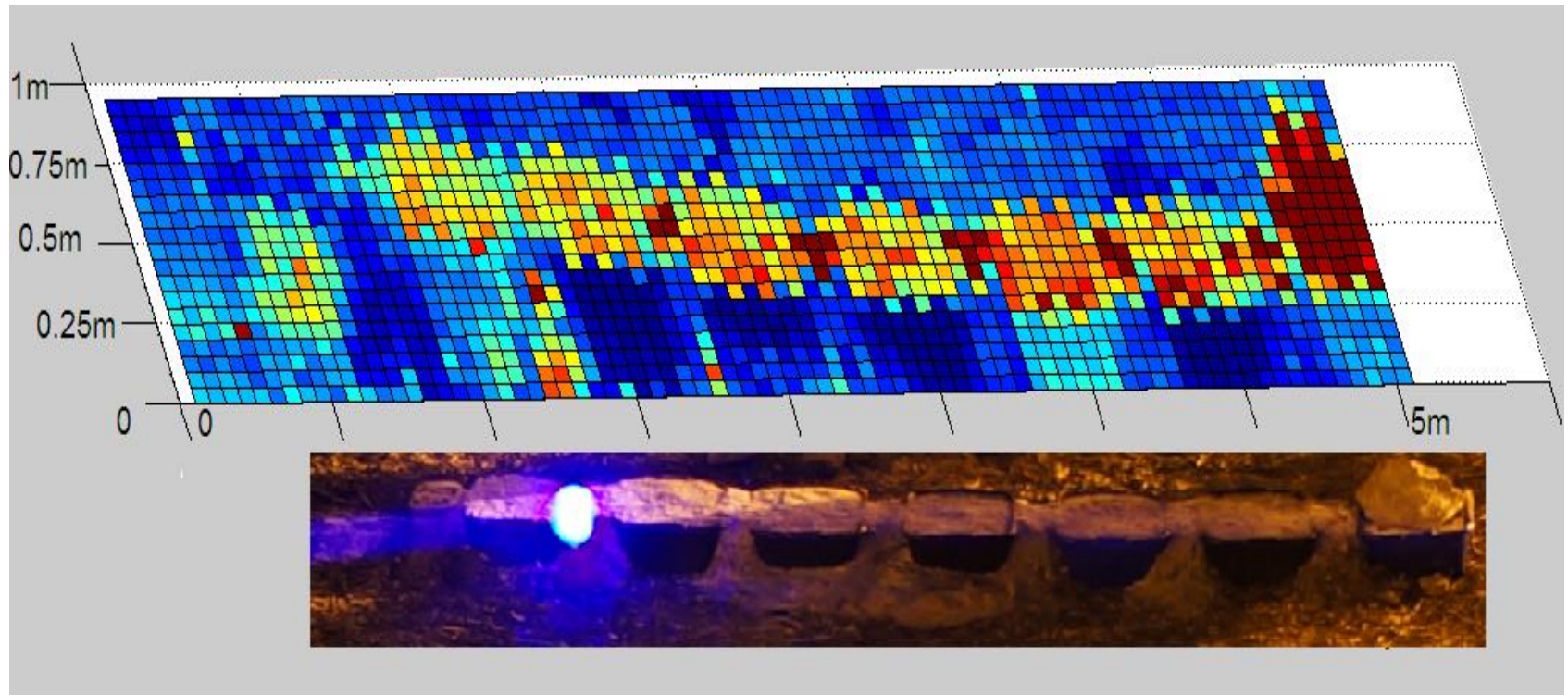


# Standoff Detection



# Standoff Detection

## Results:





# תכנון התקנים לעולם השלישי

## “Design that Matters”

שאלה: מהו ההתקן הרפואי "מציל חיים" בעל ההצלחה הגדולה ביותר?

תשובה: האינקובטור

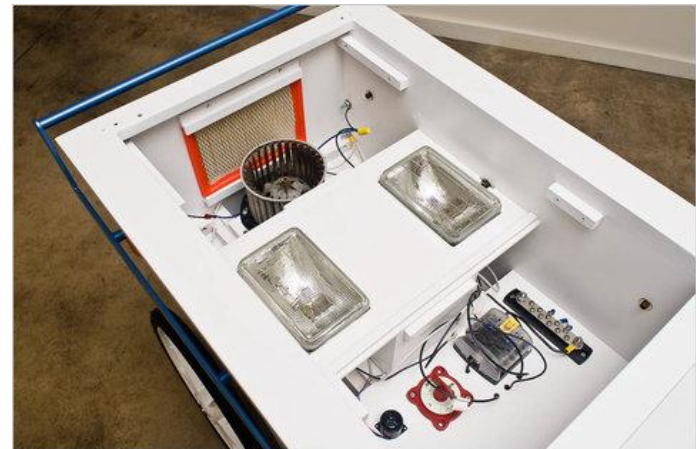
Étienne Stéphane Tarnier

1881



# Design that Matters

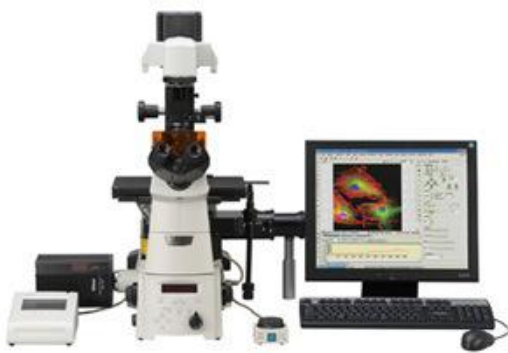
## The NeoNurture Infant Incubator



# SCOPIO

Reinventing microscopy.  
Revolutionizing diagnostics

## The Problem: Blood Count



Manual



Automated

> \$ 150,000

## The Solution:

