



EDMI Microsystems and Microelectronics

MICRO-614: Electrochemical Nano-Bio-Sensing
and Bio/CMOS interfaces

Lecture #1 - Introduction

Human Metabolism Monitoring
by Electrochemical Sensing:
Present & Future!

The 'TIME' forecast on Human++



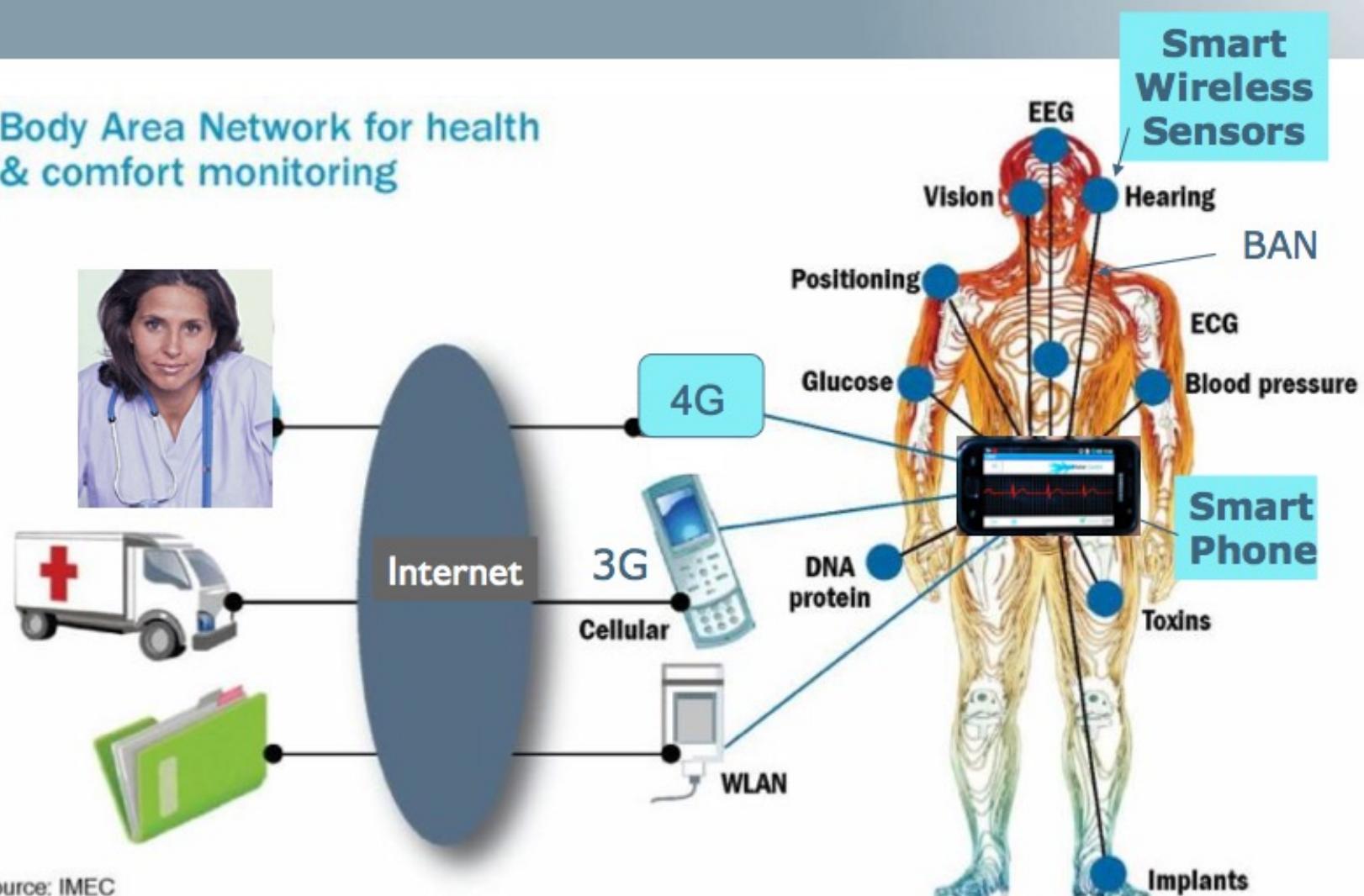
[TIME, February 2011]

(c) S.Carrara

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Fully-Connected Human++

Body Area Network for health & comfort monitoring

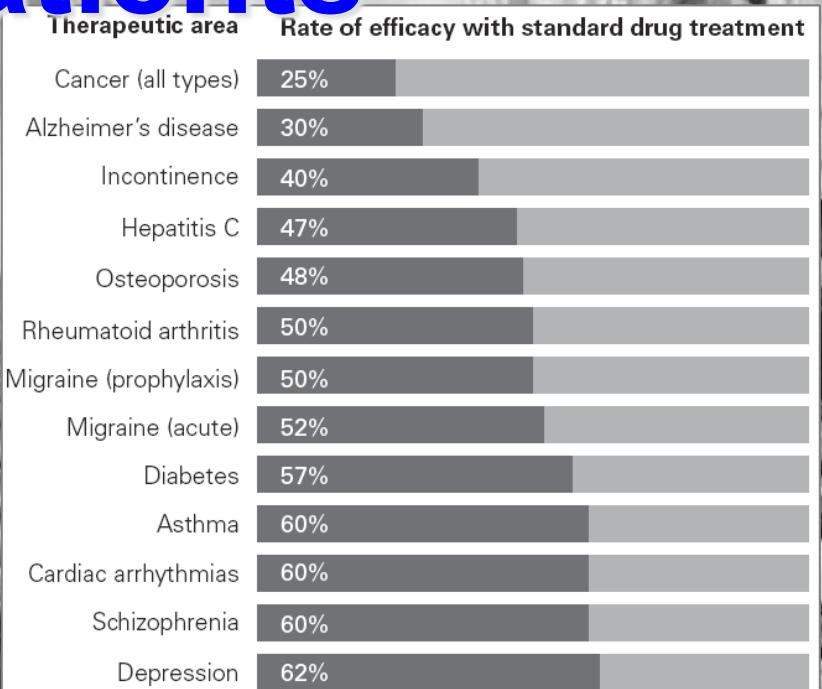
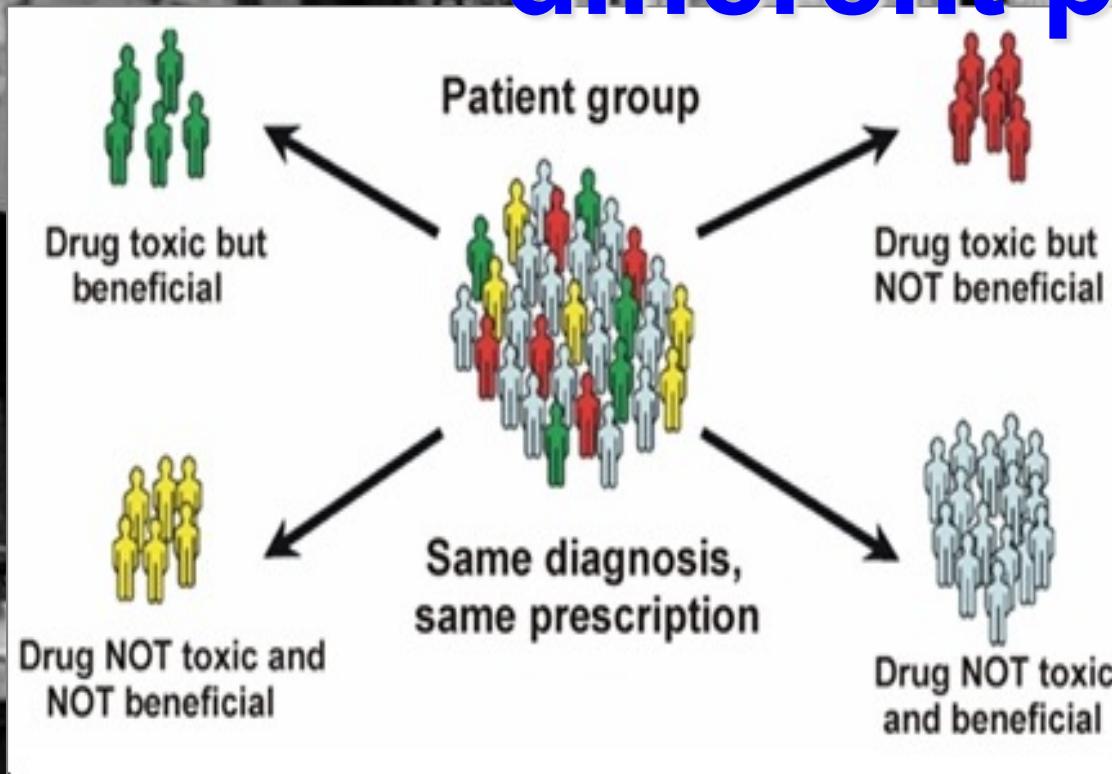


Source: IMEC

Courtesy, Hugo De Man (IMEC)

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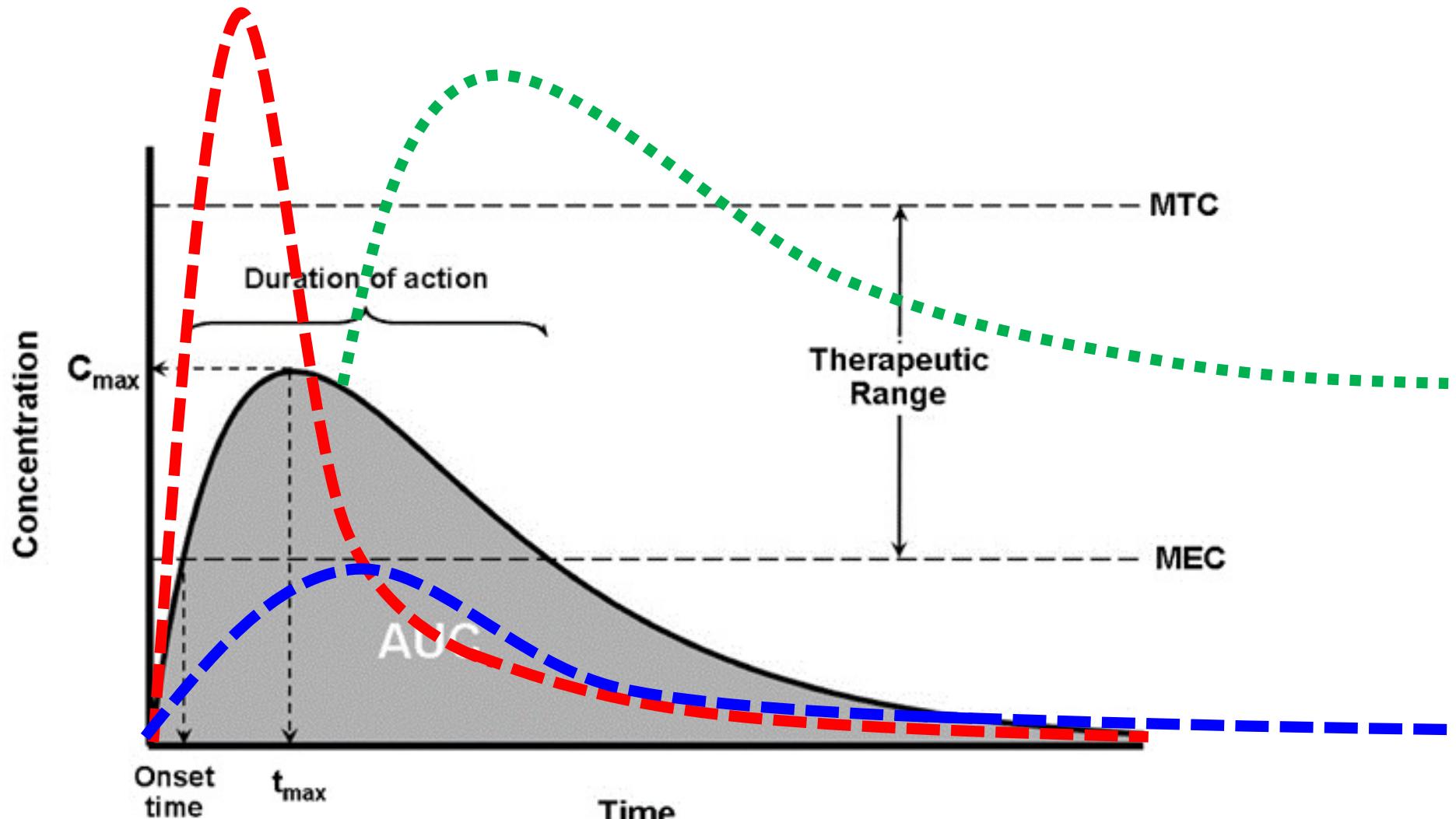
Different outcomes for different patients



For depression, the data apply specifically to the drug class known as selective serotonin reuptake inhibitors.

Source: Brian B. Spear, Margo Heath-Chiozzi, and Jeffrey Huff, "Clinical Application of Pharmacogenetics," *Trends in Molecular Medicine* (May 2001).

Patients' metabolism drive the Drugs effect in time!



Course Motivation: From Labs to Hands



- 100.000 \$ (machinery)
- 1.000 \$ the single μ -array



Label-Free

- 50 \$ (machinery)
- 0.05 \$ the single strip



Bayer HealthCare

(c) S.Carrara

Next step: the future already begun



Glucose Personal Diagnostics on our iPhones

(c) S.Carrara

Next step: the future already begun



How to use the FreeStyle Libre System

1. **Apply sensor** with applicator
2. **Scan sensor** using FreeStyle Libre Reader
3. **Get reading** on the reader

FOR FULL INSTRUCTIONS

www.freestylelibre.co.uk

OVERVIEW

HOW TO USE

FIND OUT MORE

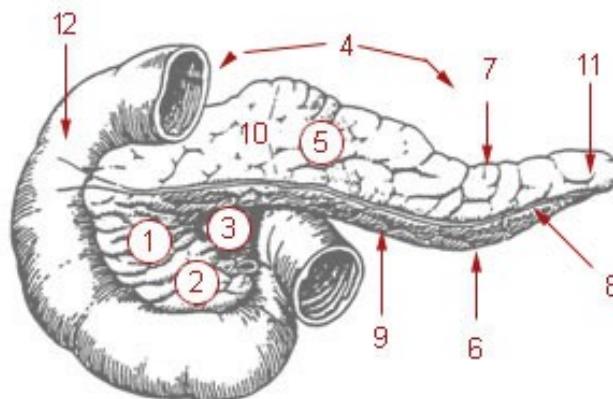
Glucose Personal Diagnostics on our Skin

(c) S.Carrara

The Pancreas Functions

IN-put Signals

Bile acids →
pH →
Syrinic proteases →
Glucose →
Glycagone pancreatic →
.....



OUT-put Signals

insulin
Lipase
Fospholipase A
Cholesterol estarase
Endopeptidase
Esopeptidase
Elastase
Ribonuclease
Enterochinase
.....

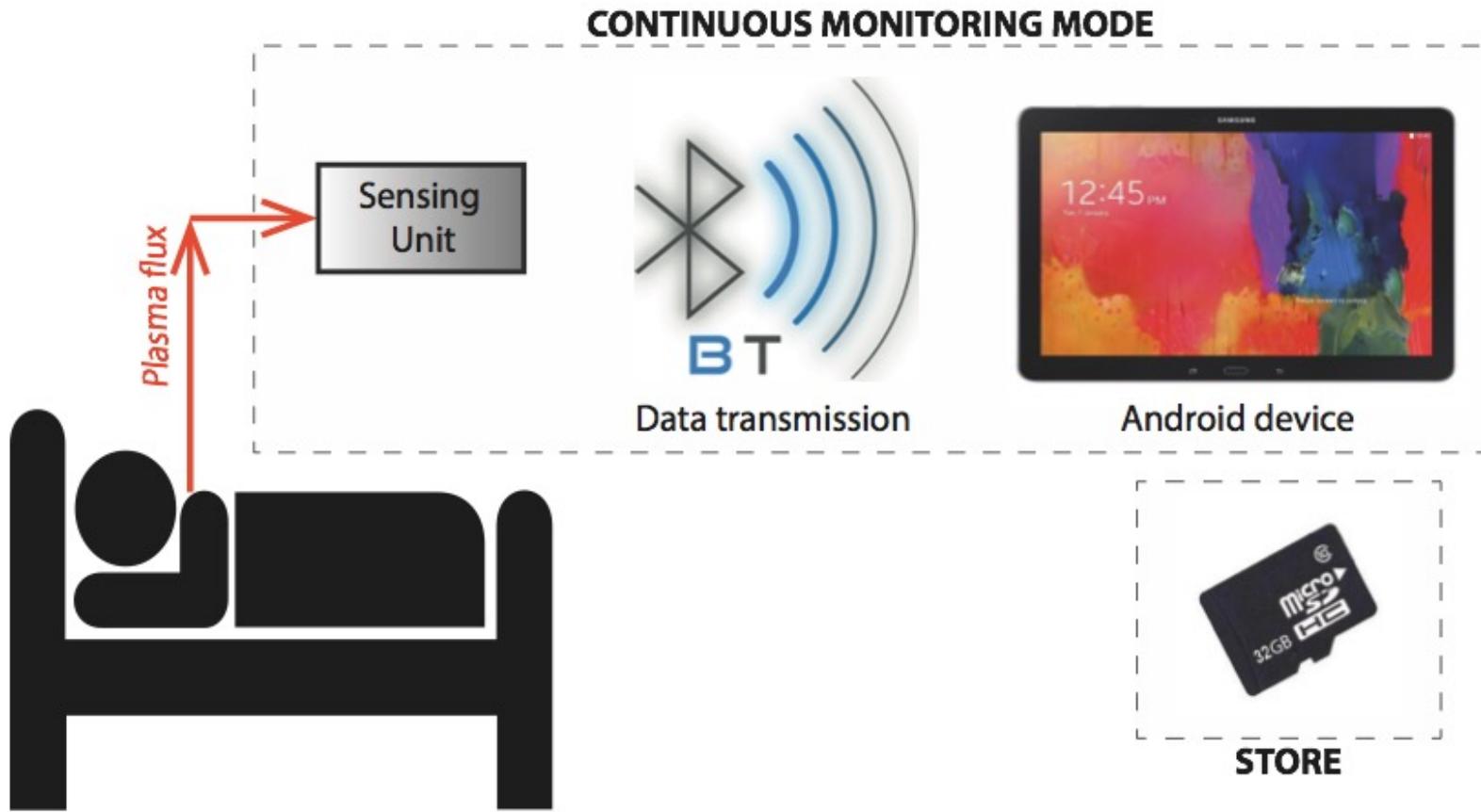
Intensive-Care-Units (ICU) Monitoring



The present monitoring scenario foresees lot of independent devices and input/output interfaces

(c) S.Carrara

Lab-on-a-chip for ICUs

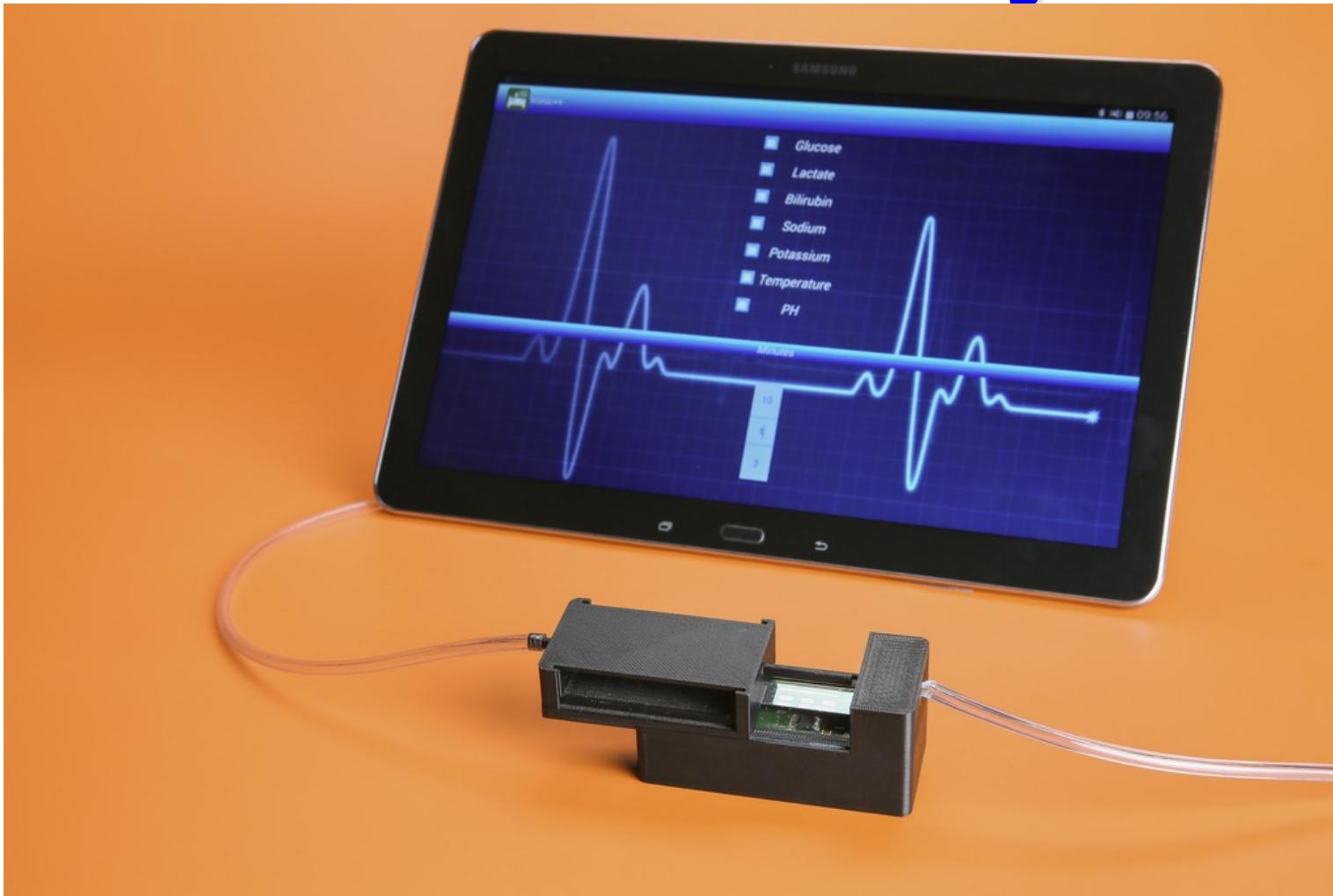


F. Stradolini, et al., *IEEE Sensors Journal* 16(2016) 3163 - 3170

Monitoring scenario where the main parameters of the patient are continuously displayed on an Android mobile device

(c) S.Carrara

The full connected system



The whole system with the Android™ interface that allows connectivity too

One Interface for Remote Monitoring of Patients in Intensive Care Units



Image | Bam Labs

The whole system with the Android™ interface that allows connectivity too

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Recommended Games

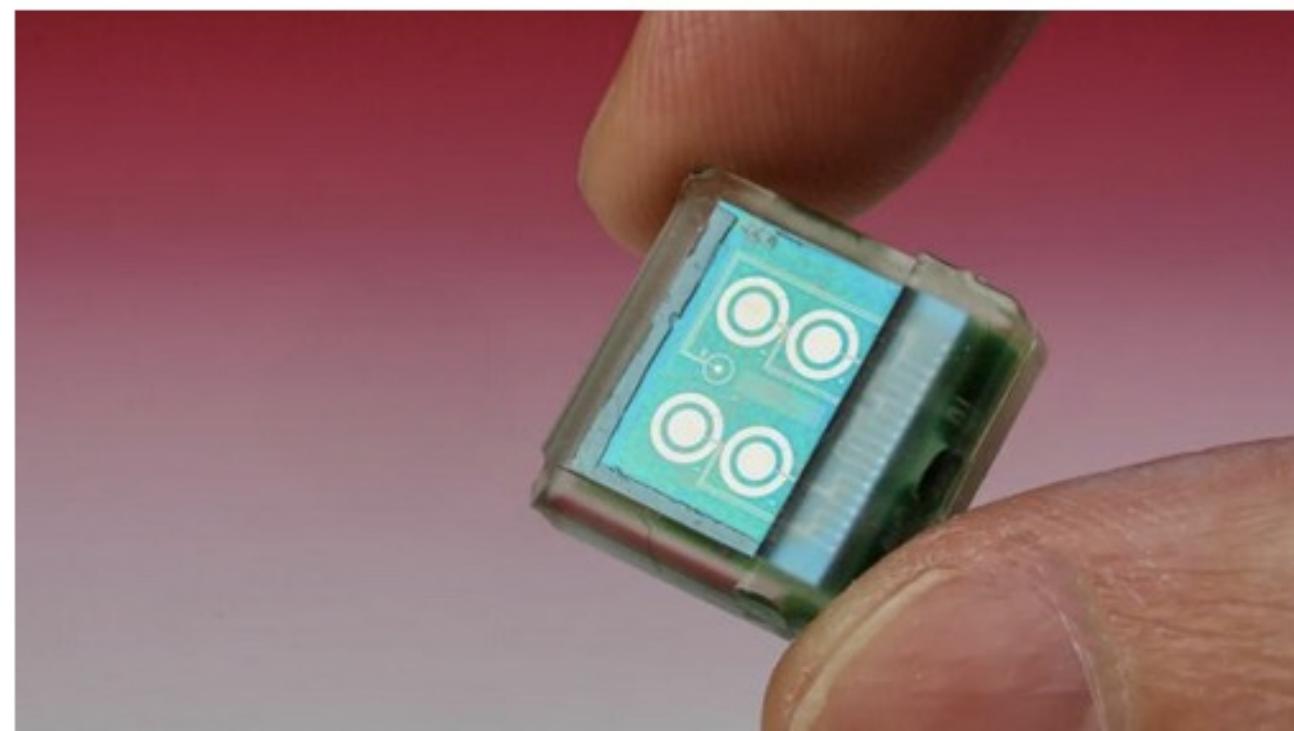


[More games »](#)

A subcutaneous biosensor chip to revolutionize tomorrow's medicine

May 29, 2015 9:26 AM

[Relaxnews](#)



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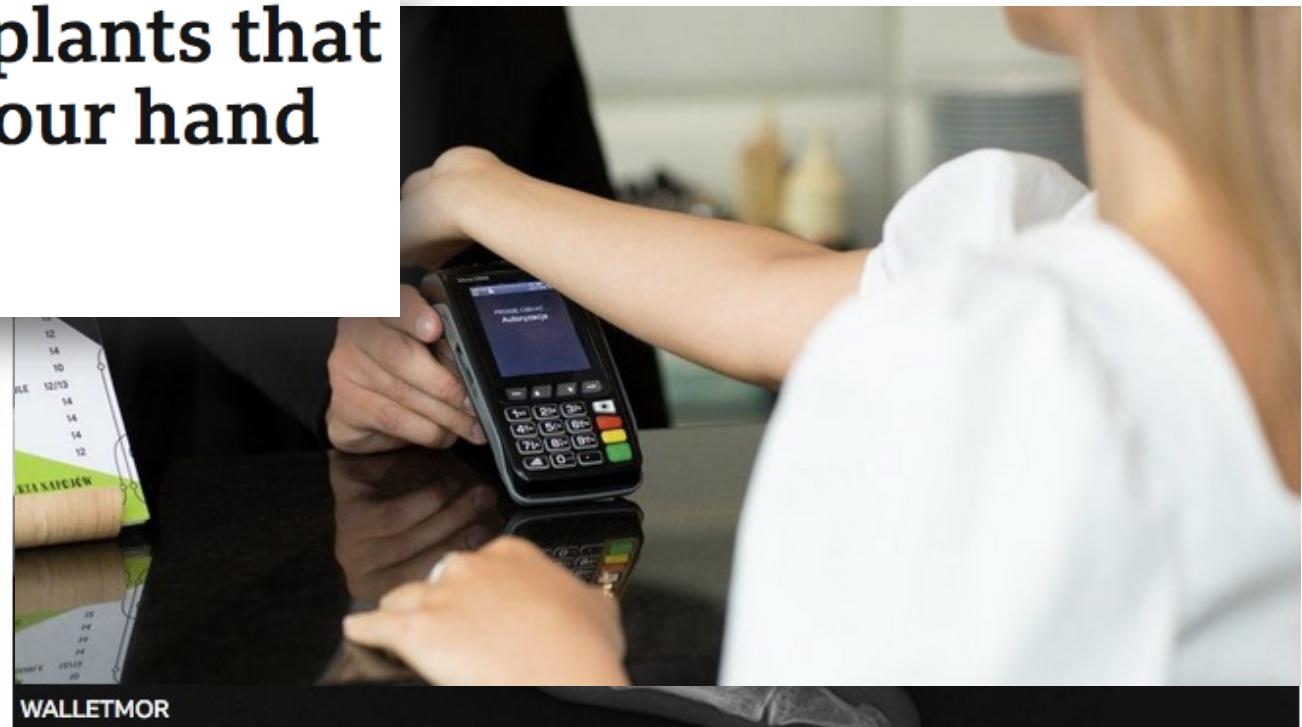
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The microchip implants that let you pay with your hand

By Katherine Latham
Business reporter

April, 11th , 2022



An x-ray showing a Walletmor implant, which are injected into a person's hand after a local anaesthetic

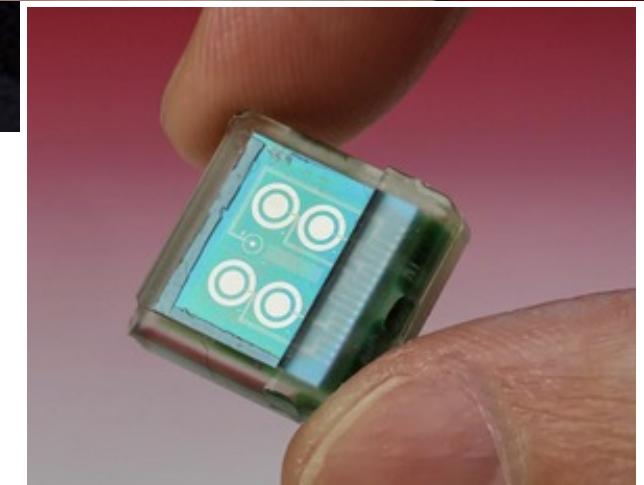
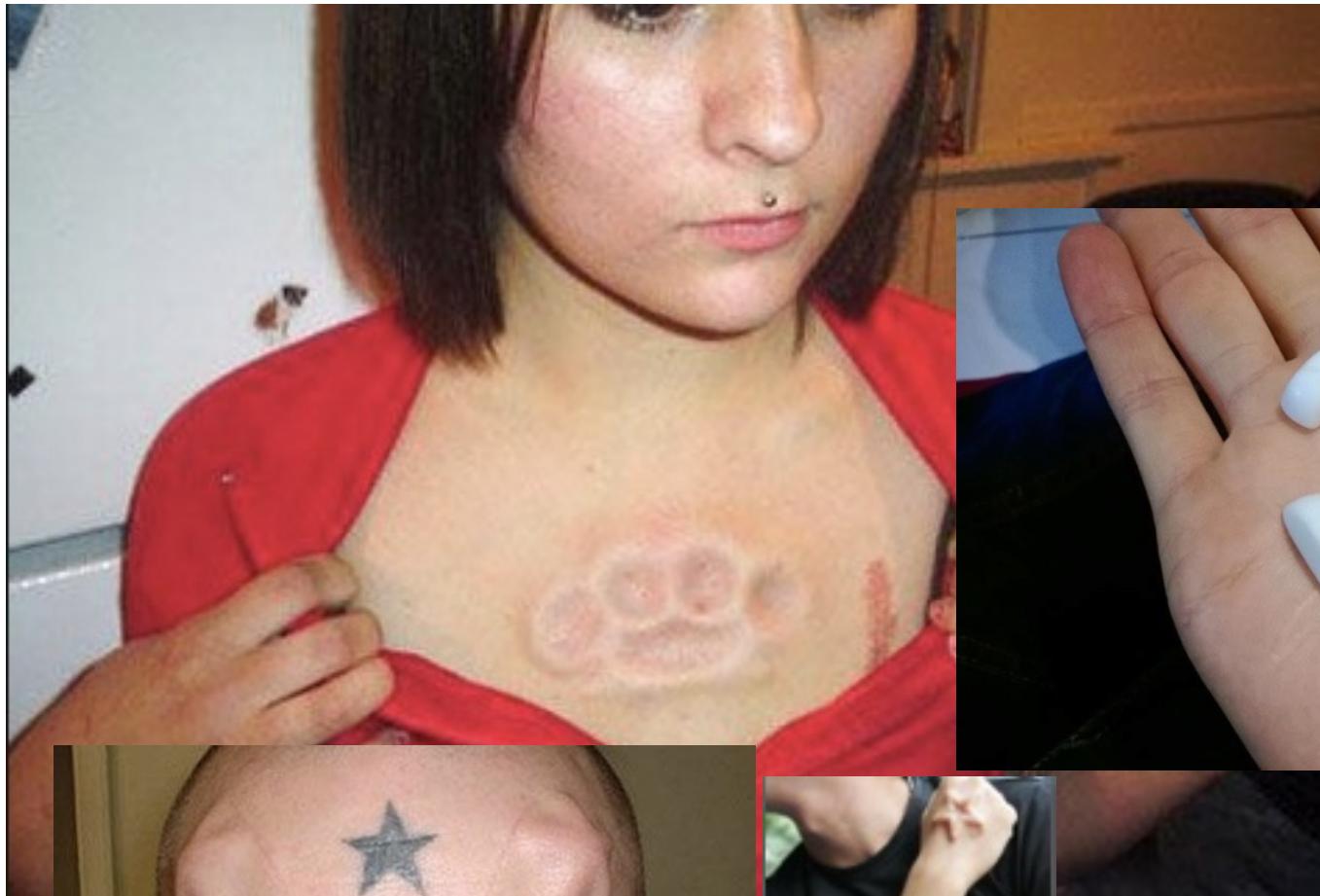
For many of us, the idea of having such a chip implanted in our body is an appalling one. but a 2021 survey of more than 4,000 people across the UK and the European Union found that 51% would consider it.

Chips under the skin? See video on Moodle!



[EuroNews, June 2015]

Under the skin for body sculpting

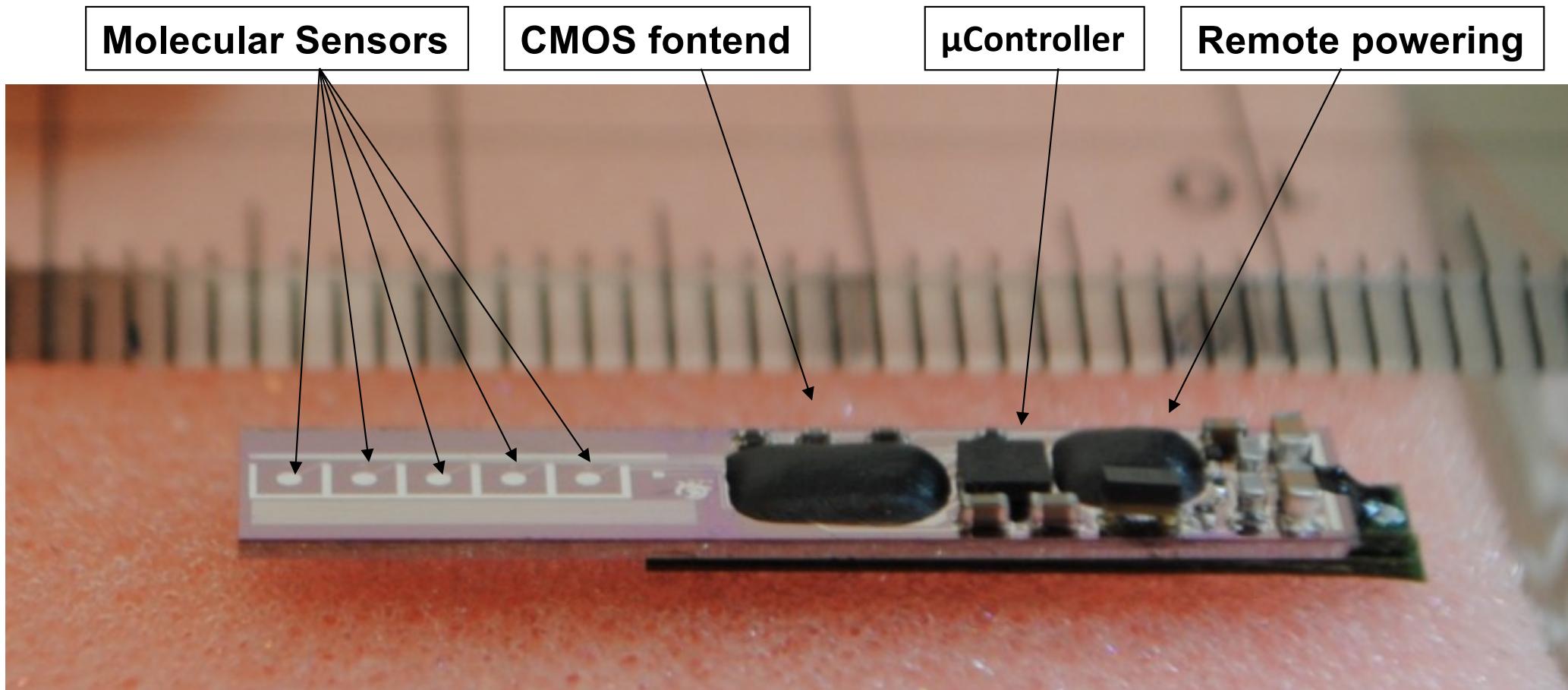


(c) S.Carrara

Enhancing human being



Size and Shape to be injectable as a Needle?



The IC has been fabricated in UMC 0.18 technology and
interfaced to the passive multi-panel platform

(c) S.Carrara

ECG monitoring by Medtronic



Mark Phelps by Medtronic, and the Reveal LINQ™ system

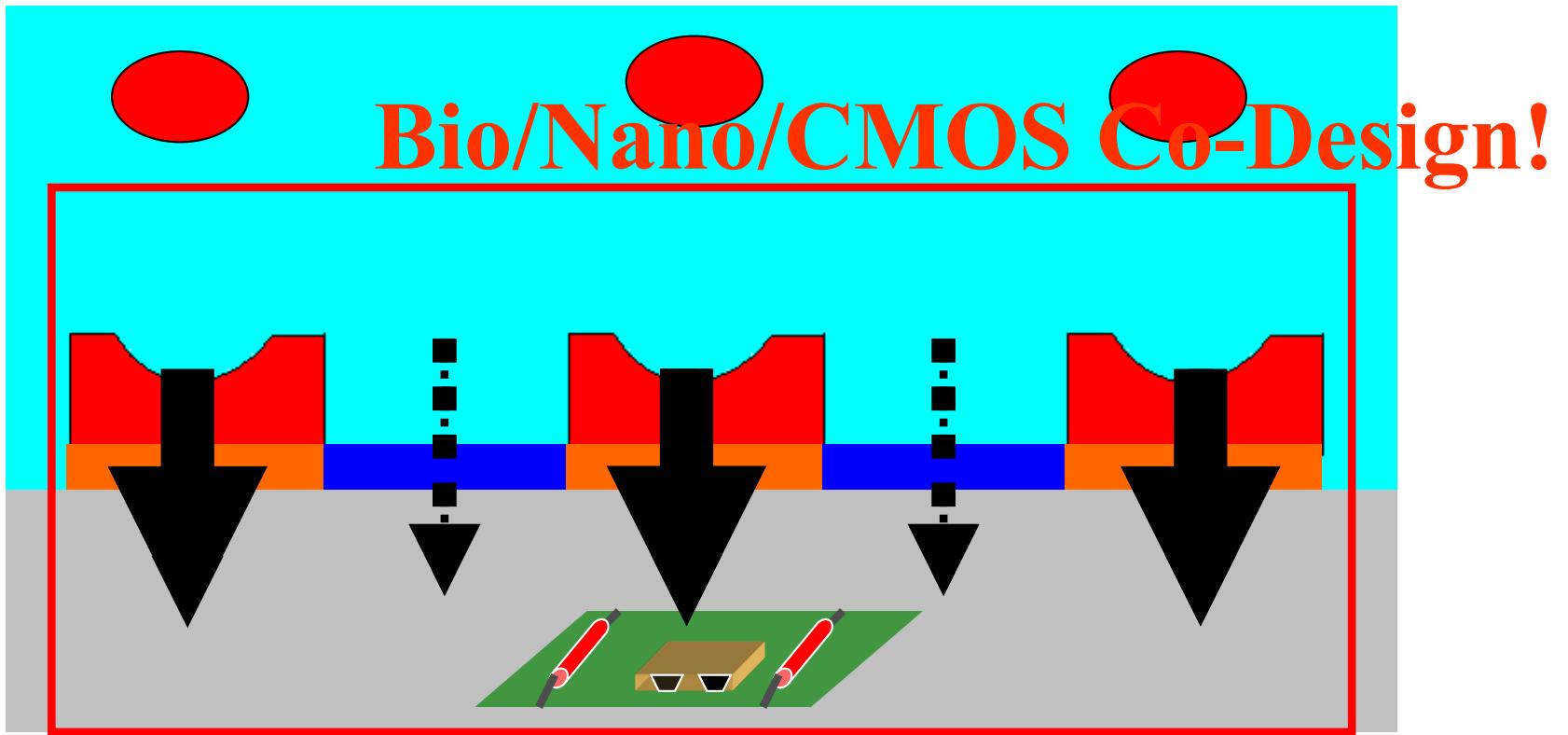
(c) S.Carrara

Toward Ultrasensitive Biosensors:

1. Fully integration of Biomolecules to assure specificity
2. Fully integration of Nano-structures to assure sensitivity
3. Proper CMOS frontends to assure
 - (i) Correct Voltage driving
 - (ii) Precise Current measurements,
 - (iii) Reliability in Temperature and pH

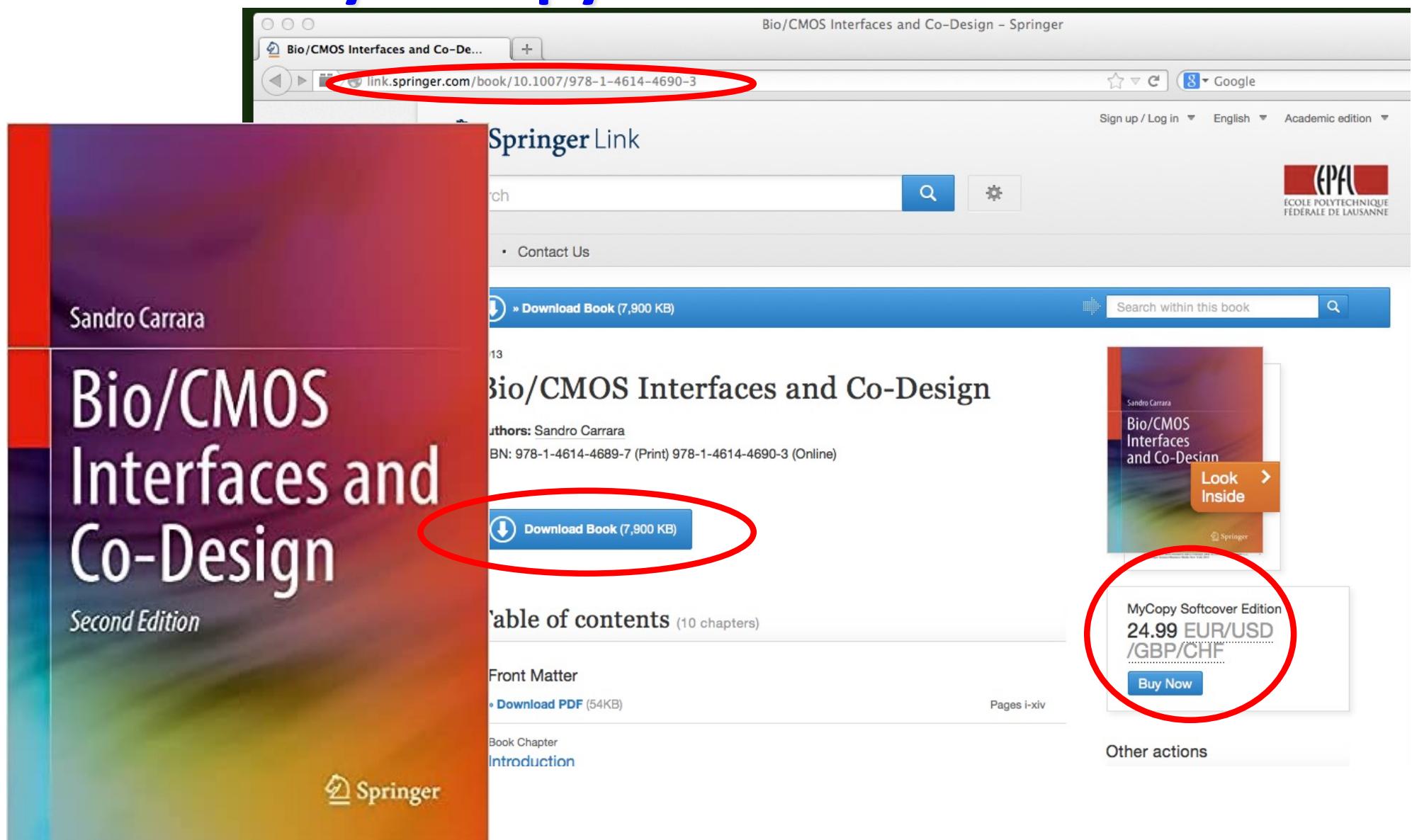
Bio/Nano/CMOS Co-design !

CMOS/Sample interface



The interface between the CMOS circuit and the bio-sample needs to be deeply investigated and organized

Get you copy of the Textbooks



The screenshot shows a web browser displaying the Springer Link page for the book "Bio/CMOS Interfaces and Co-Design" by Sandro Carrara. The page includes the book cover, a table of contents, and purchase options. Several buttons and text elements are circled in red to highlight them:

- The URL in the browser's address bar: link.springer.com/book/10.1007/978-1-4614-4690-3
- The "Download Book (7,900 KB)" button on the left sidebar.
- The "Look Inside" button on the right sidebar.
- The price "24.99 EUR/USD /GBP/CHF" and the "Buy Now" button on the right sidebar.

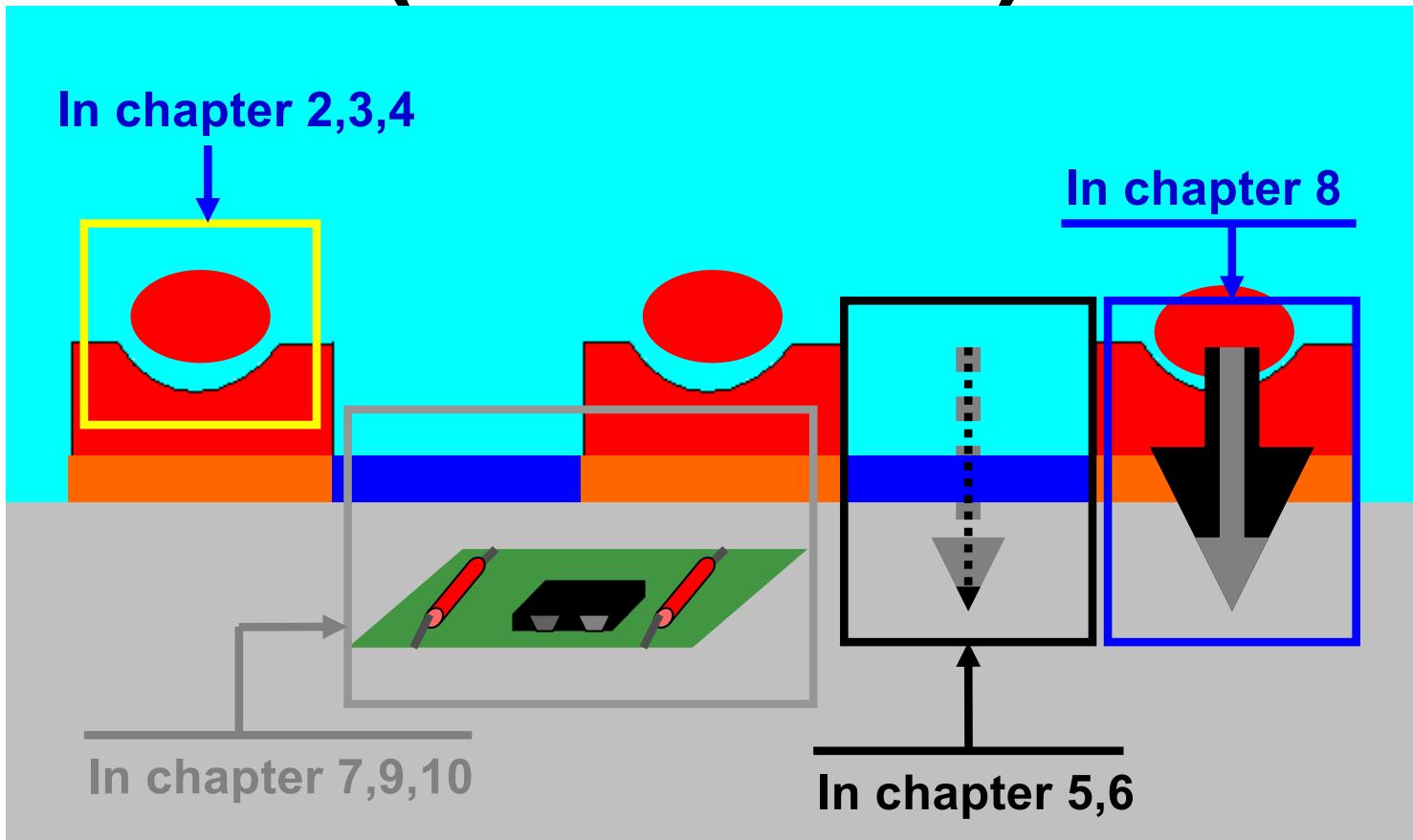
Bio/CMOS Interfaces and Co-Design
Sandro Carrara
Second Edition
Springer

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Look Inside

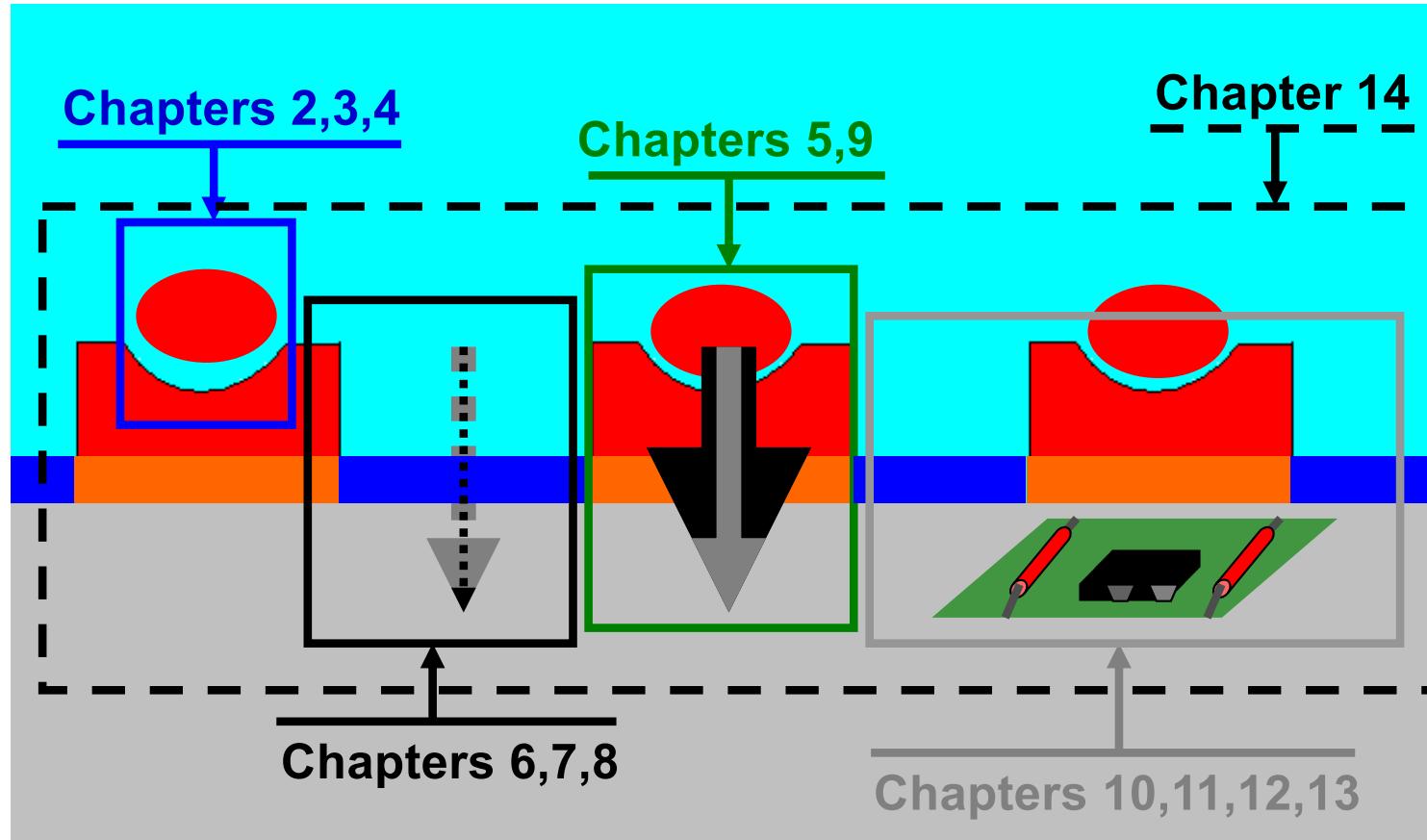
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Bio/CMOS interface book (1st Edition)



Introduction to Personal electronics, Distributed Diagnostics, and
Bio/CMOS interfaces in Chapter 1

Bio/CMOS interface book (2nd Edition)



Introduction to Personal electronics, Distributed Diagnostics, and
Bio/CMOS interfaces in Chapter 1

Course outline

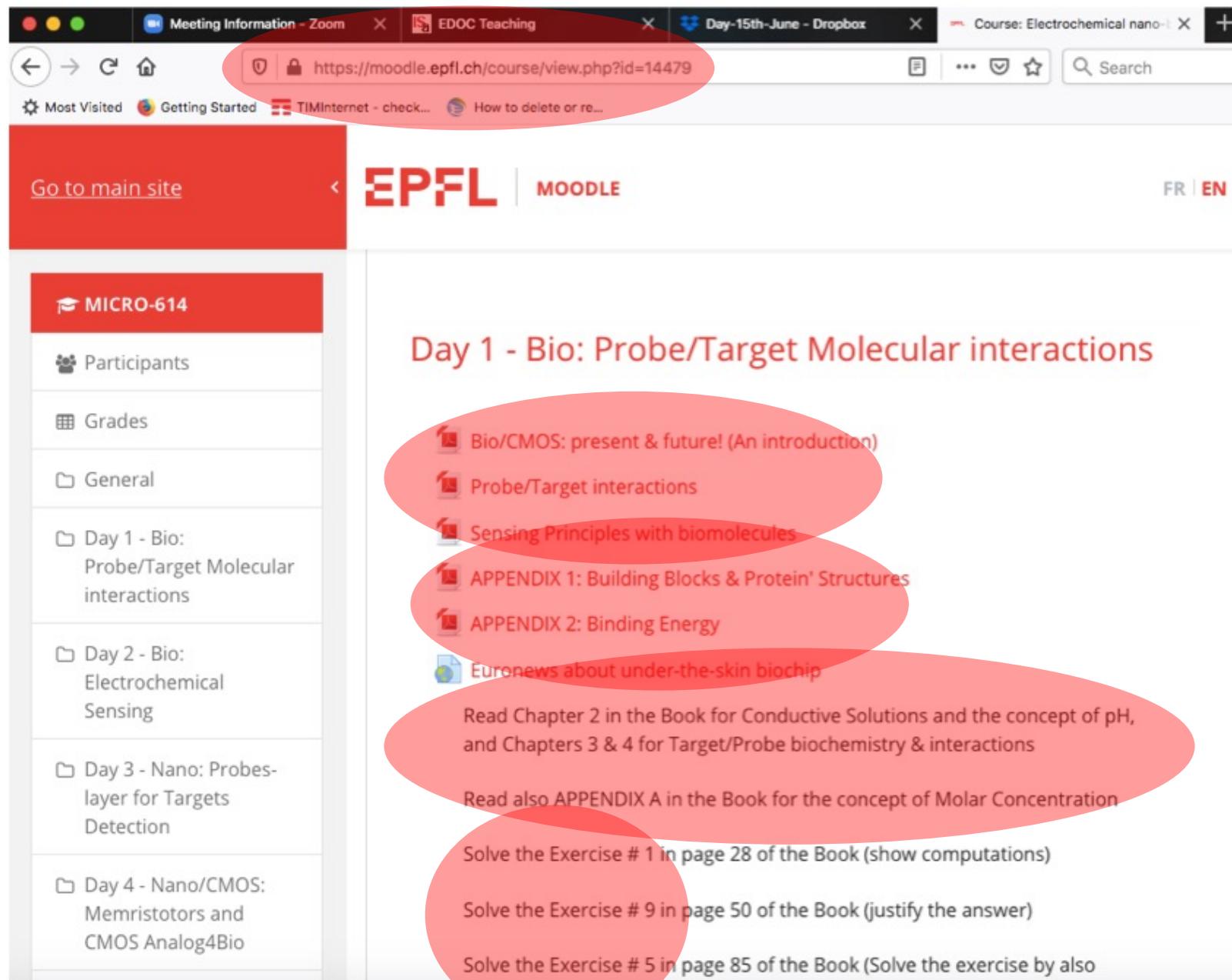
1. Intro about Metabolism Monitoring
2. Bio 1 metabolites, Peptides, Proteins & DNA
3. Bio 2 Probes/targets interaction
4. Bio 3 Detection principles
5. Bio 4 Amperometric Biosensors
6. Nano 1 Functionalization: Methods & Models
7. Nano 2 Characterisation by RM, SPR, SEM, AFM
8. Nano 3 Preventing ET
9. Nano 4 Enhancing ET
10. Nano 5 Memristive Sensing
11. CMOS 1 in Constant Bias
12. CMOS 2 in Scanning Voltage
13. CMOS 3 for DNA: Capacitive & Amperometric
14. CMOS 4 Memristive Sensing
15. CMOS 5 Beyond implantable & wearable

Bio

Nano

CMOS

To fruitfully follow the course



The screenshot shows a web browser window with the following details:

- Tab Bar:** Meeting Information - Zoom, EDOC Teaching, Day-15th-June - Dropbox, Course: Electrochemical nano..., +
- Address Bar:** https://moodle.epfl.ch/course/view.php?id=14479
- Page Header:** Go to main site, EPFL MOODLE, FR | EN |
- Left Sidebar (Course Navigation):**
 - MICRO-614**
 - Participants
 - Grades
 - General
 - Day 1 - Bio: Probe/Target Molecular interactions
 - Day 2 - Bio: Electrochemical Sensing
 - Day 3 - Nano: Probes-layer for Targets Detection
 - Day 4 - Nano/CMOS: Memristors and CMOS Analog4Bio
- Main Content Area:**

Day 1 - Bio: Probe/Target Molecular interactions

 - Topics:**
 - Bio/CMOS: present & future! (An introduction)
 - Probe/Target interactions
 - Sensing Principles with biomolecules
 - APPENDIX 1: Building Blocks & Protein Structures**
 - APPENDIX 2: Binding Energy**
 - News:** Euronews about under-the-skin biochip
 - Reading:** Read Chapter 2 in the Book for Conductive Solutions and the concept of pH, and Chapters 3 & 4 for Target/Probe biochemistry & interactions
 - Reading:** Read also APPENDIX A in the Book for the concept of Molar Concentration
 - Exercises:**
 - Solve the Exercise # 1 in page 28 of the Book (show computations)
 - Solve the Exercise # 9 in page 50 of the Book (justify the answer)
 - Solve the Exercise # 5 in page 85 of the Book (Solve the exercise by also)