

# IoT and Behavior Change: Can We Build a GPS for Our Brains?

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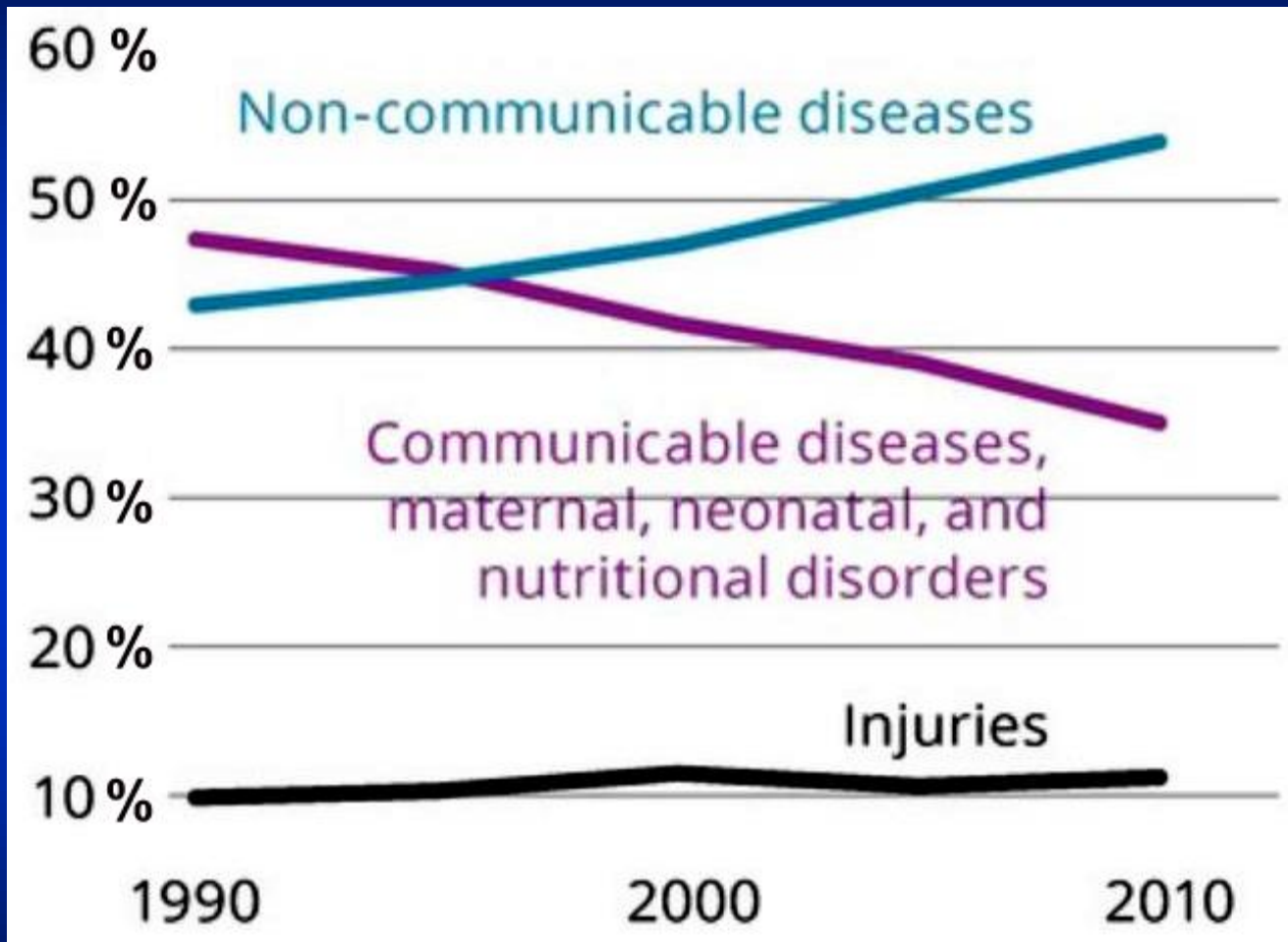
Sept 2016

# Introduction

# Health and Disease in Middle Ages



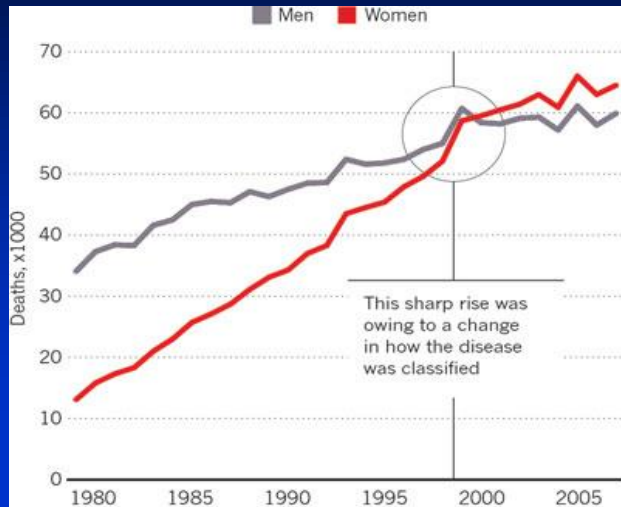
# The Tipping Point



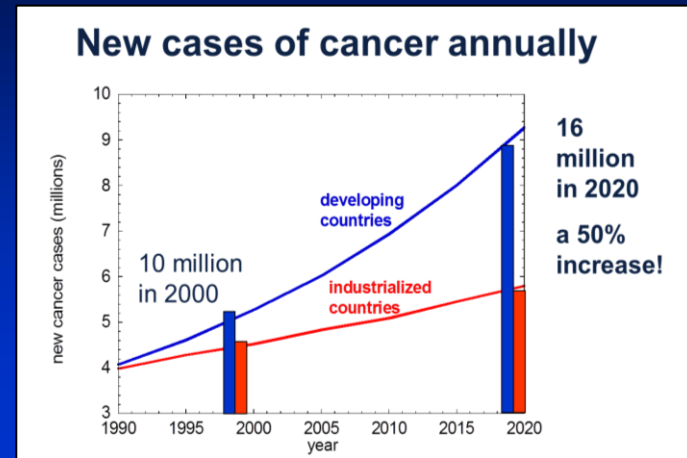
# Non-Communicable Diseases

- Cancer
- Diabetes
- Cardiovascular Disease, Stroke
- Chronic Obstructive Pulmonary Disease
- Depression

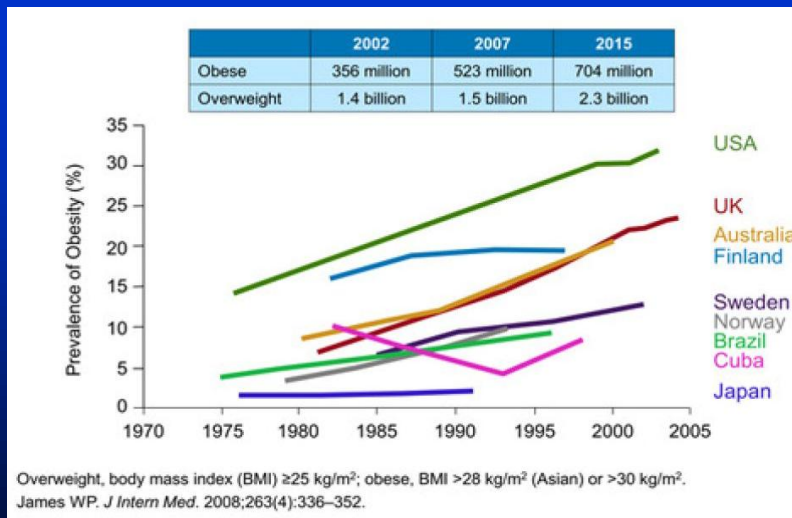
# All are trending up globally



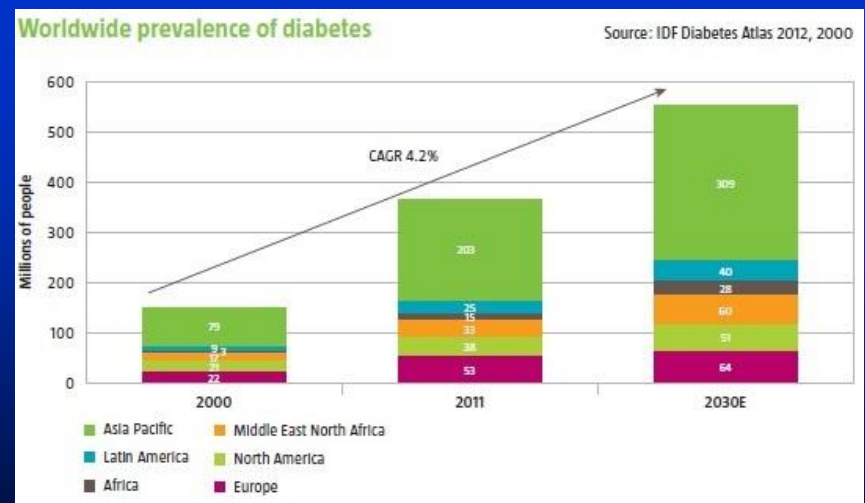
## COPD



## Cancer



## Obesity



## Diabetes

# Where are the underlying causes?

- Genetic factors
- Environmental factors
  - smoke, pesticides
- Behavioral factors
  - diet, nutrition
  - activity, exercise
  - substance abuse (e.g. smoking)
  - sleeping
  - etc.

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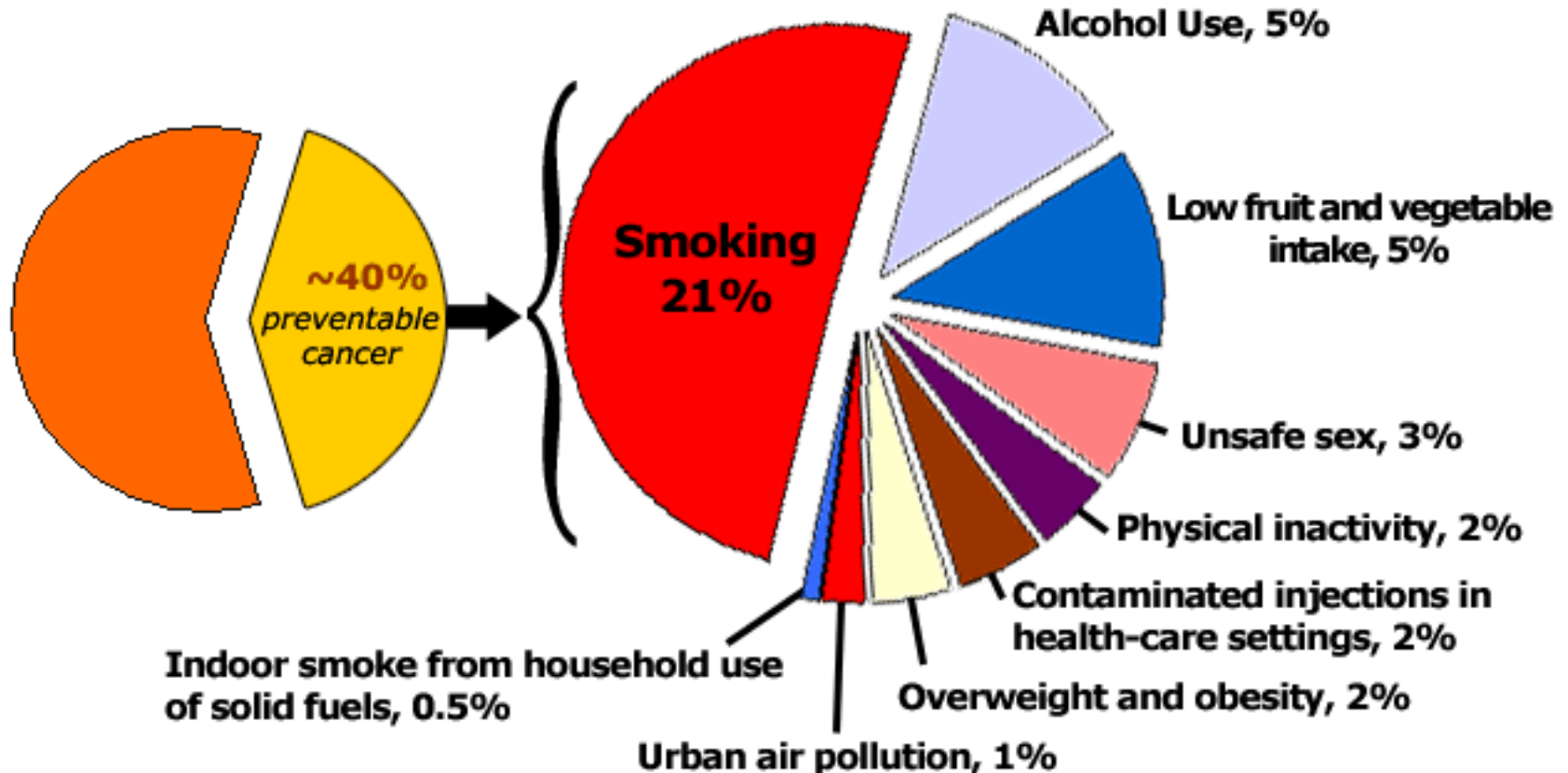


# Where are the underlying causes?

- Genetic factors
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# Example: Cancer

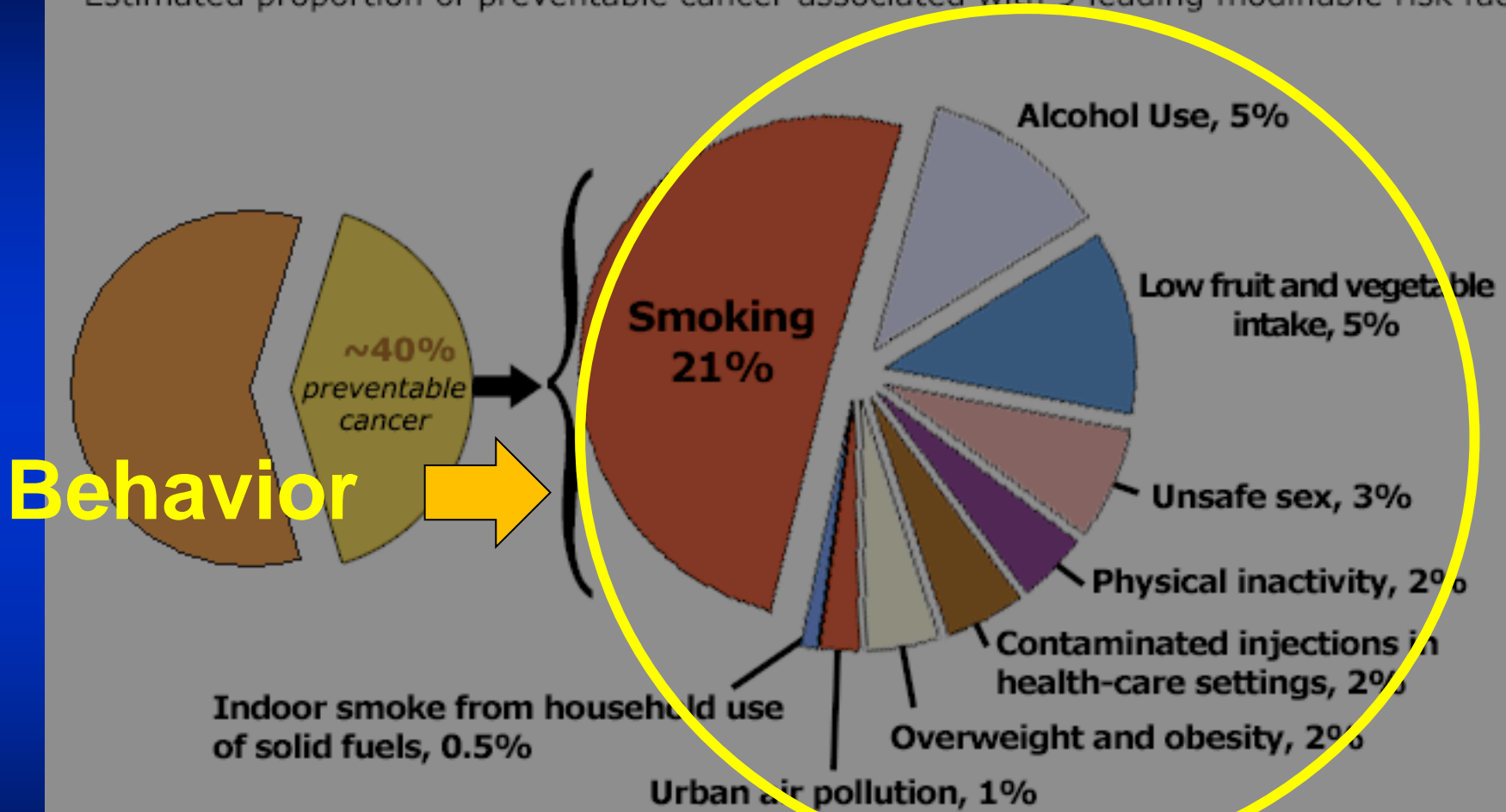
Estimated proportion of preventable cancer associated with 9 leading modifiable risk factors



Danaei G, Vander Hoorn S, Lopez AD, Murray CJ, Ezzati M. Causes of cancer in the world: comparative risk assessment of nine behavioural and environmental risk factors *The Lancet*, 2005, 366:1784-1793

# Example: Cancer

Estimated proportion of preventable cancer associated with 9 leading modifiable risk factors



Danaei G, Vander Hoorn S, Lopez AD, Murray CJ, Ezzati M. Causes of cancer in the world: comparative risk assessment of nine behavioural and environmental risk factors *The Lancet*, 2005, 366:1784-1793

# Behavior Medicine

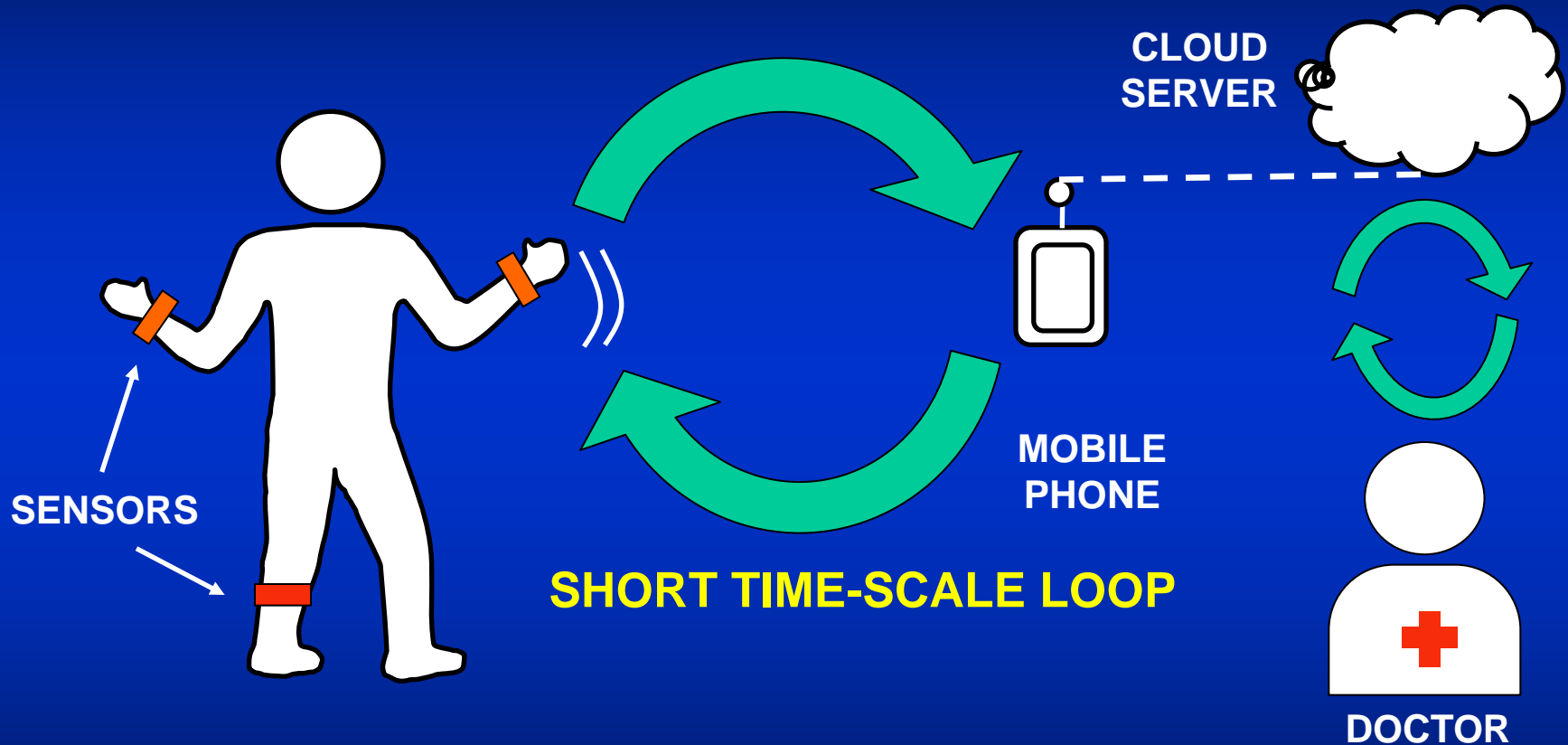


- Unhealthy behaviors
- Obesity/exercise
- Substance abuse
- Relationships
- Cancer, pain management

# mHealth (2009)



# Just-in-Time Intervention



Fletcher et al, IEEE EMBC 2011

# Commercial Devices



# Many Commercial Apps

## What Am I Tracking?





# Best Buy Wearables



# McDonald's Wearable



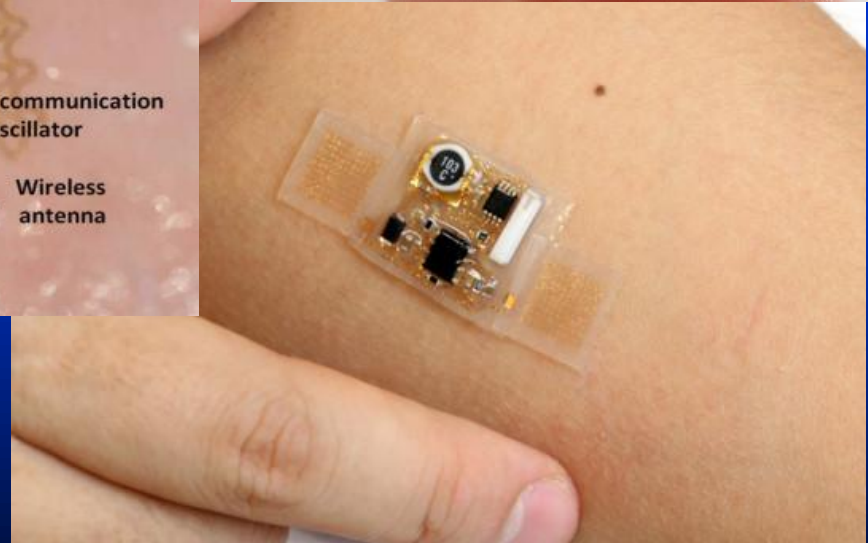
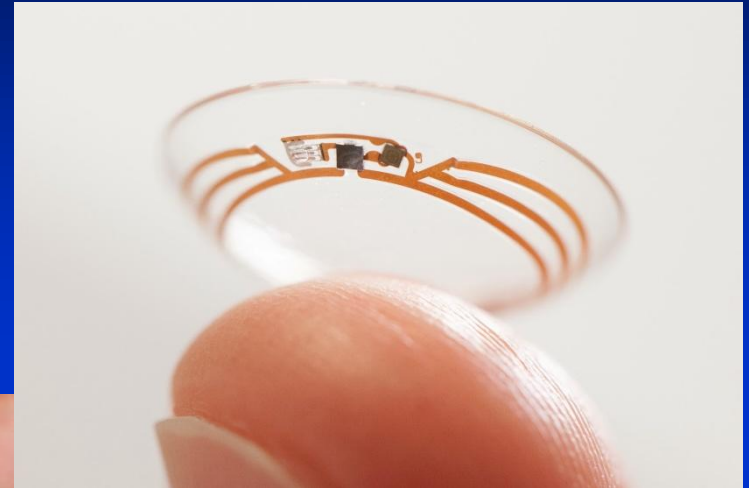
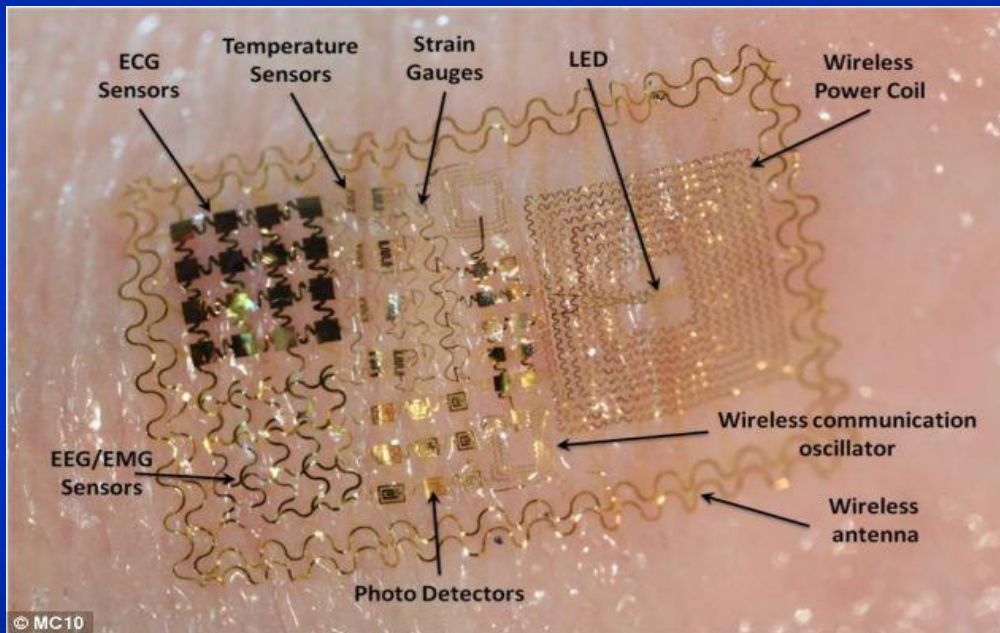
# Wearables Challenges

**WEARABLES ARE TOTALLY FAILING THE PEOPLE WHO NEED THEM MOST**

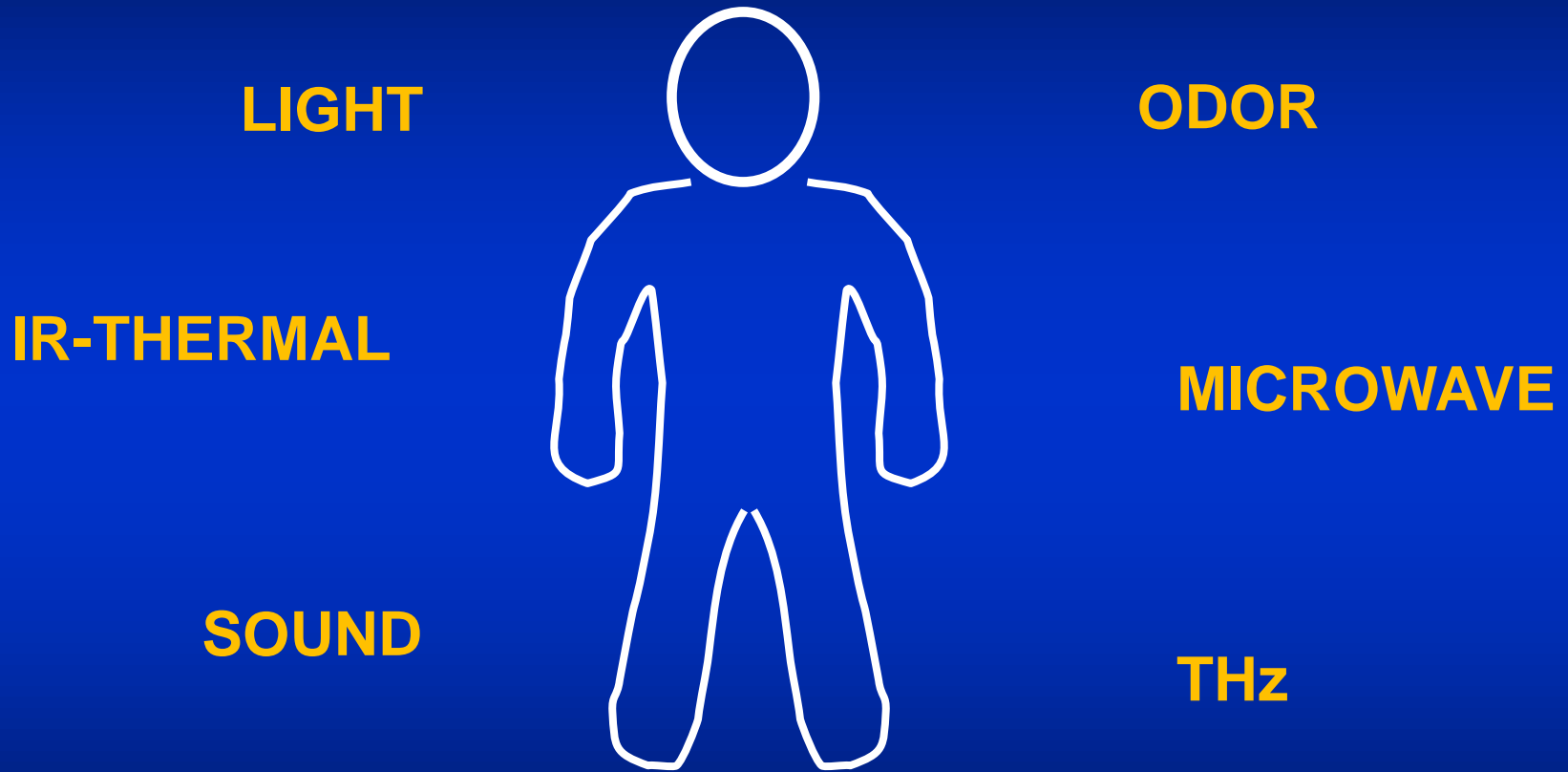


# New Directions

# and Embeddables

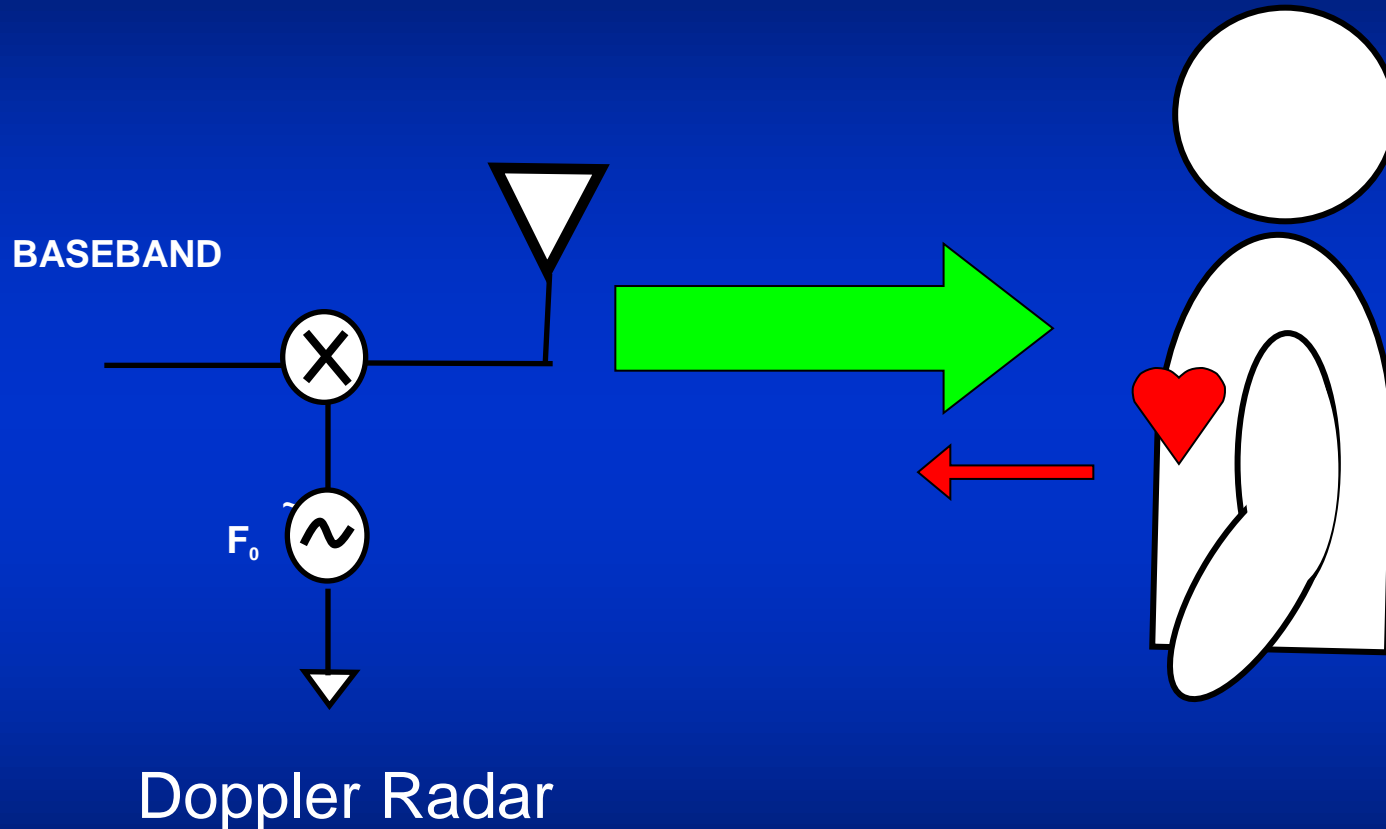


# Ubiquitous Non-Contact Sensing



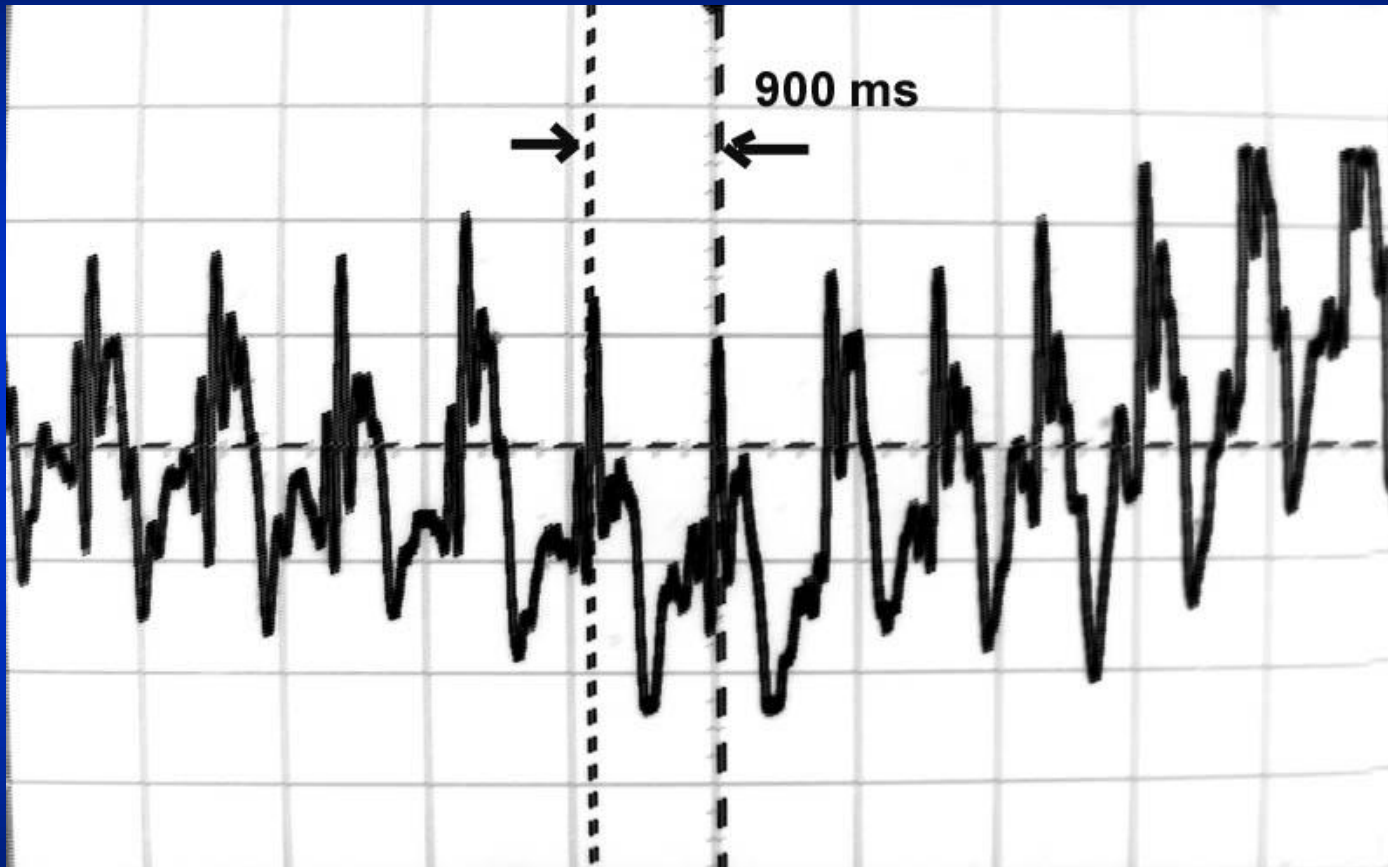
**→ No Wearable Sensors Required**

# Non-Contact Physiology



Fletcher et al, IEEE IMS (2009)

# Heart Rate Data

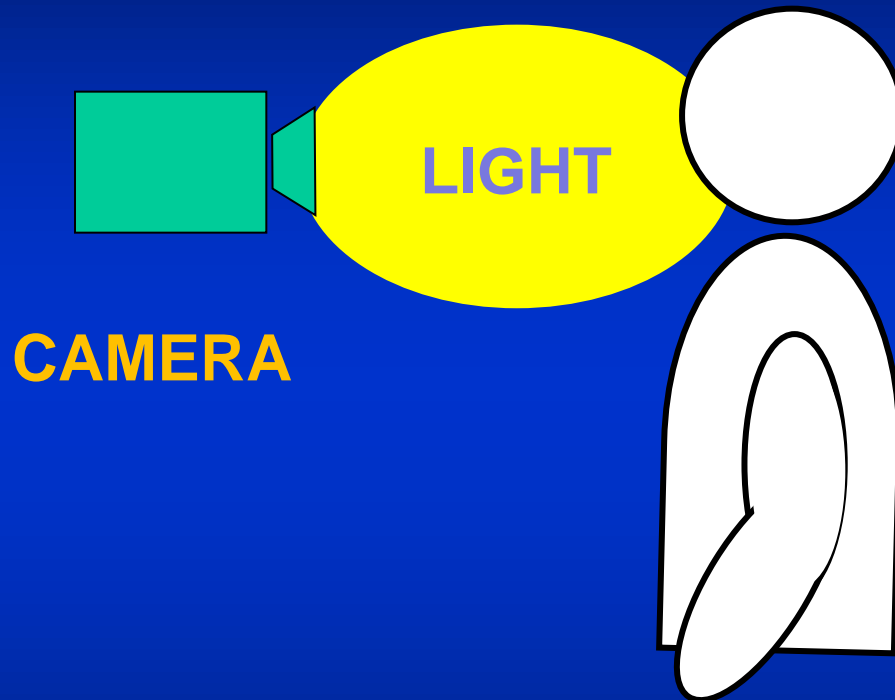


Scale = 1 Volt / div

Fletcher et al, IEEE IMS (2009)

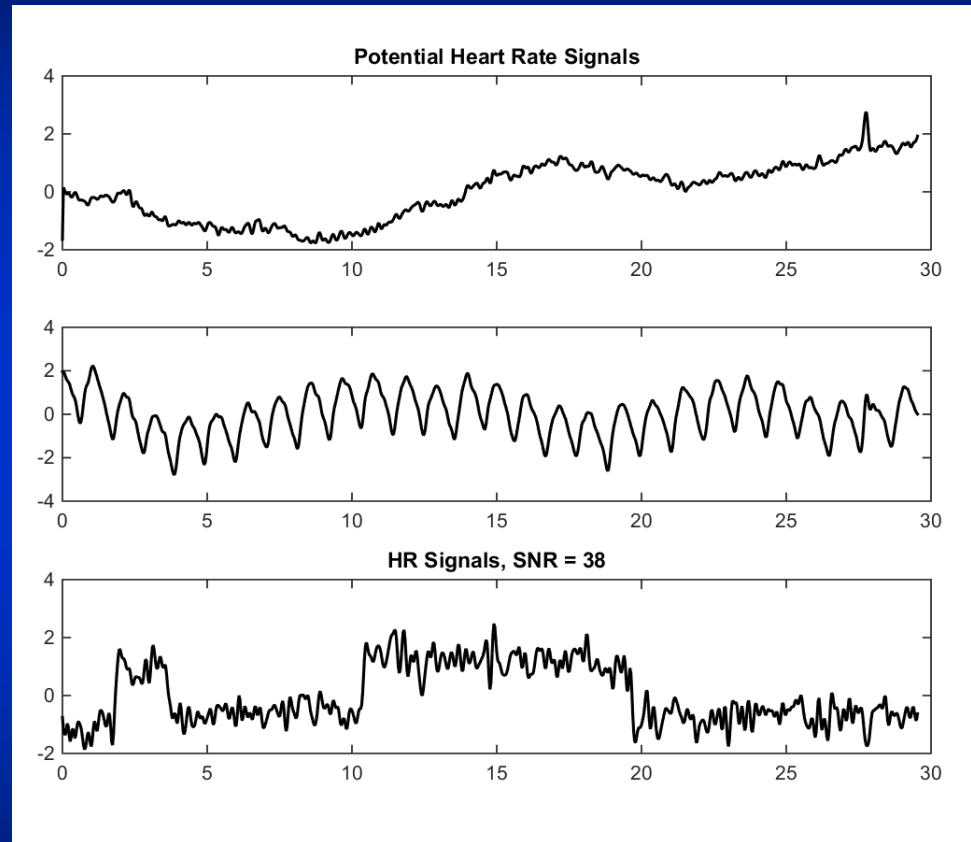
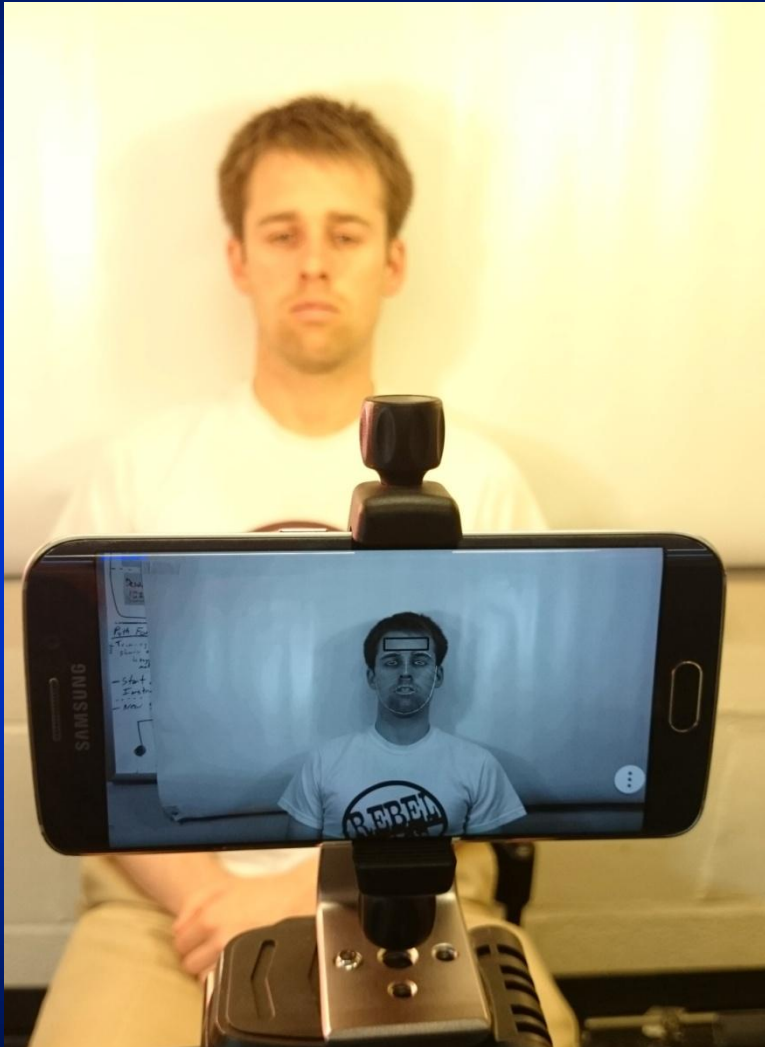


# Video Plethysmography (V-PPG)



- Measurement of HR, HRV
- Non-contact, low-cost
- a.k.a. r-PPG, PPG imaging

# Video Plethysmography



Fletcher, 2015

# Smart Mirror



Measuring cognitive load: McDuff et al, IEEE EMBC 2014

© 2000-2011 Rich Fletcher

# Thermal Imaging

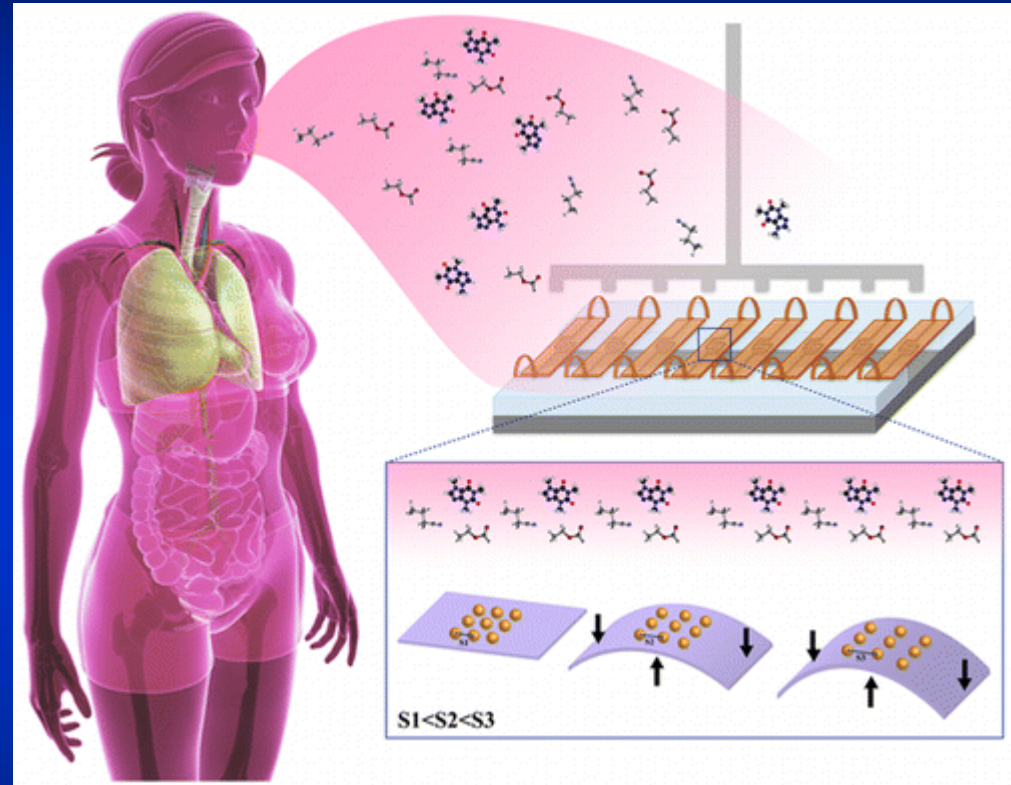


# Sniffing Out Disease



Dogs can detect:

- Blood sugar
- Epilepsy
- Parkinsons
- Skin cancer
- Stress
- Infections
- Narcolepsy
- Migraines

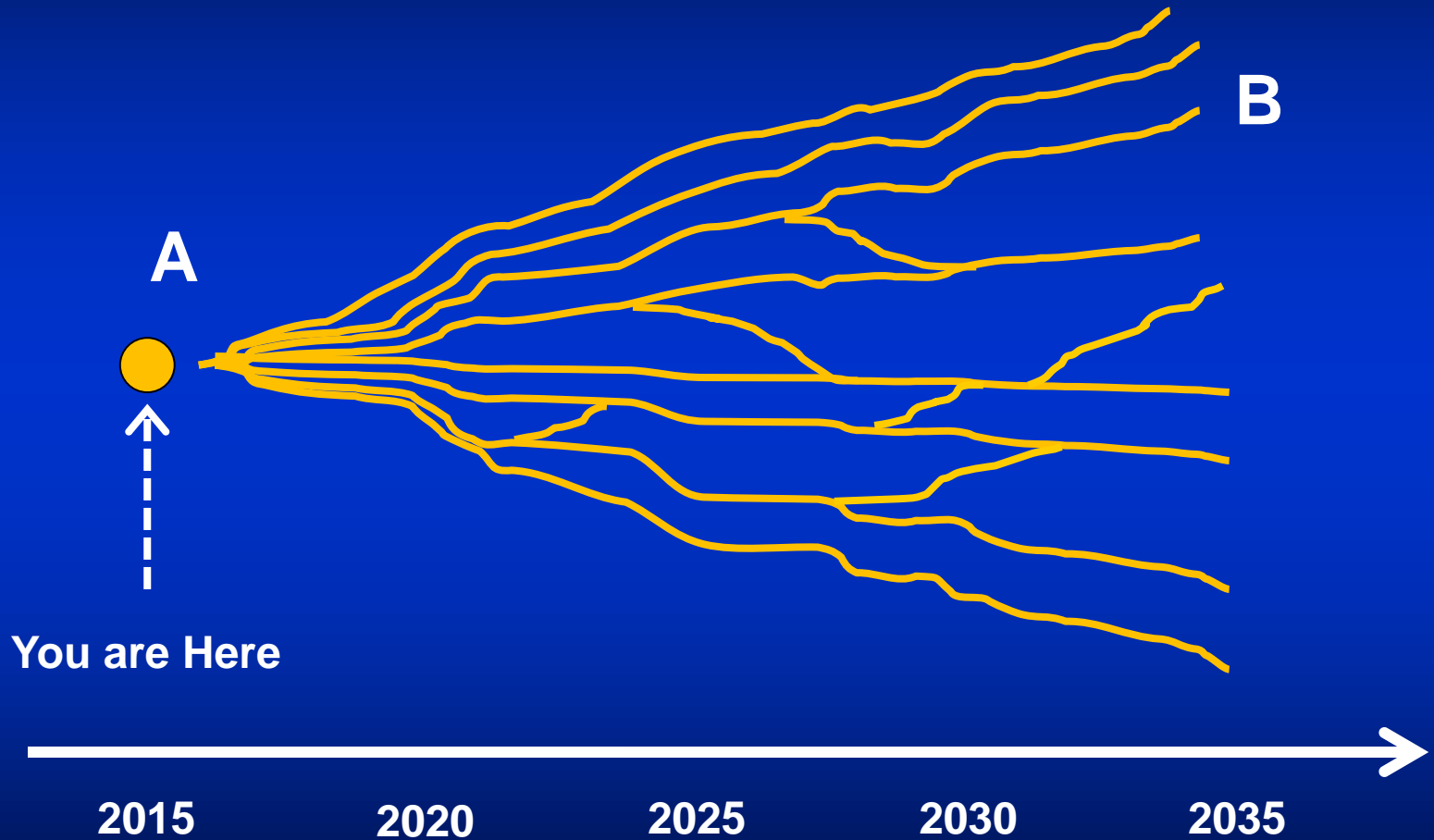


*Khan, Nano Lett., 2015, 15 (10), pp 7023–7028*

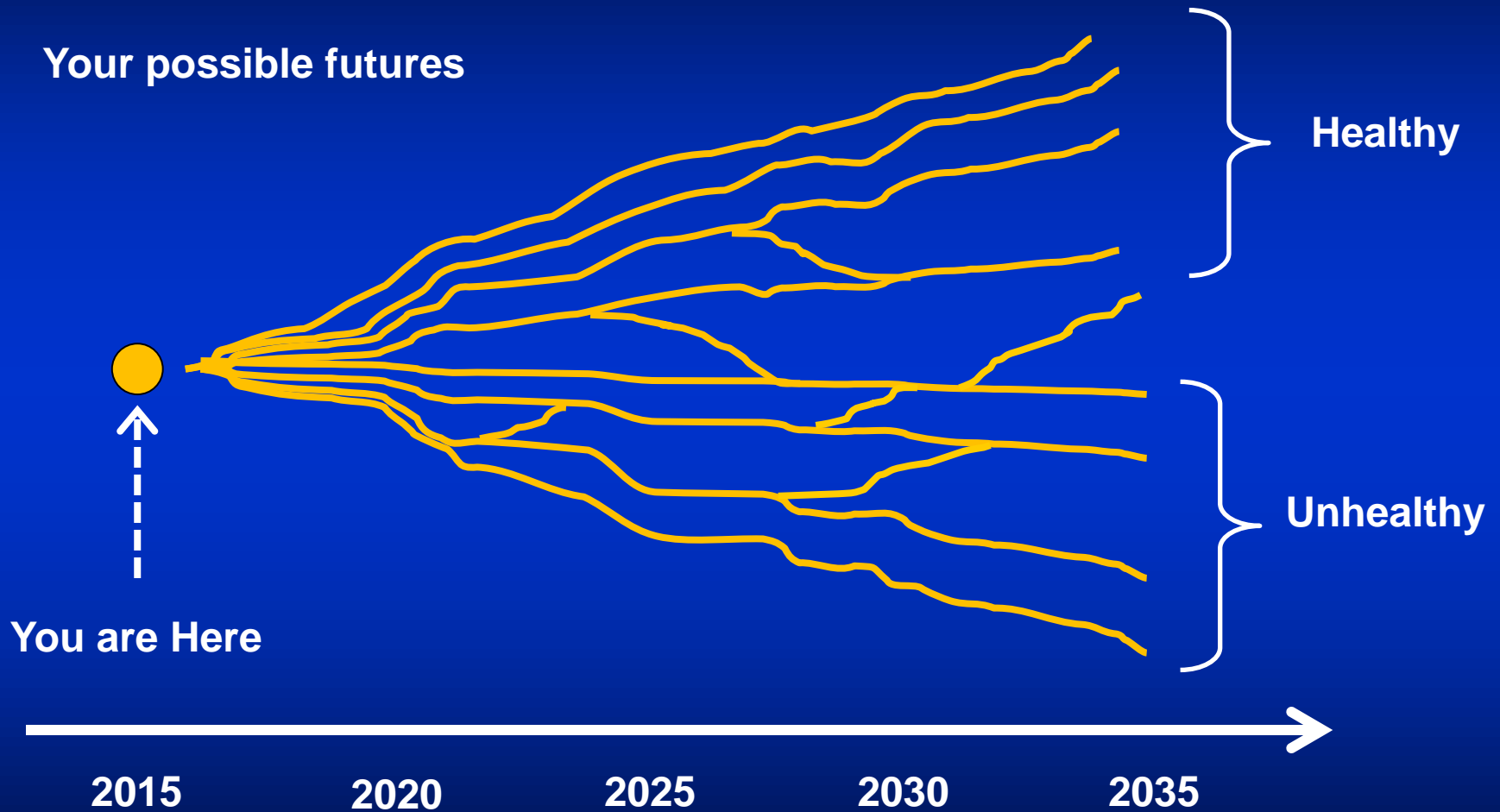
MIT Research : A. Mershin, T. Swager

# Navigating Our Behavior

# Health Trajectories

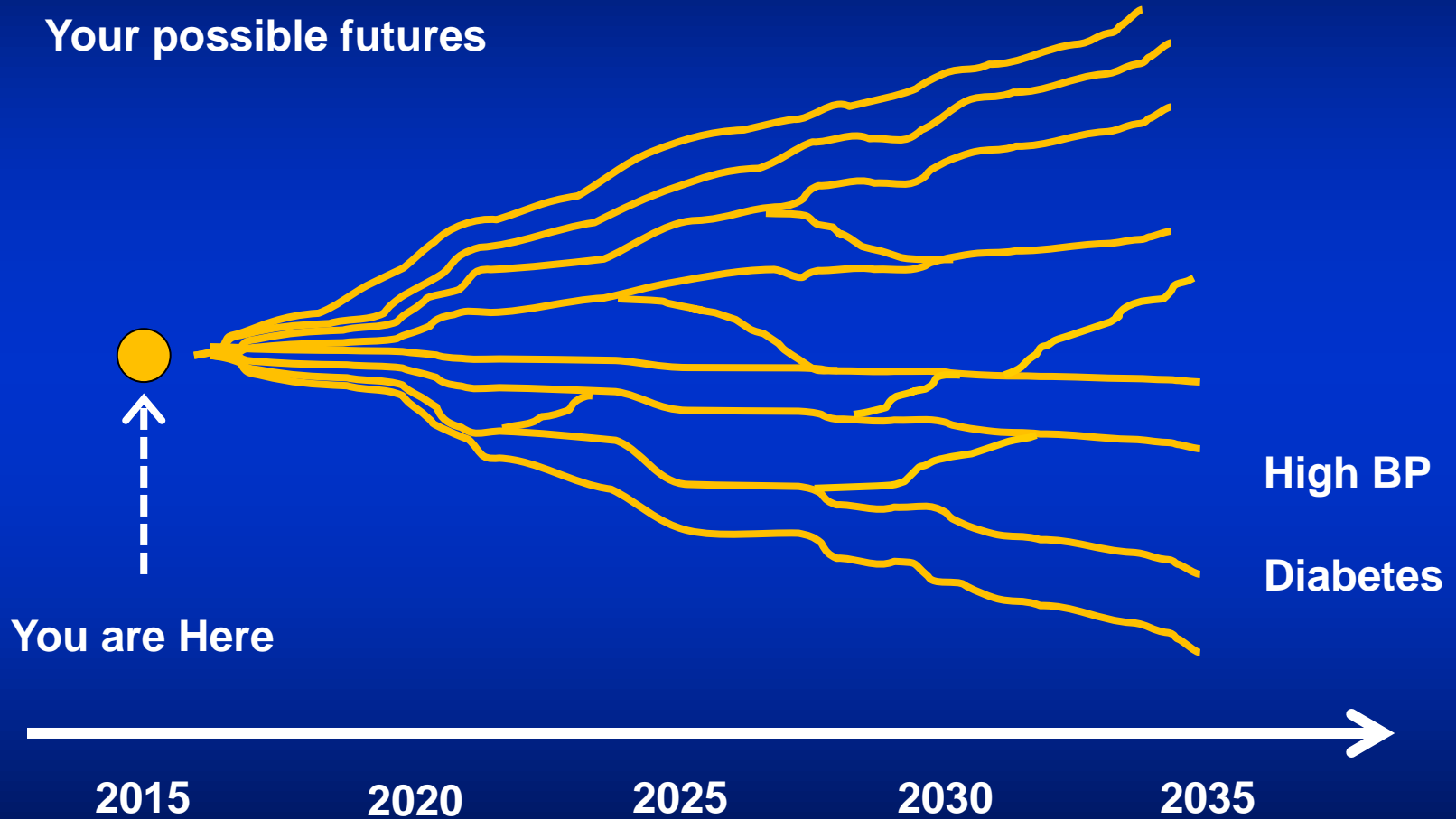


# Navigating our health

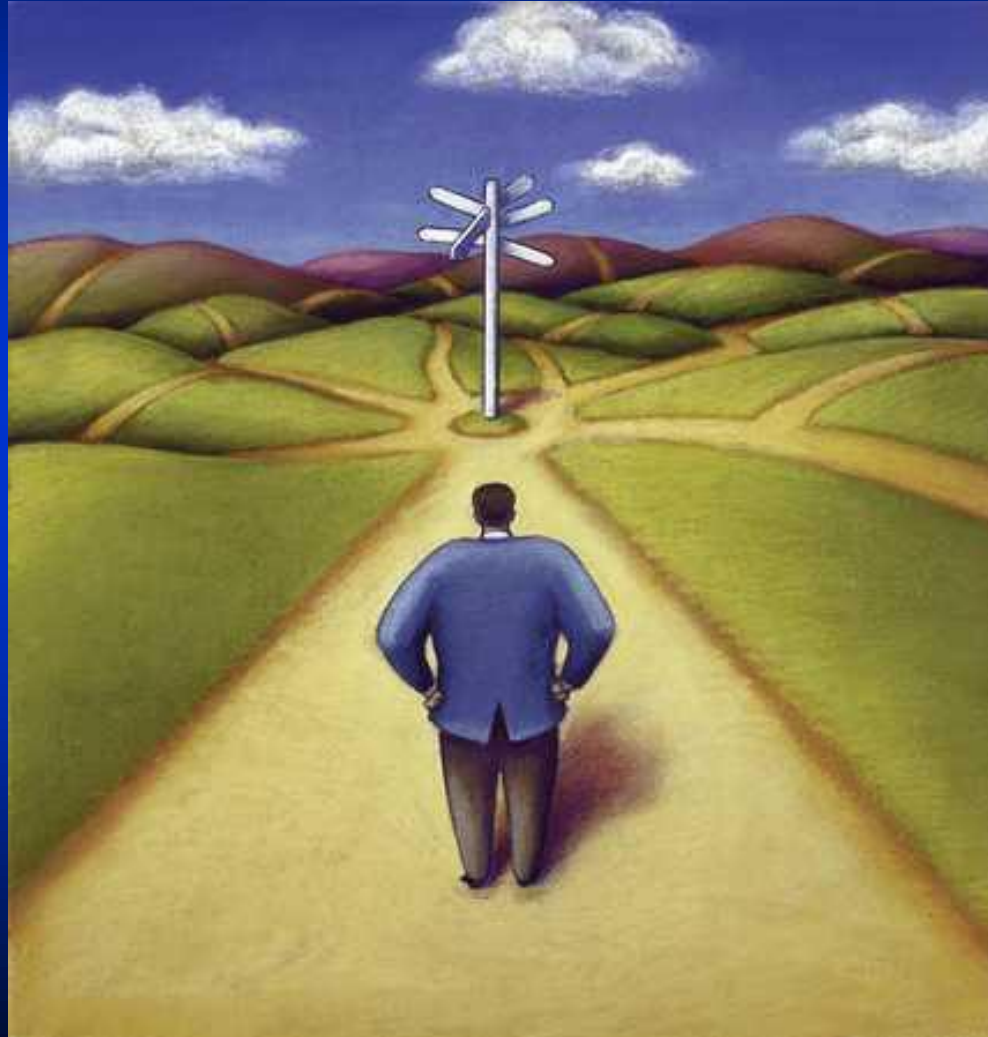




# Navigating our health



# Can we create a Navigation System?



# Mobile Interventions



# Internet of Things



- Internet of things is now enabling new sensor modalities
- TV's and Kitchen appliances now sense and interact with the users – **we can use that data!**

# Internet of Things



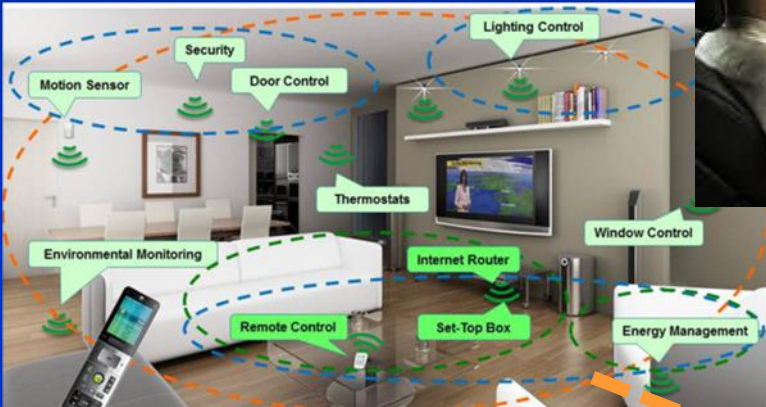
# Phones as Agents for Behavior Change



Smart Car



People



Smart Home



# Example of IoT in Use

# Example: Hotel Room Lighting



Even Hotel  
Rockville, MD



Philips Hue IRIS lamp



# Future mHealth would enable:



If jet-lagged



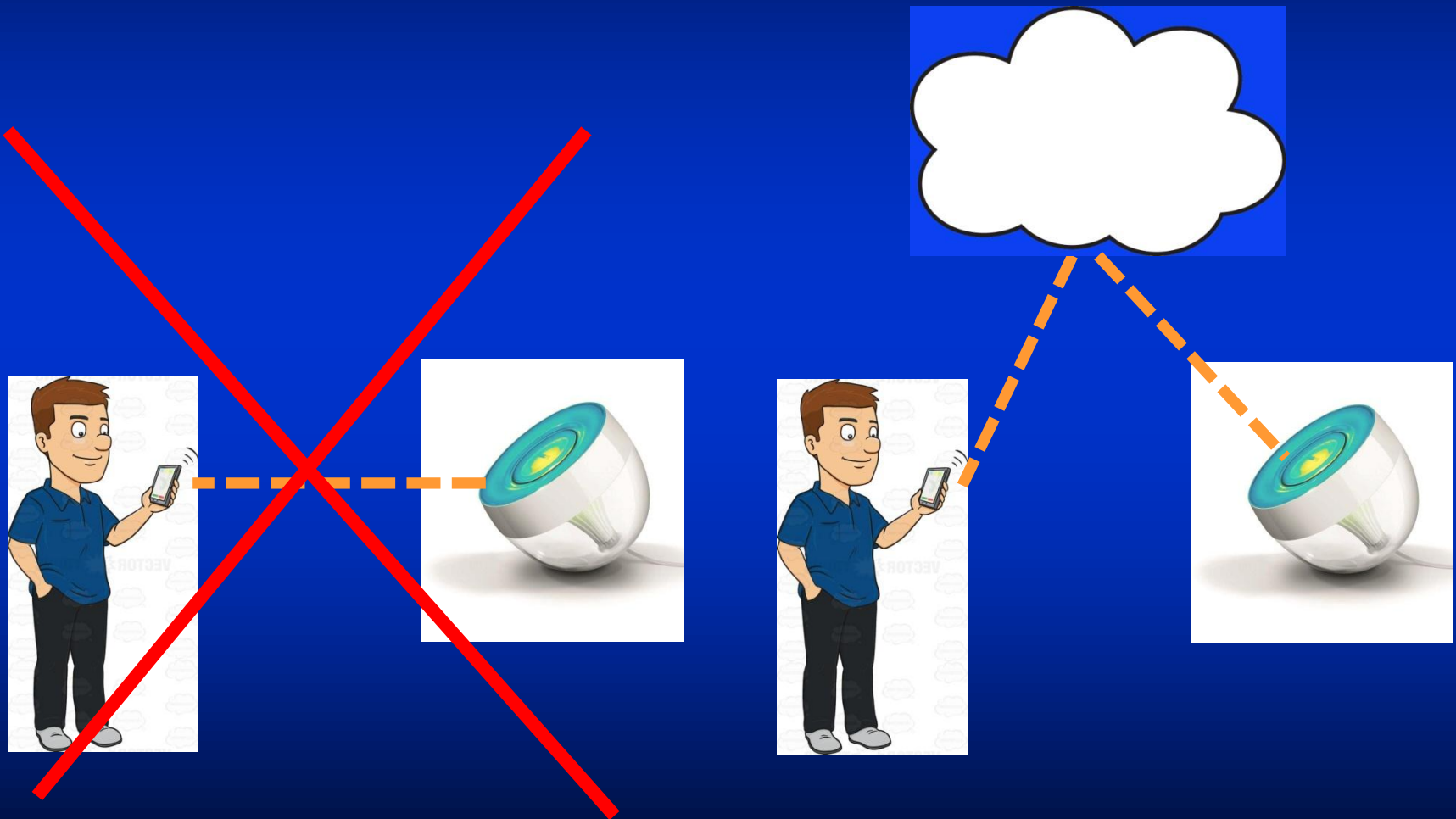
If depressed



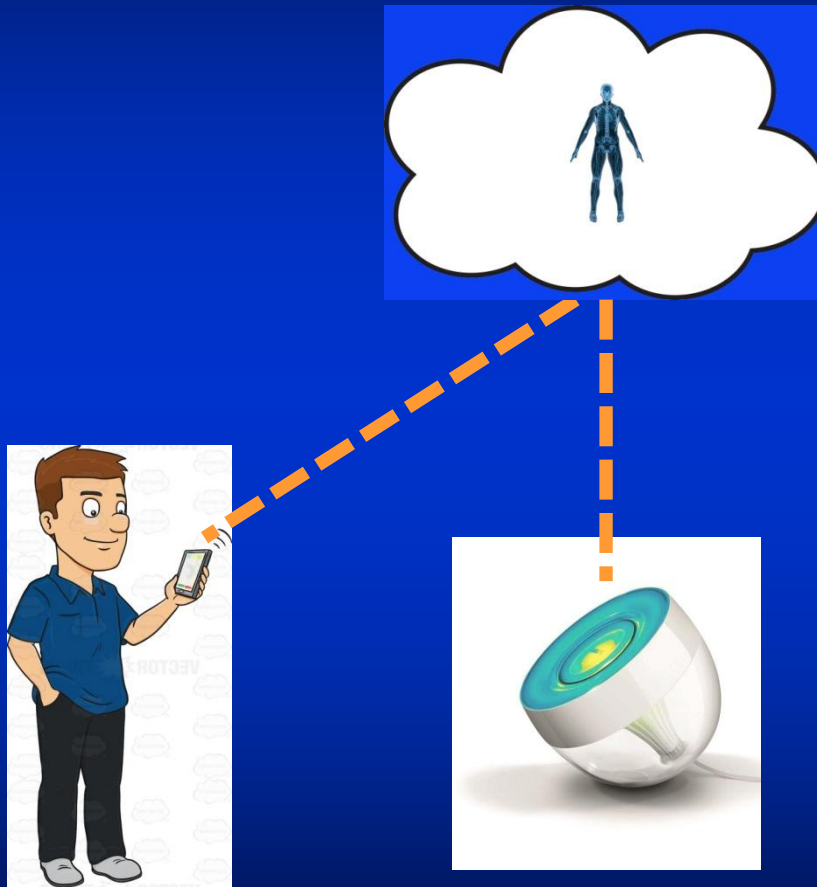
# How would this work?



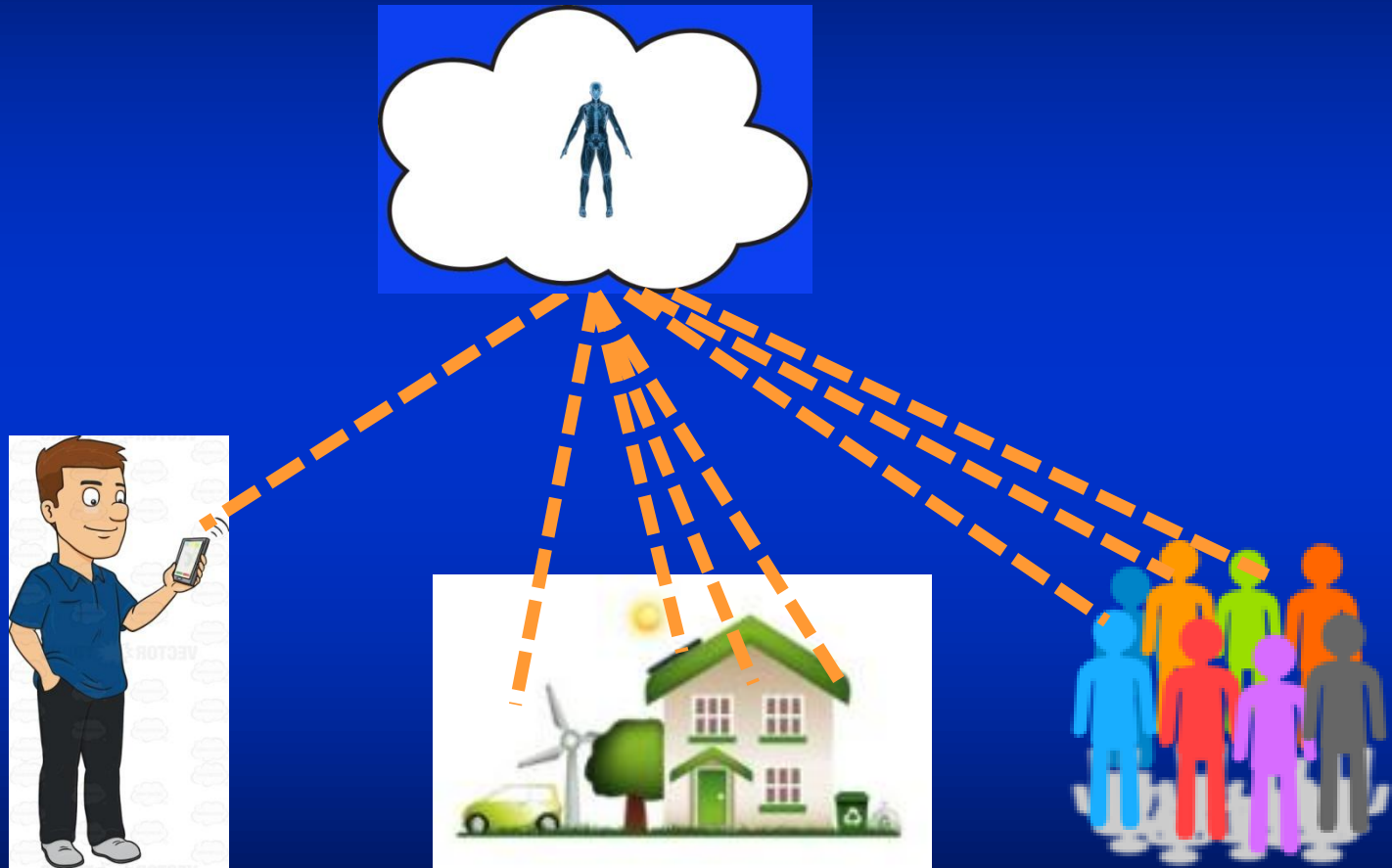
# What is the control architecture?



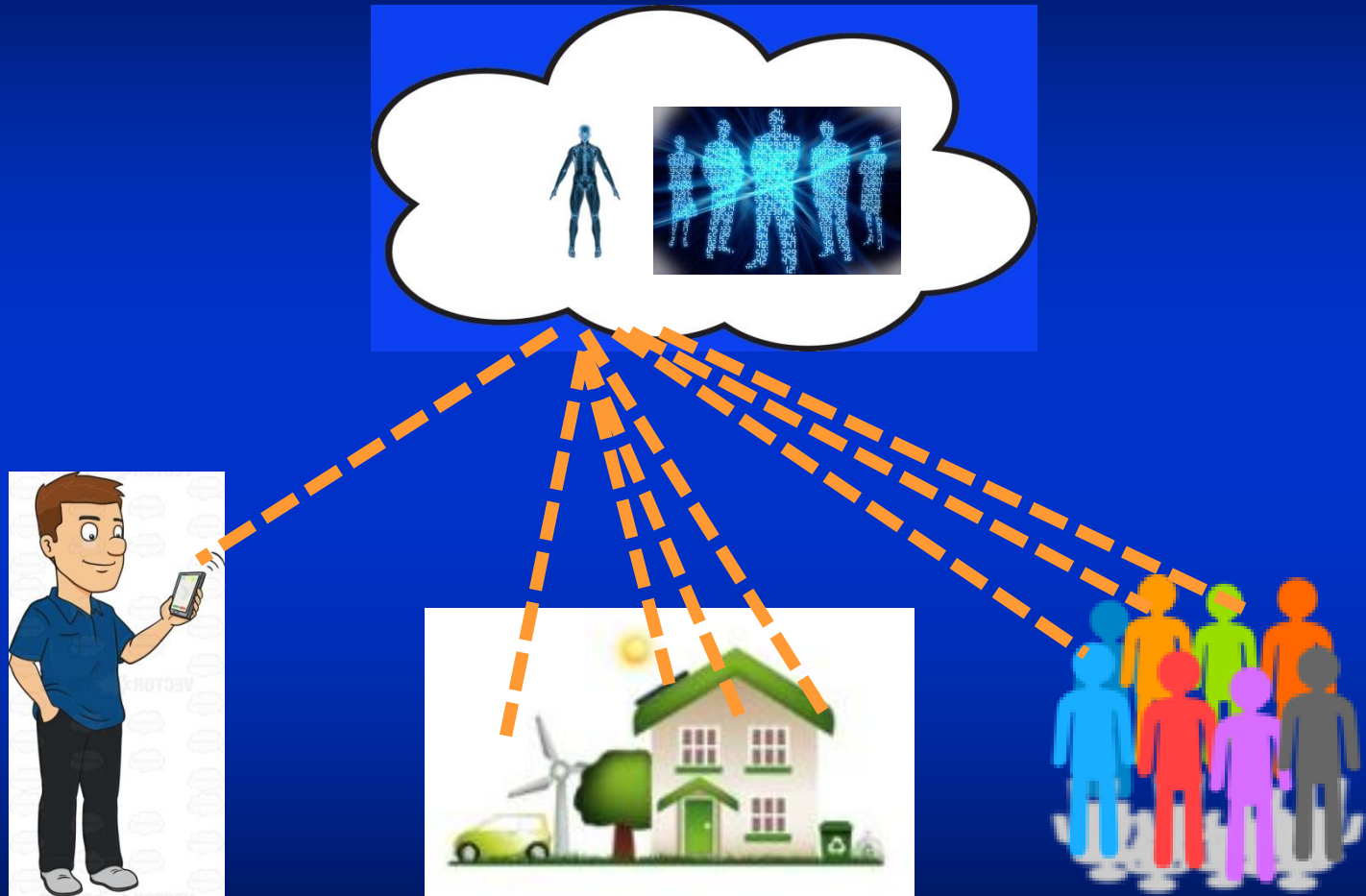
# Model in the Cloud



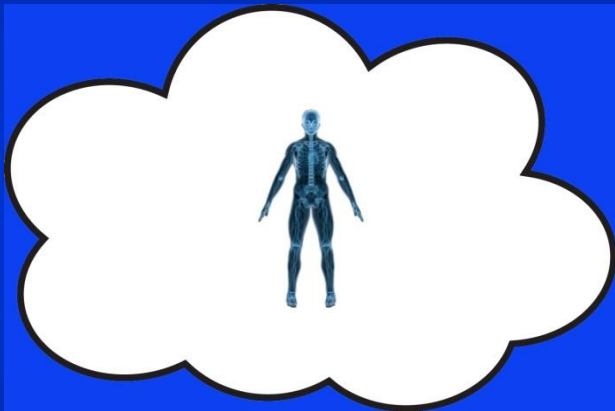
# Model in the Cloud



# Model in the Cloud



# Behavioral Model in the Cloud

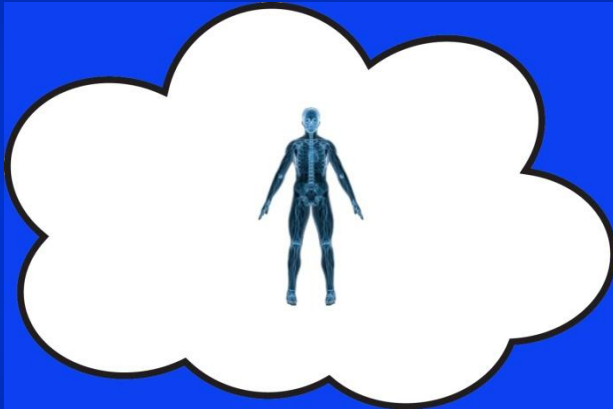


Procter & Gamble



Amazon

# Behavioral Model in the Cloud



Proctor & Gamble



Amazon

All this is possible with good data !



More than Behavior....

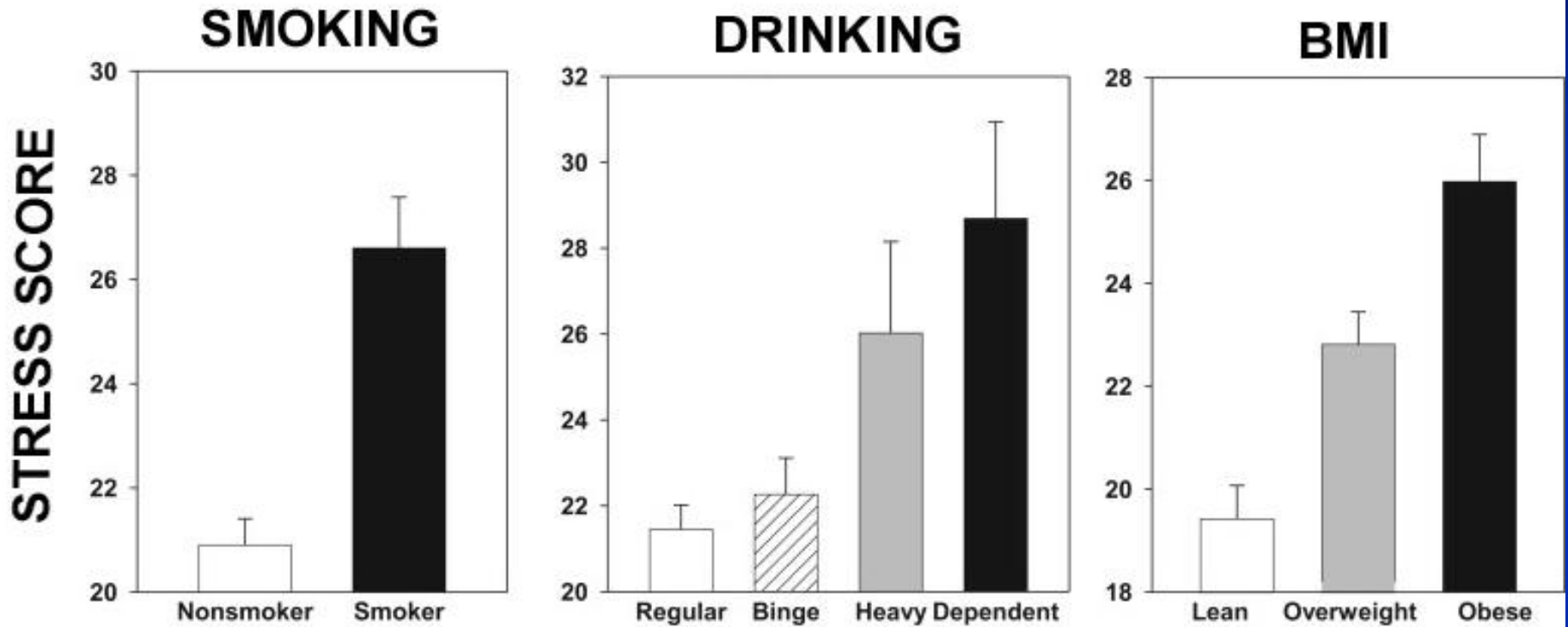
# NCD Causes, Risk Factors

GENES + BEHAVIOR = NCD  
DISEASE

# A New Factor

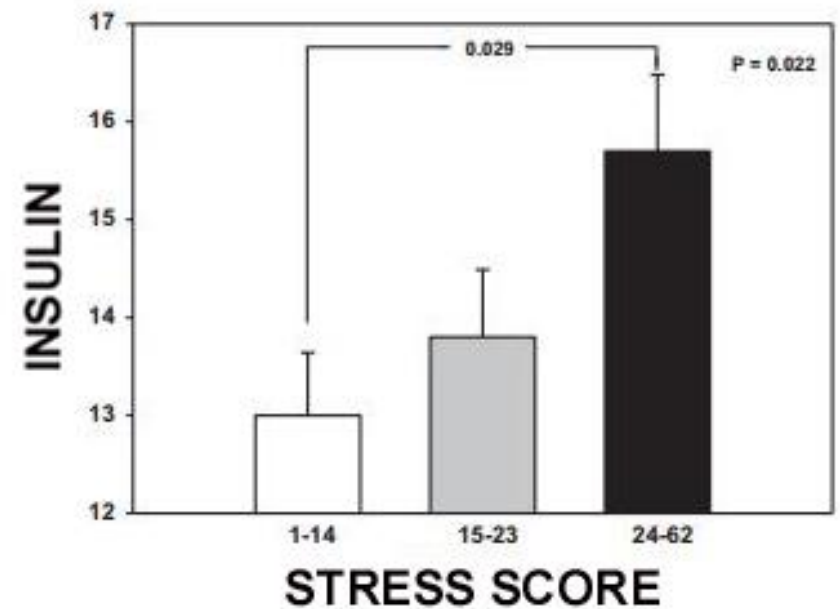
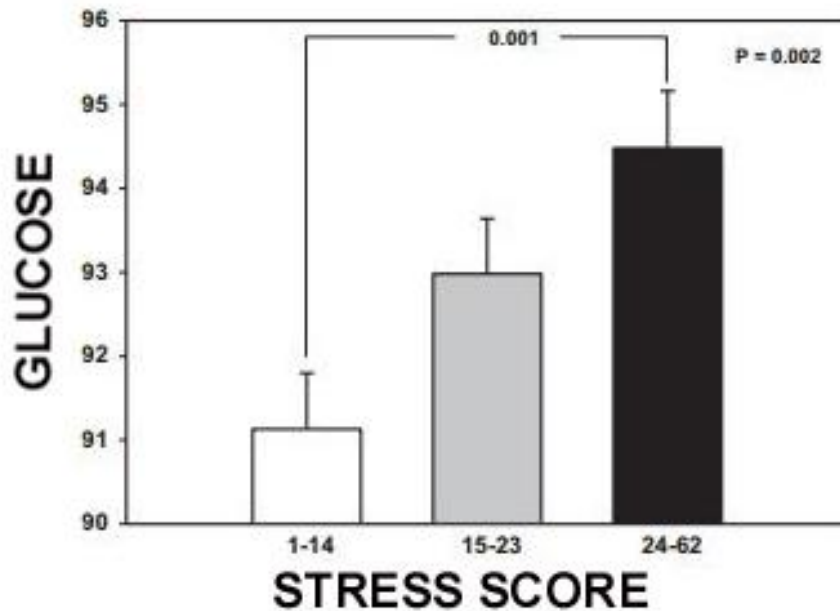
GENES + BEHAVIOR + AFFECT (STRESS) = NCD DISEASE

# Stress and Addictive Behavior



Sinha, Biol Psychiatry 2013, 73:827-835

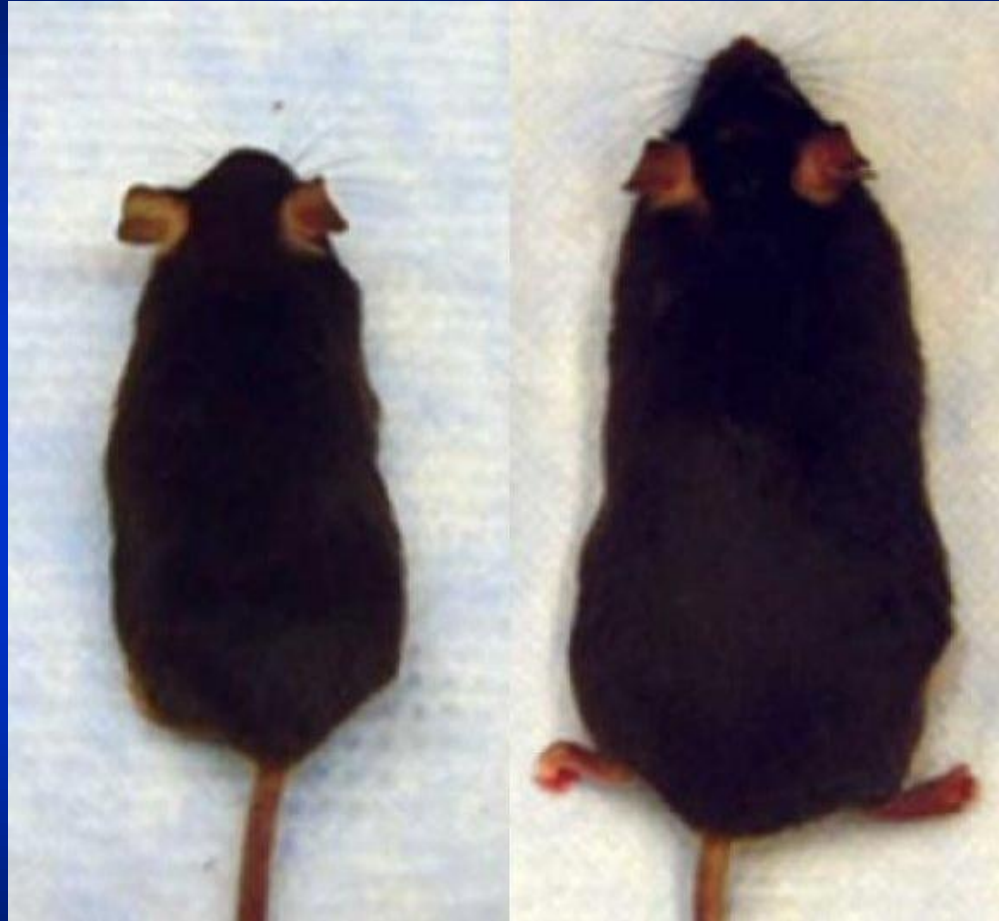
# Stress and Pre-Diabetes Factors



Sinha, Biol Psychiatry 2013, 73:827-835

# Stress and Weight Gain

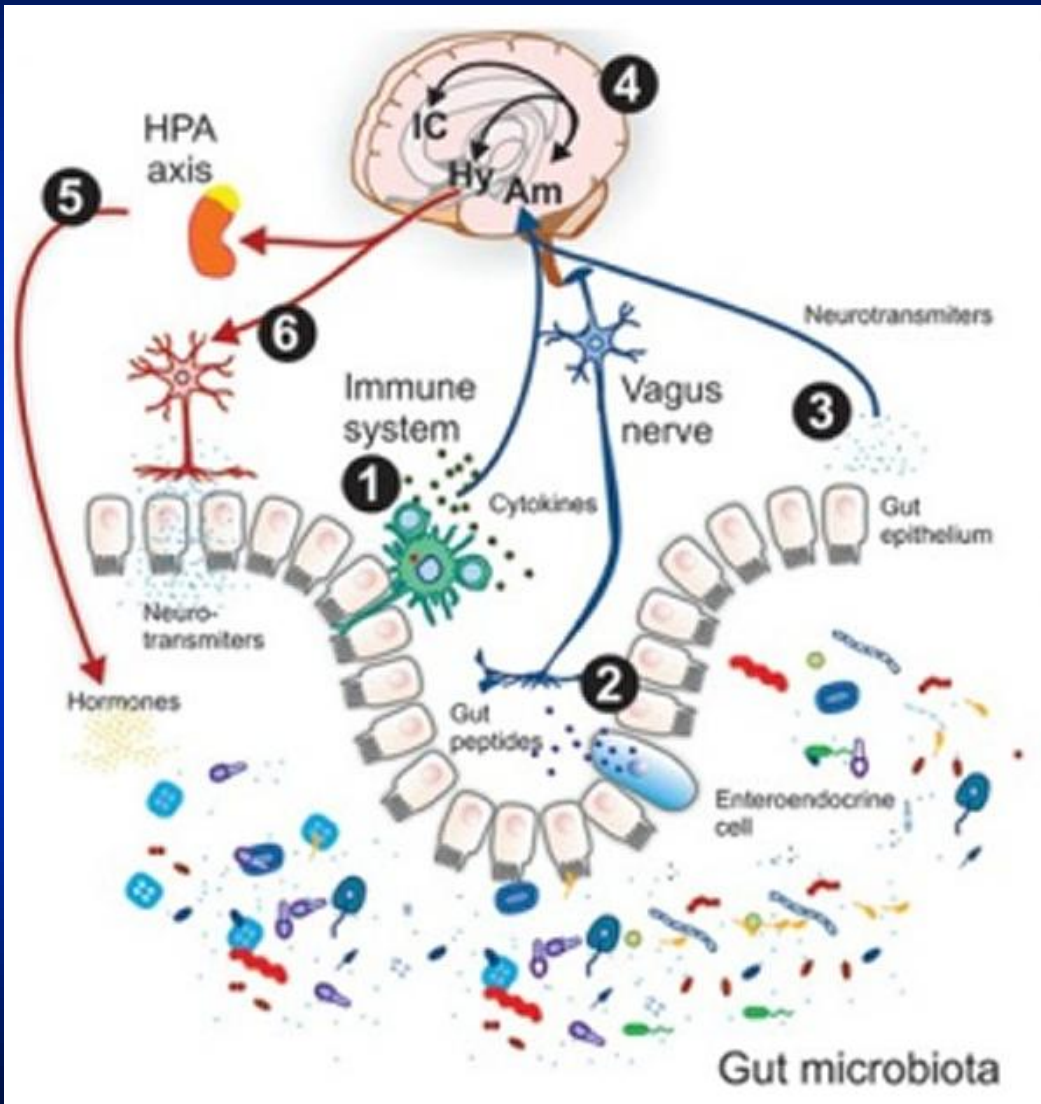
Not  
Stressed



Stressed

*Kuo et al, Nature medicine 13.7 (2007): 803-811*

# Brain Gut Pathways



*Montiel-Castro et al, Front Interg Neuro (2013)*

# Brain Gut Pathways



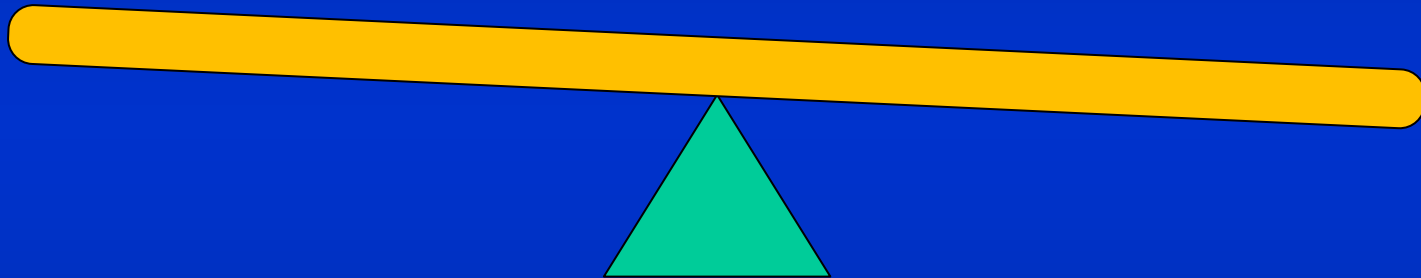
*Montiel-Castro et al, Front Interg Neuro (2013)*



# Disregulation, Instability

Too little  
growth

Too much  
growth



Neuro-  
degenerative

Cancer

Health = Homeostasis = staying in balance

# Reducing Stress



# Technology as Training Wheels



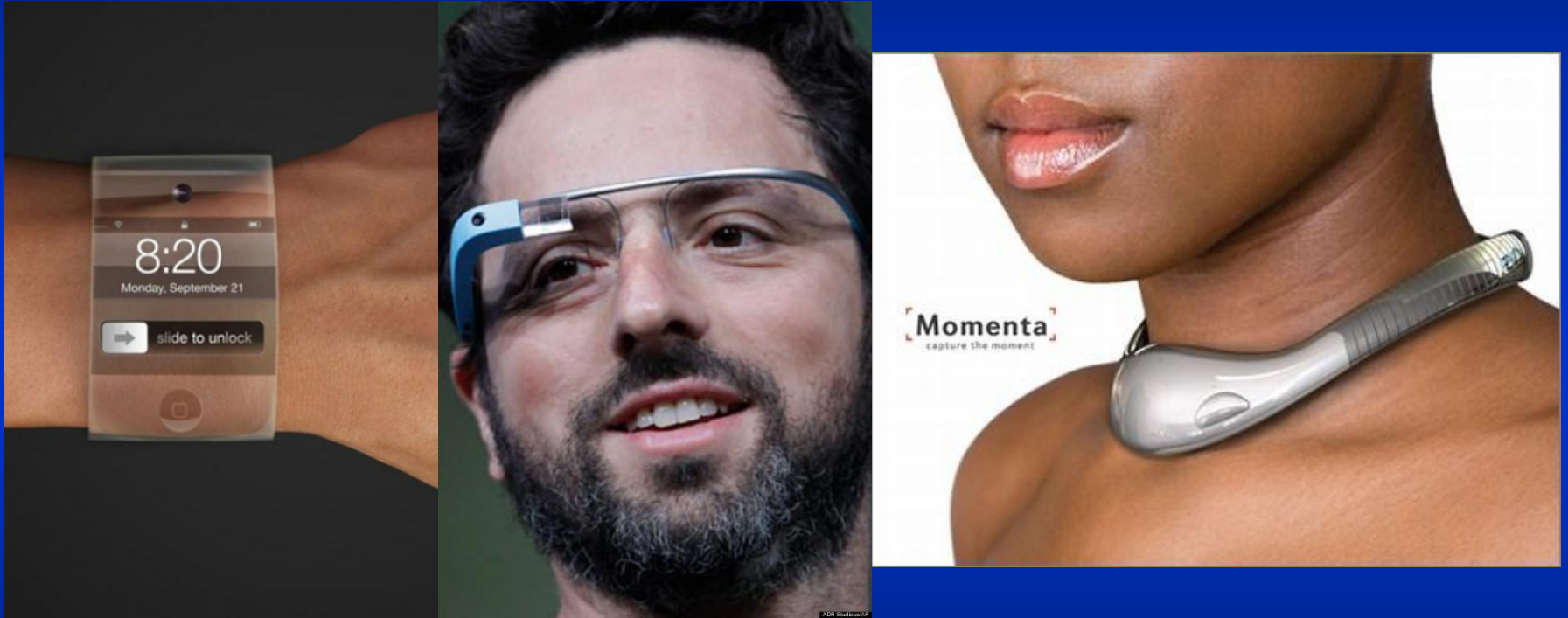
Self-Agency

# Summary

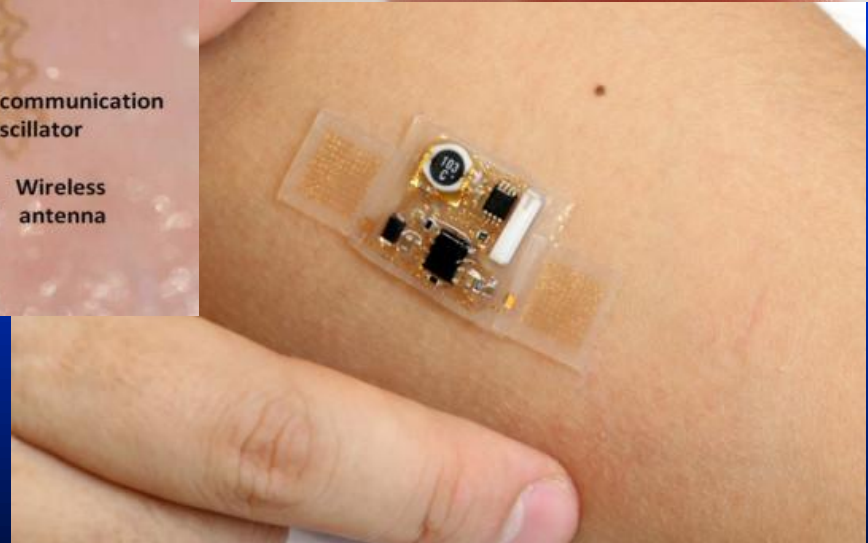
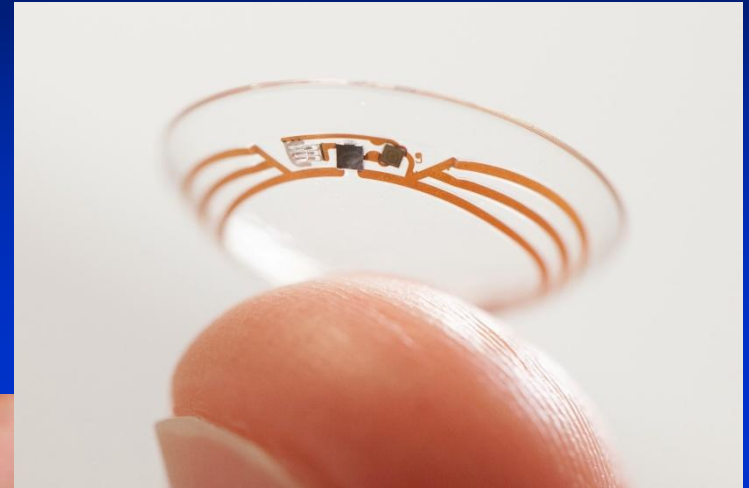
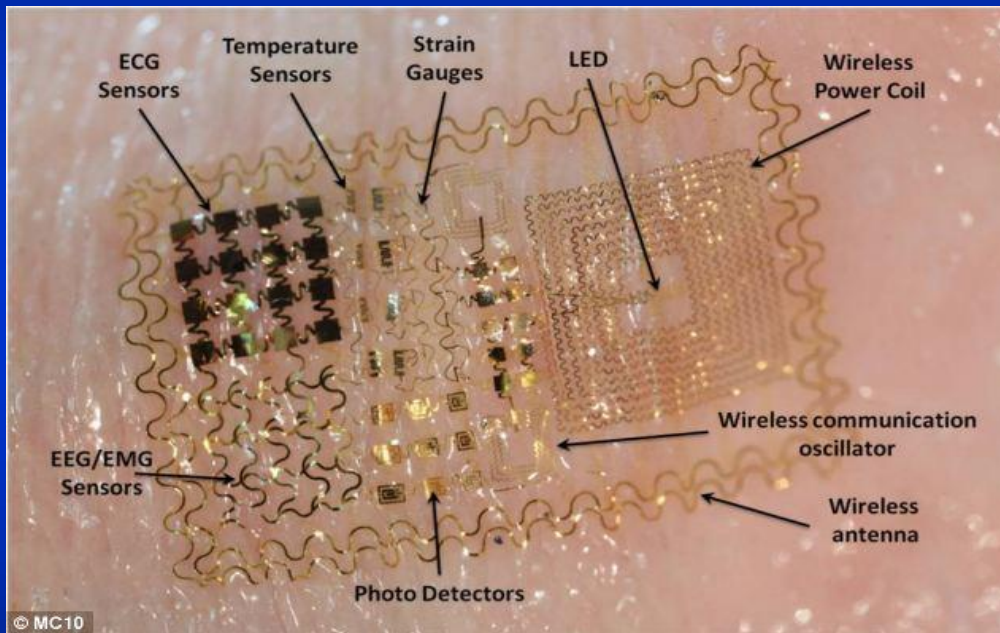
# Future Technologies for Behavior Medicine will include not only phones, ....



# But also wearables



# and Embeddables



# ... and Smart Furniture





# ... and Beds



... and Car Seats,



... and our own Body!



- Body
- Mind, Brain

# Thankyou.

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