Turning Your Smart Phone into a Tricorder

Jie Chen, Ph.D. Professional Engineer

Lava University on Nov 6, 2015

Research Officer, National Institute of Nanotechnology, Canada

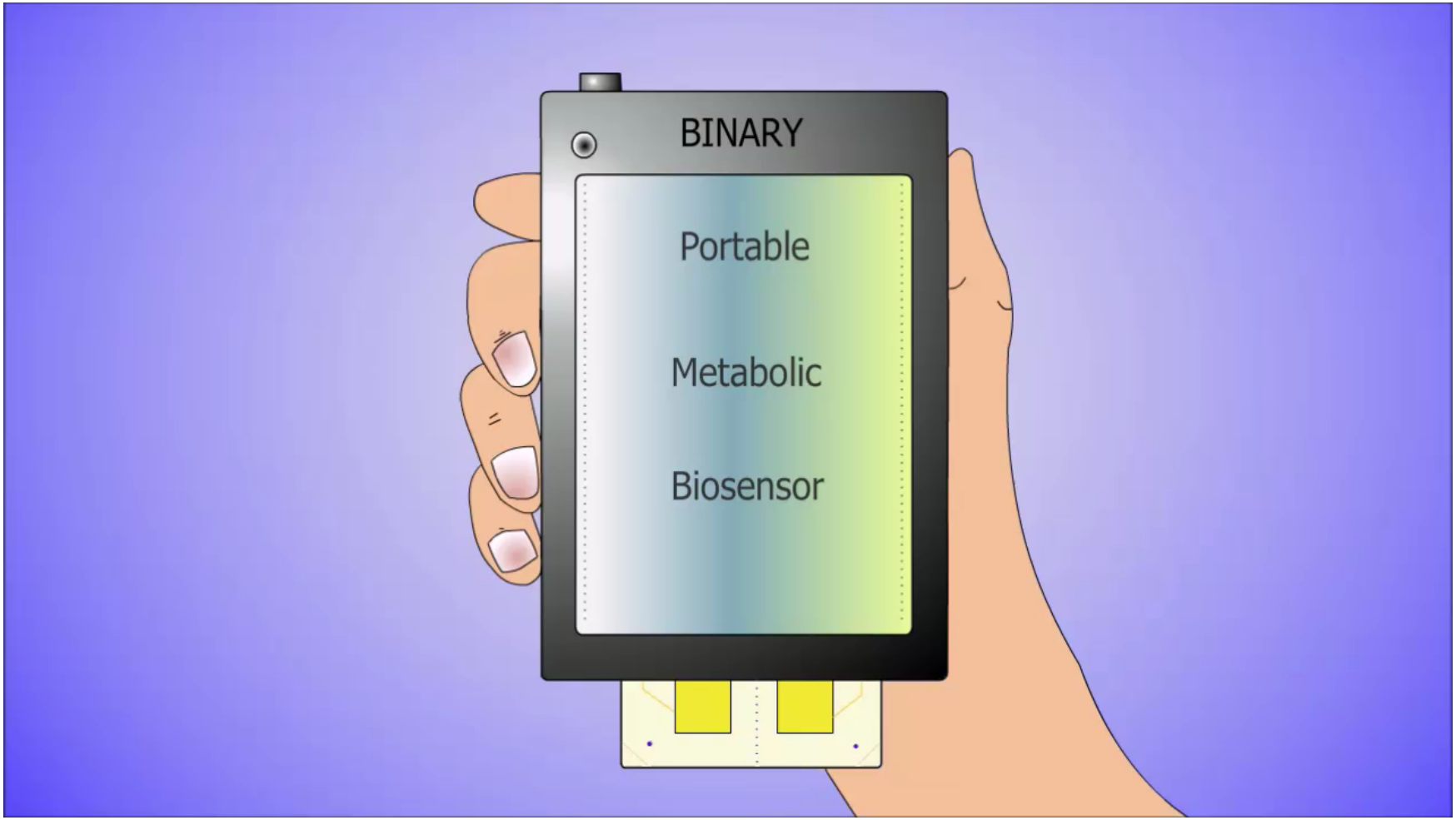
Professor, Faculty of Engineering, University of Alberta, Canada

National Institute
for Nanotechnology

UNIVERSITY OF
ALBERTA

1. **Background**
2. **Turning Your Smart Phone into a Tricorder**
3. **Tricoder Applications**
4. **Conclusion**

Turning Your Smart Phone into a Tricorder



Disease Burden in Canada

Disease	Number of new cases per year	Number (%) of Canadian living with disease	Cost of treatment (million $)
Alzheimer	60,000	280,000 (0.74%)	$431
Parkinson	5,500	100,000 (0.31%)	$201
Stroke	50,000	300,000 (1%)	$665
Heart Disease	1,200,000	16,000,000 (5%)	$6,818
Asthma	138,000	2,744,000 (8%)	$705
Atherosclerosis	112,000	544,000 (1.7%)	$19,800
Schizophrenia	10,240	259,200 (0.81%)	$1,637
Lung Cancer	25,600	39,884 (0.12%)	$163
Prostate Cancer	25,500	150,135 (0.47%)	$1,033
Breast Cancer	23,590	153,777 (0.48%)	$1,161

Healthcare Mandates

- **Diagnostic**

  Do you have a given disease/condition?

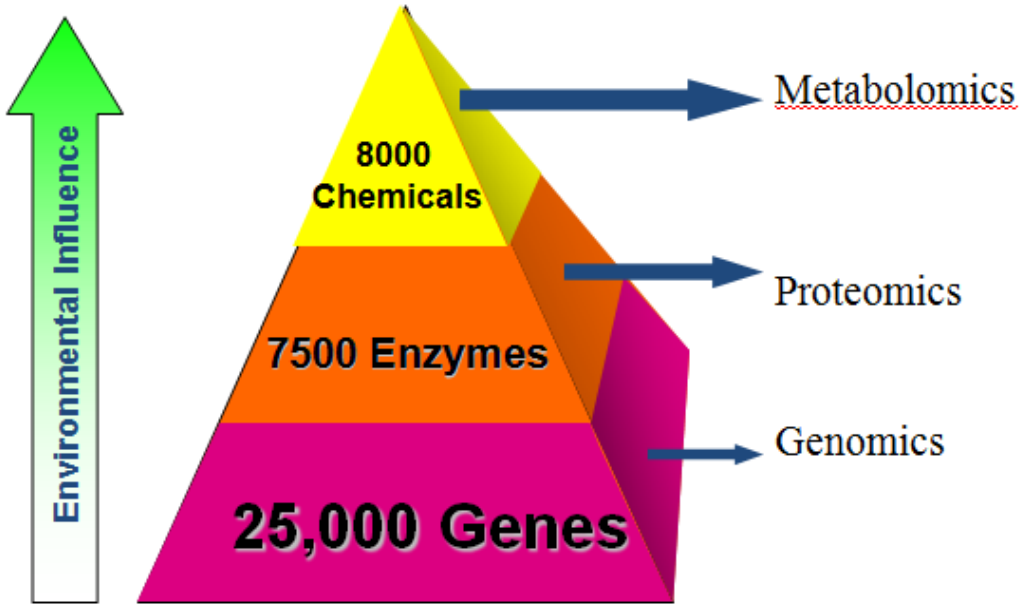
- **Prognostic**

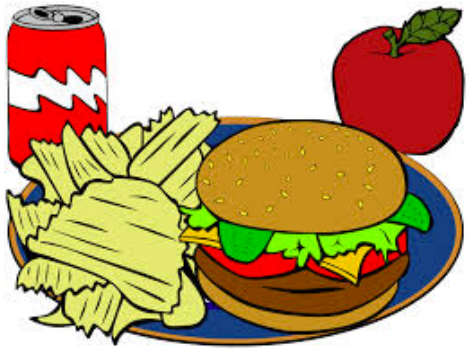
  How well will you do with this disease/condition?

- **Predictive**

  Odds of getting a given disease/condition.

Environmental Influence





Food

Protein

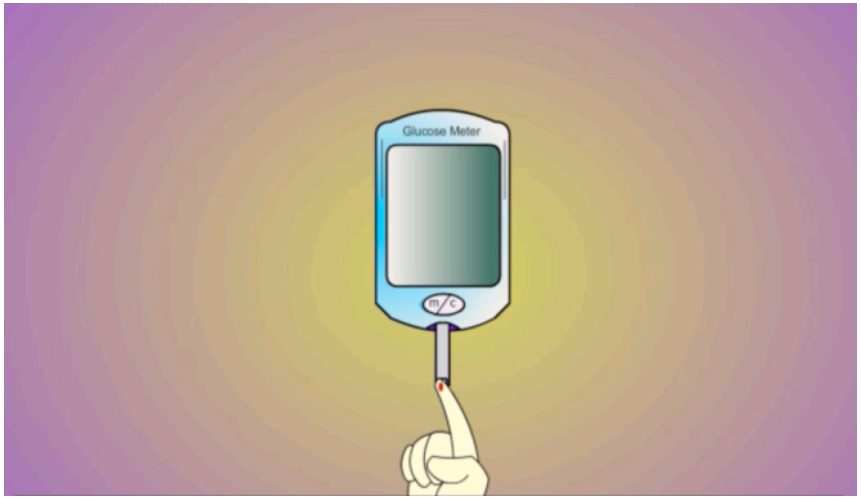
List of Metabolites

Glycerol	Indoxyl sulfate	Carnosine
Vitamin D	Choline	Vitamin B12
Phenylalanine	Lactate	Folate
Tyrosine	Glutamate	Taurine
Leucine	Glutamine	Bilirubin
Aminoadipic acid	Glucose	ADMA
TMAO	Formate	Pyruvate
Betaine	Aldosterone	Cortisol
Homocysteine	Testosterone	Dopamine
Uric acid	Estradiol	HPHPA

Utilizing Biomarkers

- Historically we have stuck with the idea

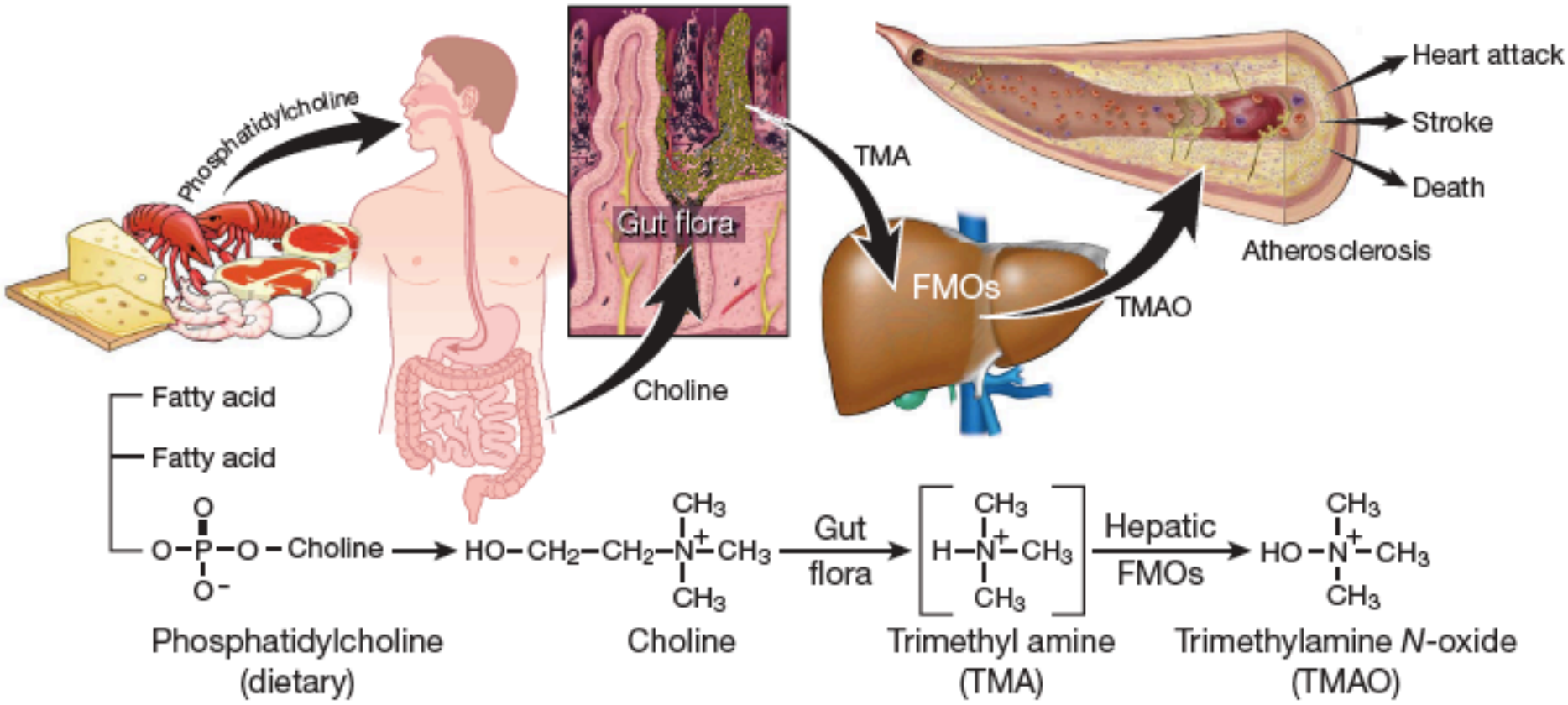
  one biomarker = one disease



This limits accuracy, precision and sensitivity/specificity

Glucose (> 6.1 mM – diabetes)

Fatty Acid



Nat Med. 2011 Apr;17(4):448-53. Epub 2011 Mar 20.

Metabolite profiles and the risk of developing diabetes.

Wang TJ, Larson MG, Vasan RS, Cheng S, Rhee EP, McCabe E, Lewis GD, Fox CS, Jacques PF, Fernandez C, O'Donnell CJ, Carr SA, Mootha VK, Florez JC, Souza A, Melander O, Clish CB, Gerszten RE.

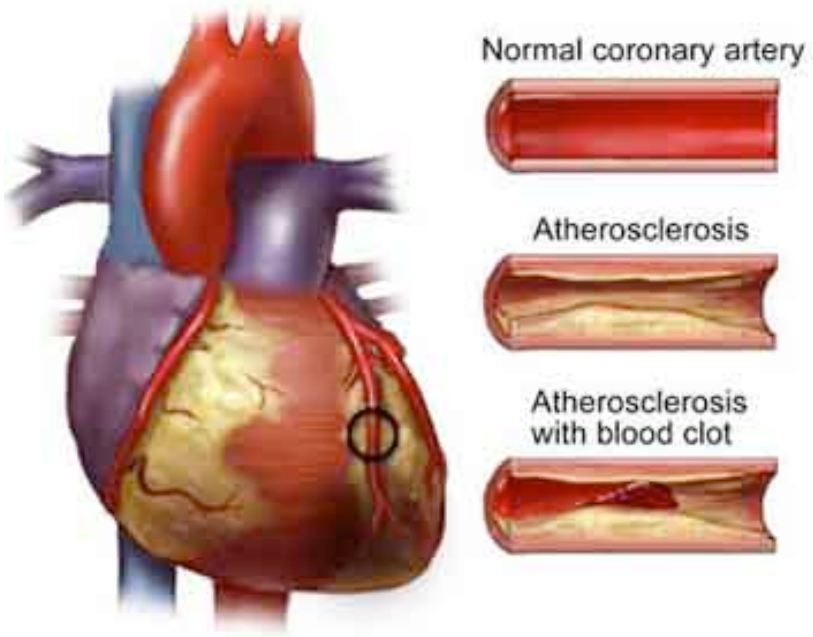
Cardiovascular Research Center, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts, USA. tjwang@partners.org

Discovering Biomarkers

- Omics technologies now suggest

  many biomarkers = one disease

- This improves accuracy, precision and sensitivity/specificity
- The problem is the math (or biomarker model) gets much more complicated



Cholesterol (> 5.2 mM – CVD risk)
Triglycerides (> 1.8 mM – CVD risk)

List of Metabolites

Glycerol	Indoxyl sulfate	Carnosine
Vitamin D	Choline	Vitamin B12
Phenylalanine	Lactate	Folate
Tyrosine	Glutamate	Taurine
Leucine	Glutamine	Bilirubin
Aminoadipic acid	Glucose	ADMA
TMAO	Formate	Pyruvate
Betaine	Aldosterone	Cortisol
Homocysteine	Testosterone	Dopamine
Uric acid	Estradiol	HPHPA

Discovering Biomarkers

- Historically we have stuck with the idea

hCG (human chorionic gonadotrophin) is a hormone secreted in pregnancy that is made by the developing embryo soon after conception. It is used for pregnancy test.

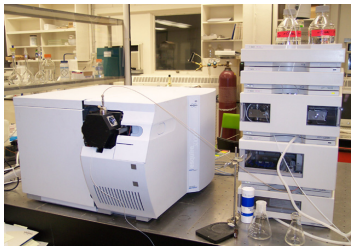
The Test Cost

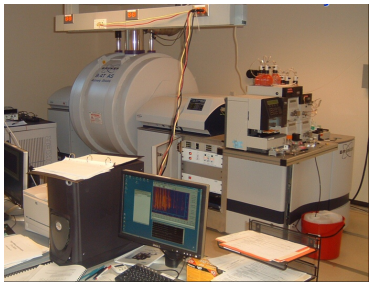
Metabolite	Cost of Test
Betaine	$113.70
Choline	$100.00
Estradiol	$125.00
Formate	$84.00
Glucose	$45.00
Glutamate	$98.94
Glutamine	$98.94
Glycerol	$48.50
Taurine	$98.94
Vitamin D	$210.00

Total: $1023.02 for 10 tests

DynaLIFE Dx

What Are the (Standard) Metabolomic Technologies?





- UPLC, HPLC
- CE/microfluidics
- LC-MS
- FT-MS
- QqQ-MS
- NMR spectroscopy
- X-ray crystallography
- GC-MS
- LIF detection

- Instruments are large (500 kg) and not portable
- Expensive (>$1 million), hard to use (requires PhD)

The Problem…

- Metabolomic analysis is expensive, non-portable and difficult to do

- Need to make small (palm size), inexpensive (<$1,000 for an instrument, $1 for a test), easy-to-use (Smartphone application), portable (farm/industry friendly) devices

The Solution…

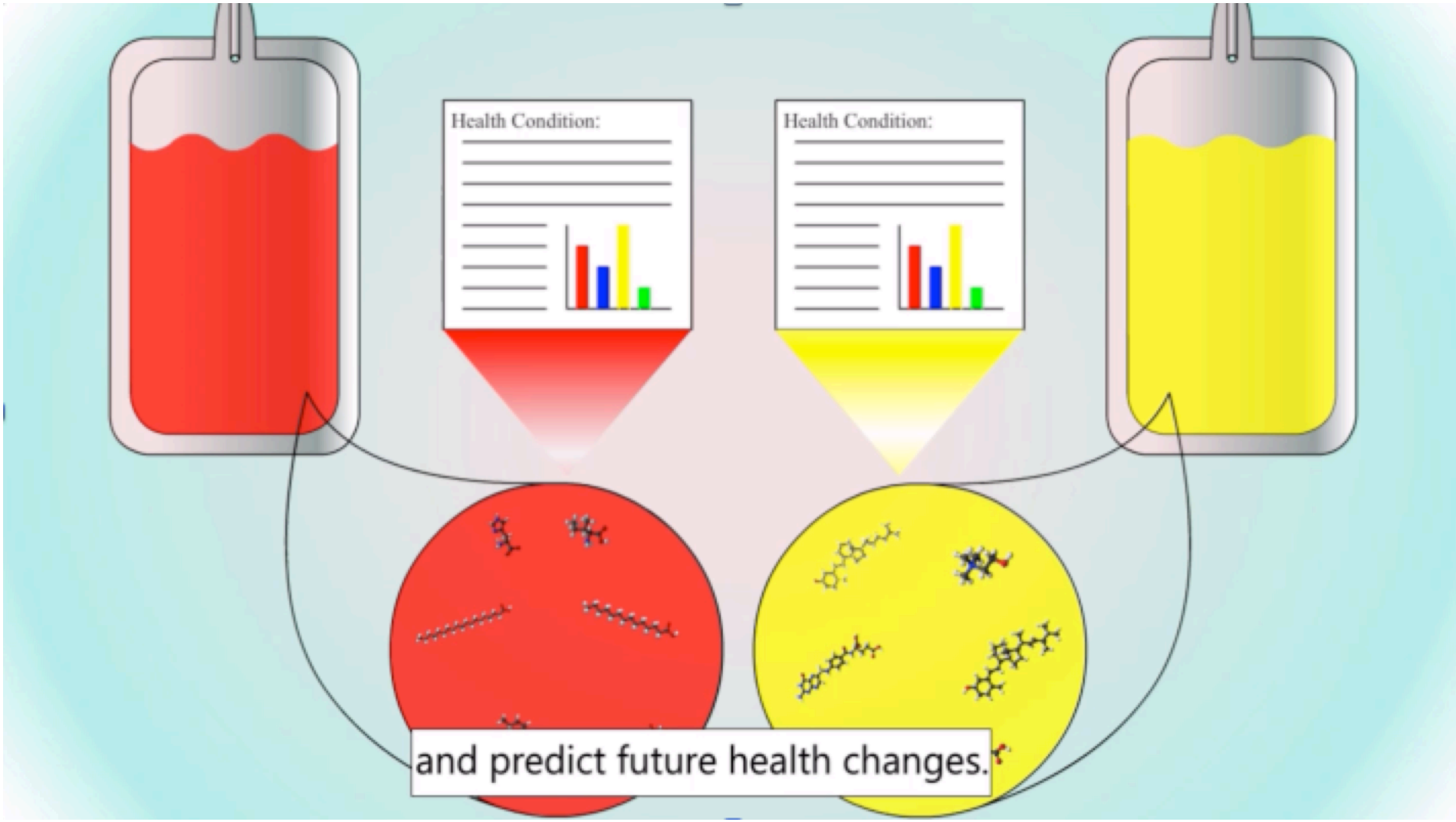
- Easy-to-use, platform specific kits
- Nanoelectromechanical devices (NEMS)
- Microfluidics
- Engineered biosensors
- Integration of extraction, separation & detection on a single platform

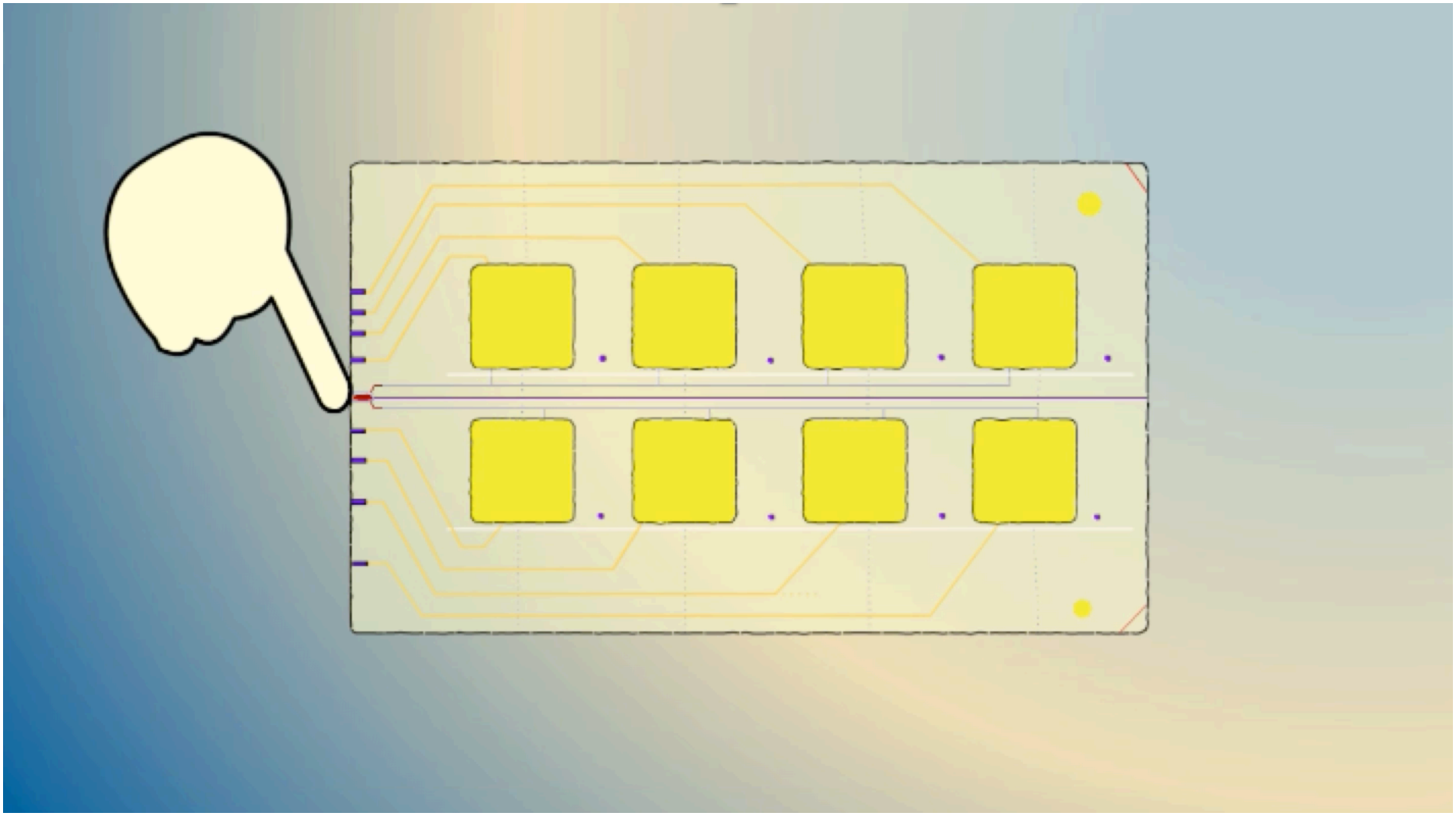
StarTrek & Tricorders

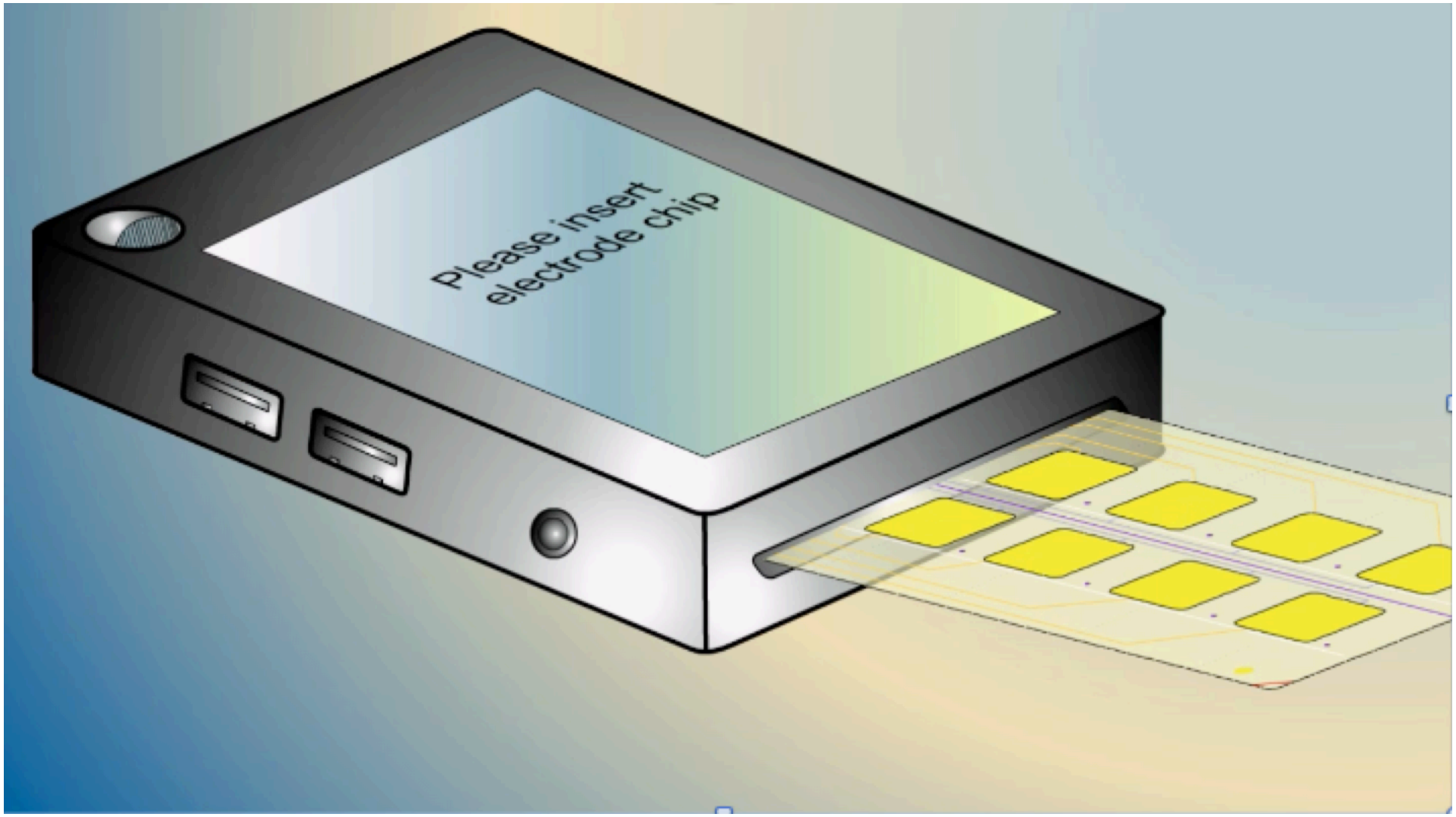
1. Background
2. Turning Your Smart Phone into a Tricorder
3. Tricoder Applications
4. Conclusion

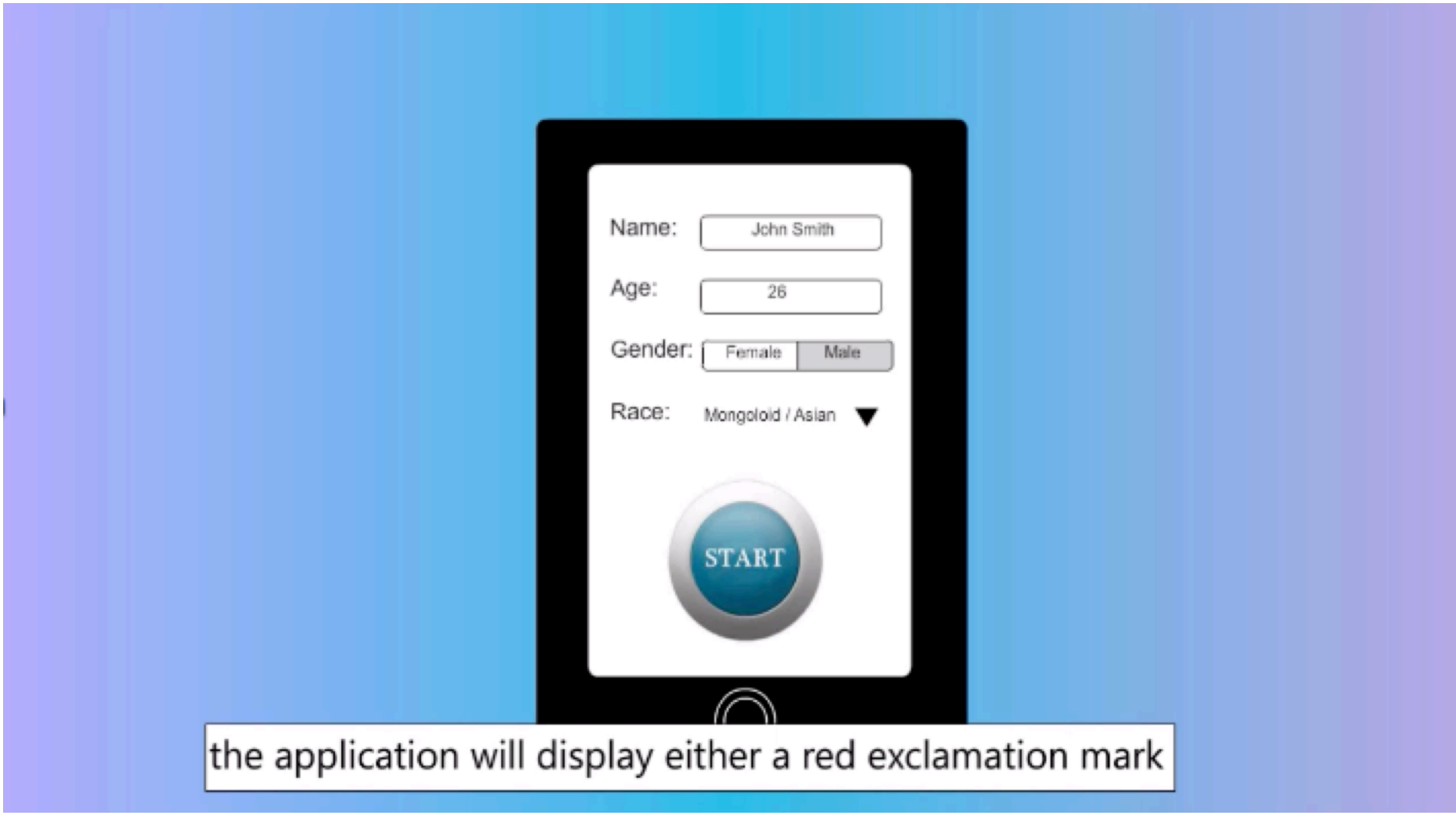
List of Metabolites

Glycerol	Indoxyl sulfate	Carnosine
Vitamin D	Choline	Vitamin B12
Phenylalanine	Lactate	Folate
Tyrosine	Glutamate	Taurine
Leucine	Glutamine	Bilirubin
Aminoadipic acid	Glucose	ADMA
TMAO	Formate	Pyruvate
Betaine	Aldosterone	Cortisol
Homocysteine	Testosterone	Dopamine
Uric acid	Estradiol	HPHPA


Health Condition:
Health Condition:
and predict future health changes.

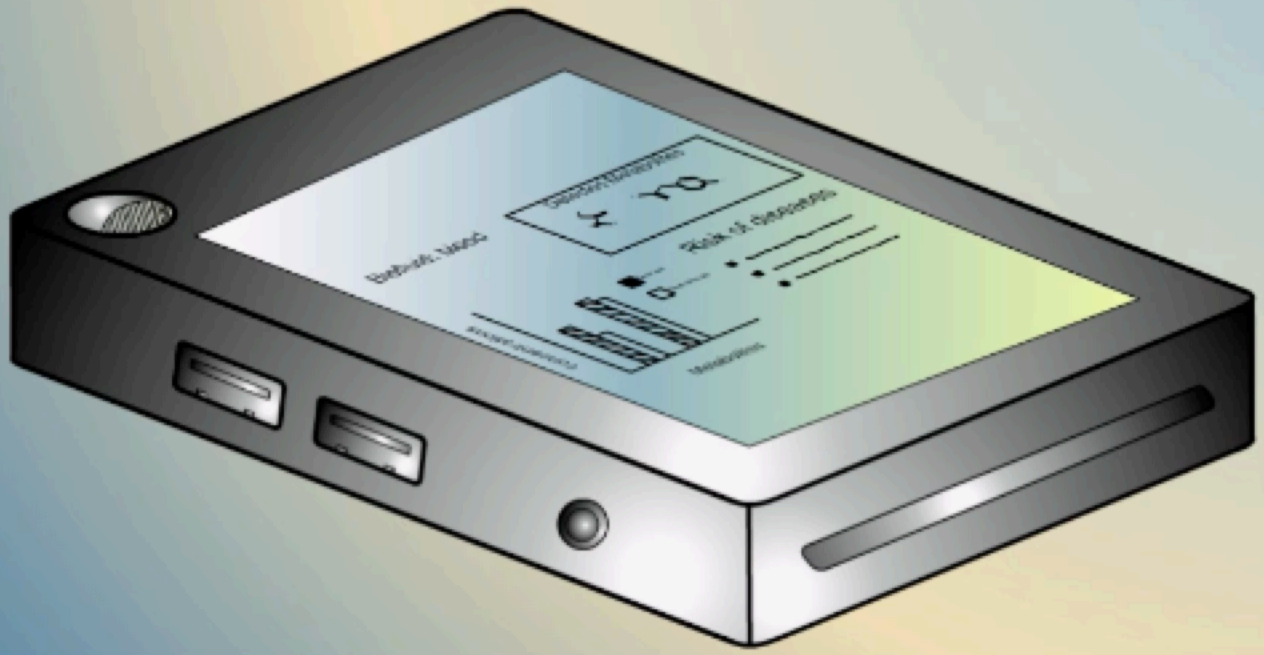



Please insert
electrode chip



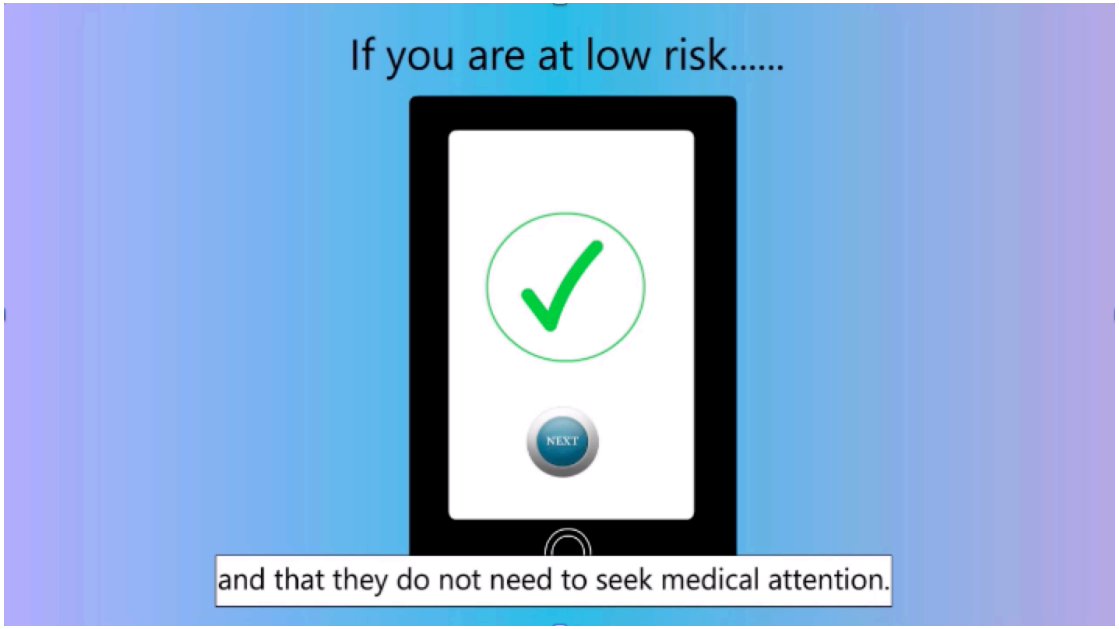
the application will display either a red exclamation mark

Analyzing



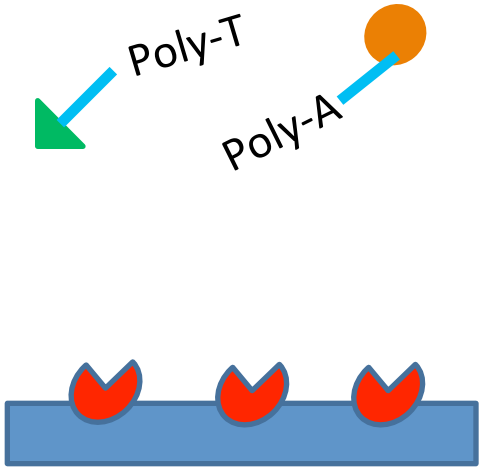
present in biofluids by using electrical impedance-based detection.

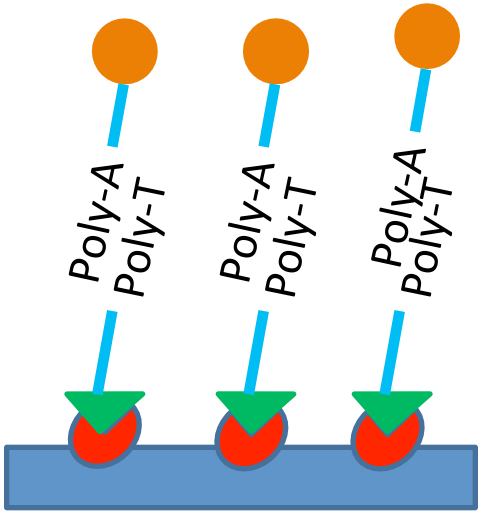
If you are at high risk.....
NEXT
signifying that the patient's health is at risk and that they should seek medical attention

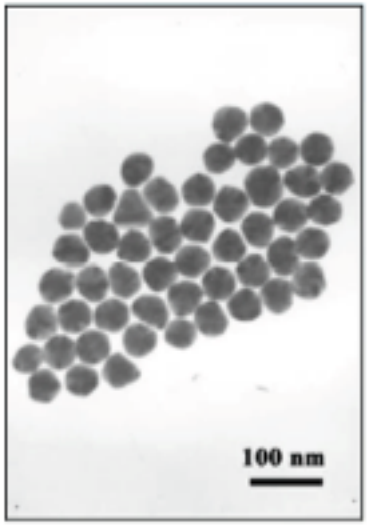

If you are at low risk.....
NEXT
and that they do not need to seek medical attention.

Proof-of-concept Design

- Synthesize streptavidin-poly-T
- Synthesize GNPs-poly-A
- Detect the signal on bio-molecule sensor







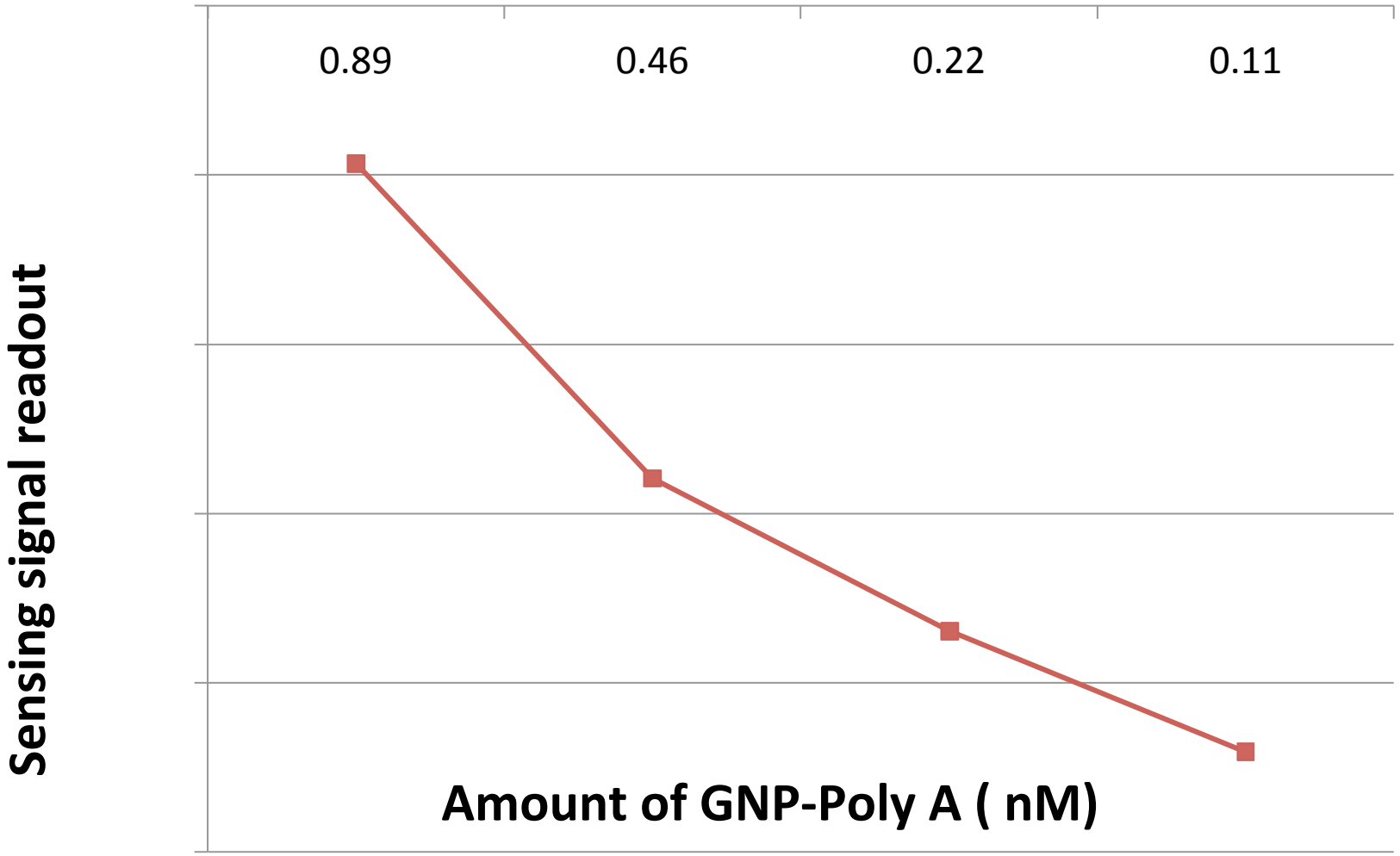
Gold Nanoparticle

Test Sequence: The structure of Poly A and Poly T

Poly T 5'-/5ThioMC6-D/CCC CCC CCC CTT TTT TTT TTT TTT TTT TTT -3'

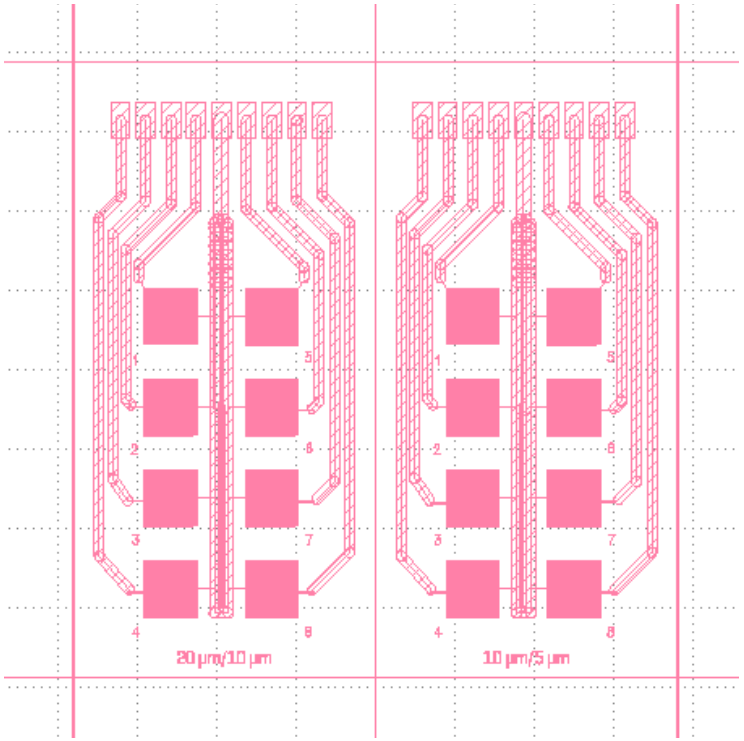
Poly A 5'-AAA AAA AAA AAA AAA AAA AAC CCC CCC CCC CCC CCC CCC CCC CCC/ 3ThioMC3-D/-3'

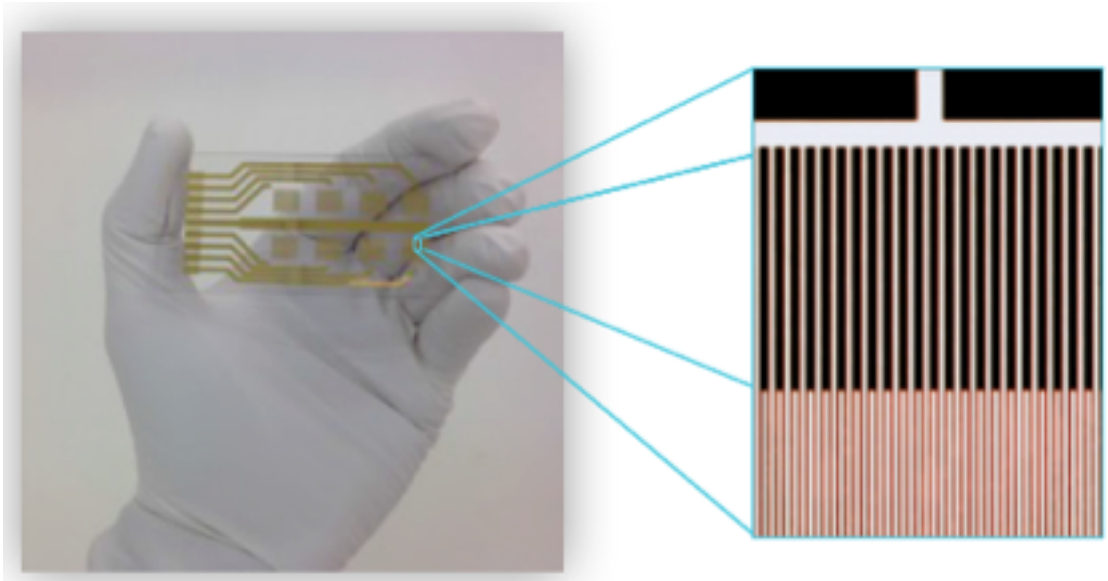
Experimental results

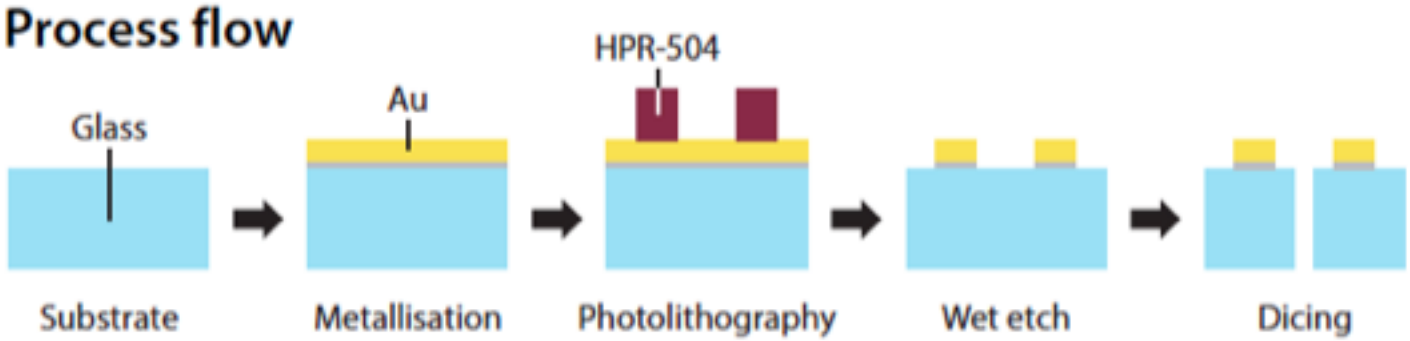


The amount of GNP-Poly A is 0.24, 0.48, 0.96, 1.44 nM

Electrode Sensor Chips (Nanotechnology)

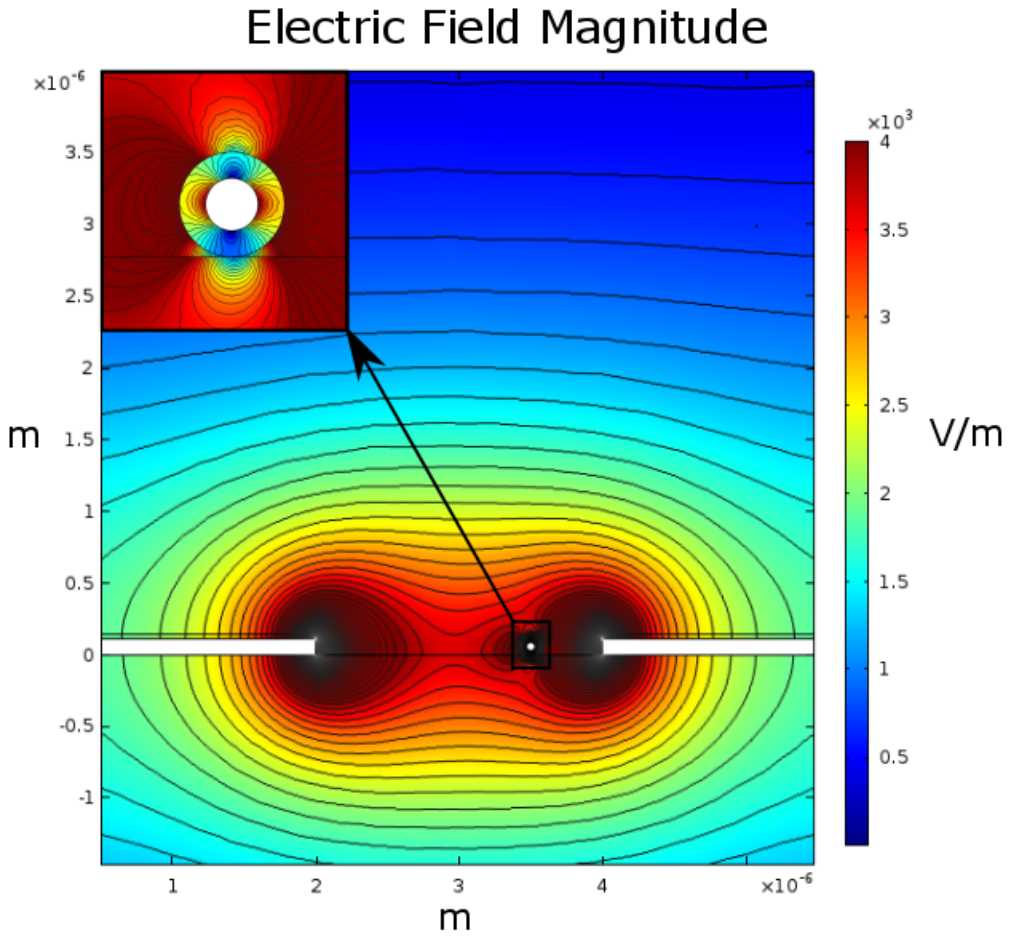






nanofab.ualberta.ca

Analytical and Numerical Simulations

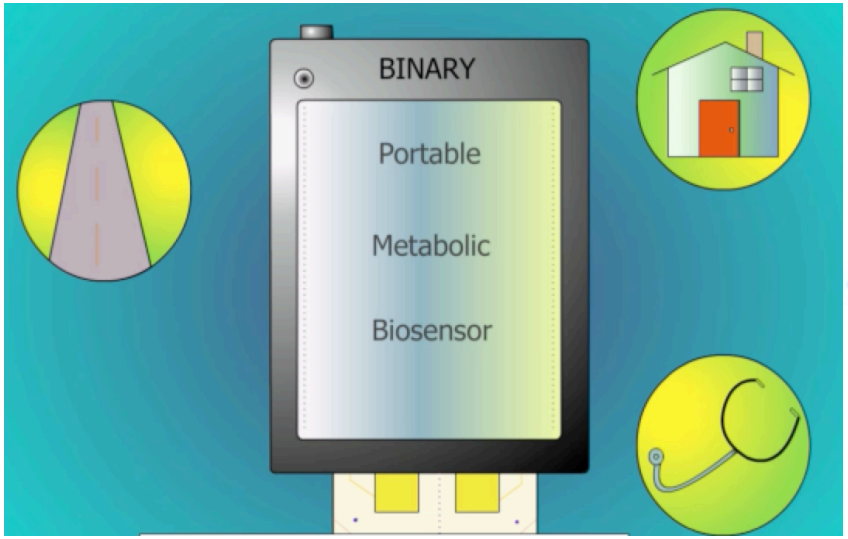


Sensitivity of 2D vs 3D simulations

Signal measurement

Biosensor

Bluetooth



WiFi

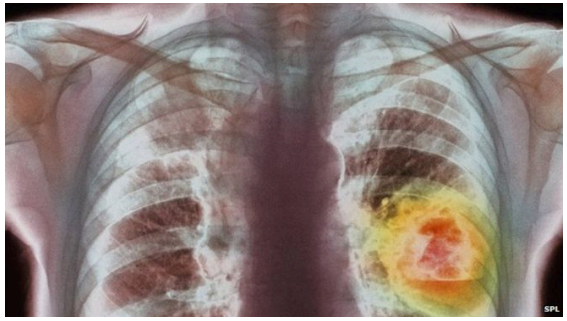
Cloud network defense

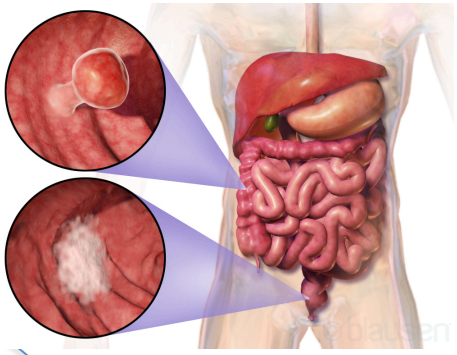
Internet

At home, on the road, or in the clinic

1. **Background**
2. **Turning Your Smart Phone into a Tricorder**
3. **Tricoder Applications**
4. **Conclusion**

UNIVERSITY OF ALBERTA



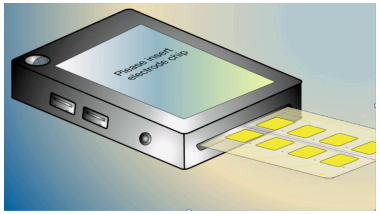


Lung cancer

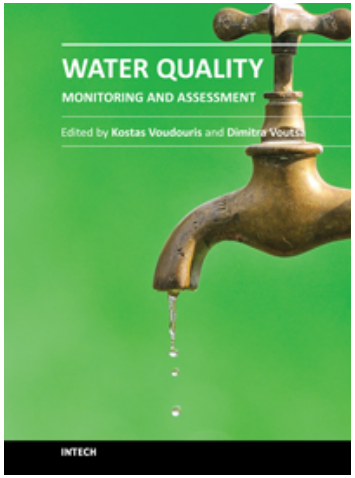
Colorectal cancer

Salt monitoring

Water quality monitoring



Biosensor



Early warning of plant diseases

Food quality monitoring

Conclusion

- Easy-to-use, platform specific kits
- Microfluidics
- Engineered biosensors
- Integration of extraction, separation & detection on a single platform