



‘Biosensors – a key to our future health!’

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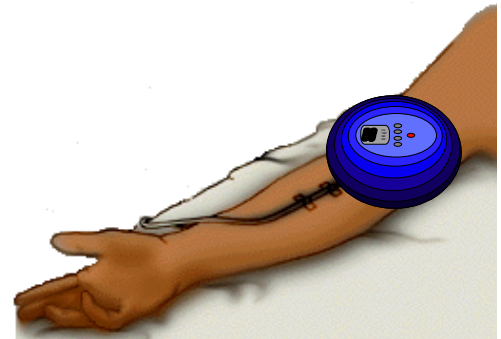
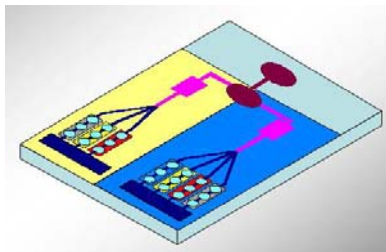
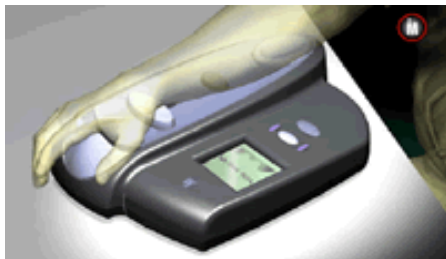
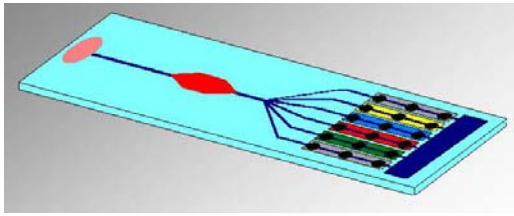
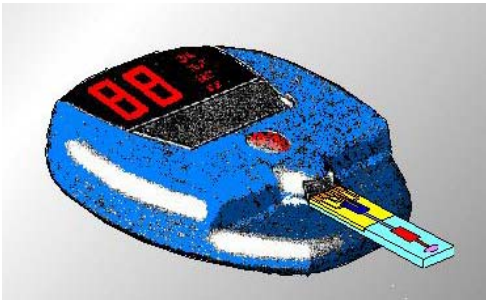
**FOBIS Biomedical Sensors Foresight Workshop
Stockholm, March 3rd 2006**





- ***Oct 1, 2005***
- ***Focus on next-generation Biomedical Diagnostics***
- ***Home-use & Point of Care***
- ***€23m Investment***
- ***Industry-Academic Partnership***





Outline

- **Background**
- **BDI Vision**
- **Examples**
- **Trends**
- **Recent Predictions from Expert Groups**
- **Conclusions**

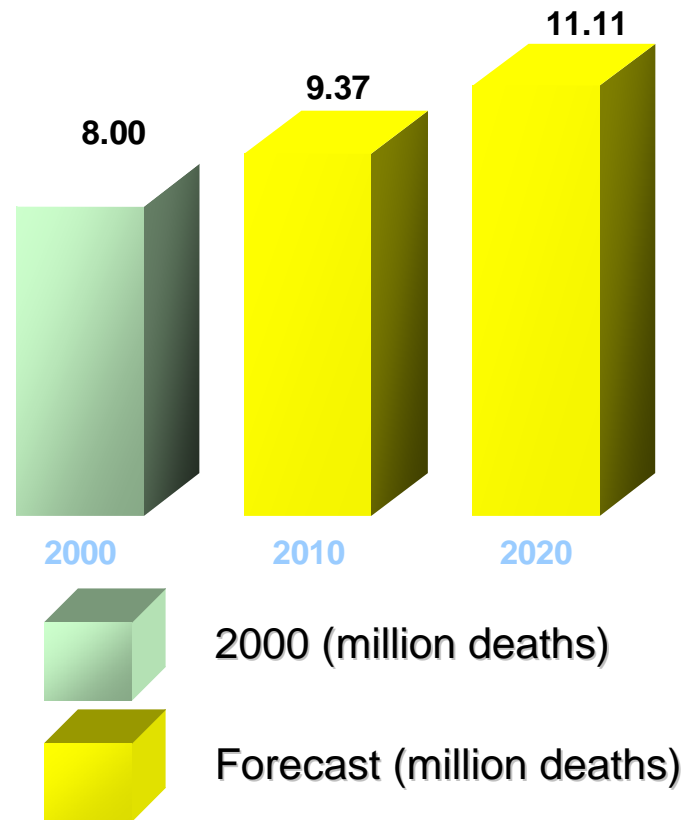


Global Healthcare Challenge

- Chronic diseases
 - Cardiovascular (CVD)
 - Cancer
 - Diabetes
- Increased life-expectancy
- Healthcare costs

Coronary Mortality

Worldwide Forecasts



World Health Organization



BDI: A Vision of Future Health

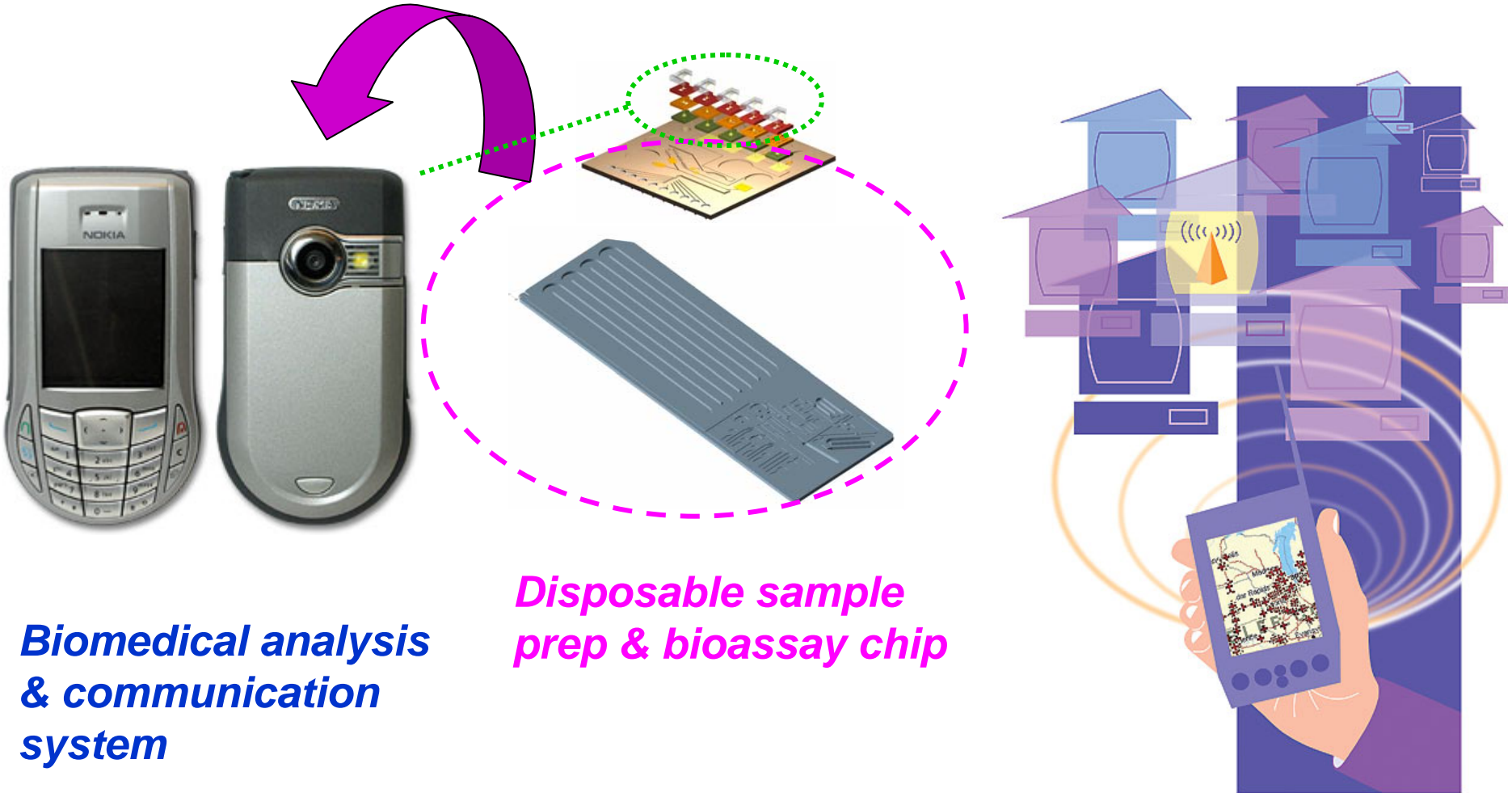
- **Revolutionary diagnostic devices:**
 - **Early warning of life-threatening events**
 - **Control of chronic diseases**
 - **Link therapy and monitoring**
 - *'personalised medicine'*
 - *theranostics*
 - **Monitor well-being**
- **Self Test - Home Use**
- **Point of Care (POC) – Doctors' surgeries...**



'keeping people out of hospital...'



Biosensors + E-Health



**Biomedical analysis
& communication
system**

**Disposable sample
prep & bioassay chip**



The Challenge(s)

- **Major scientific challenge**
 - **Smart, rapid, miniature systems**
 - **Low concentrations of Biomarkers**
 - **Small volumes of complex fluids**
 - **Sensitivity, reliability**
- **Integration of diverse technologies**
- **Ethics, adoption, cost, reimbursement...**



Examples: Diseases

- **Cardiovascular Disease**
- **Diabetes**
- **Colon Cancer**



Example: Cardiac Wellness Biochip

- **Critical Problem:**

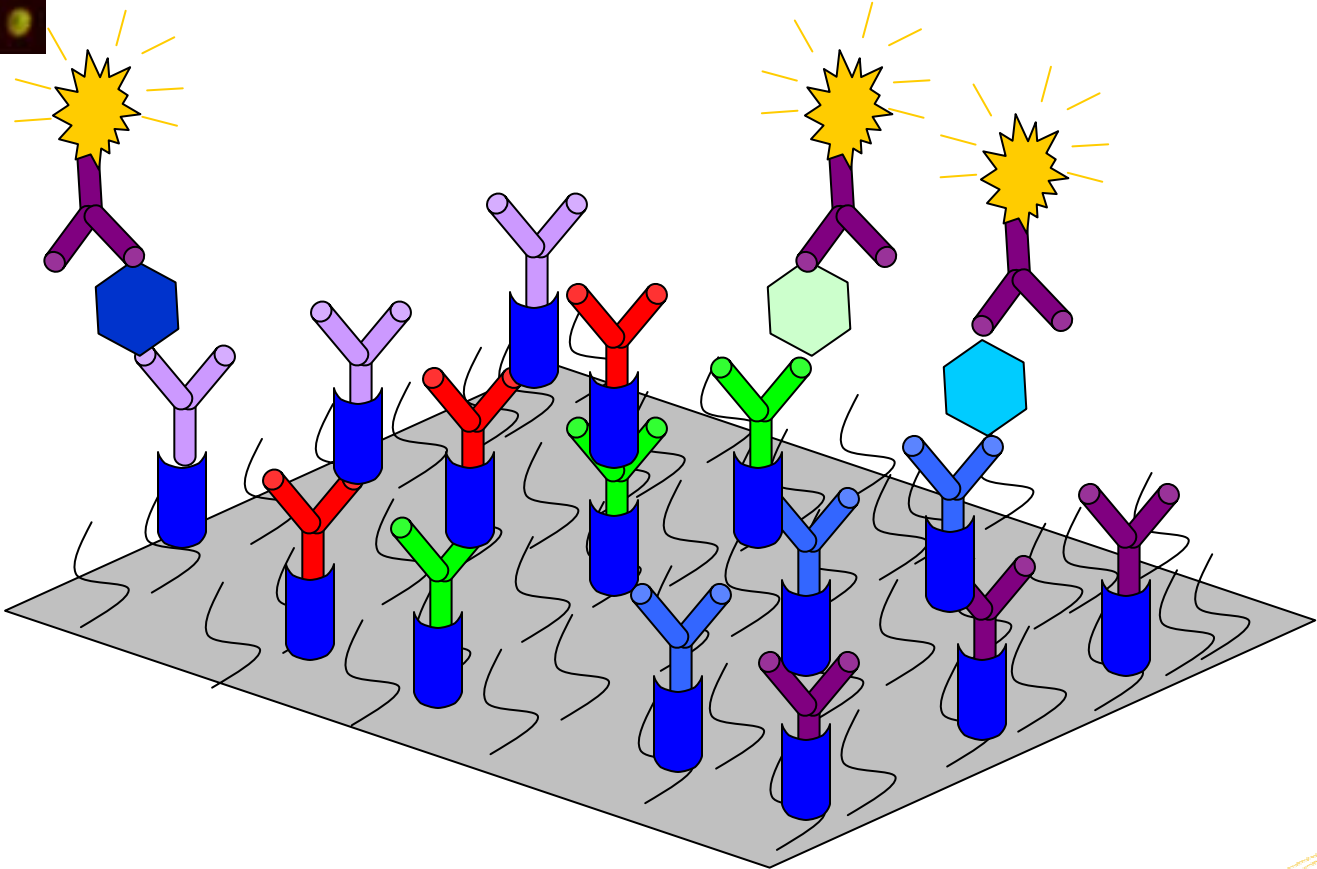
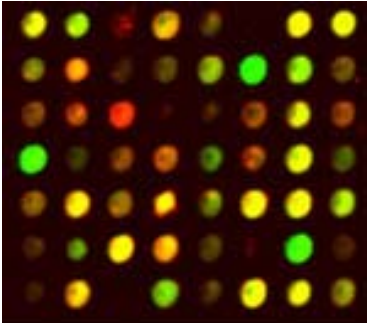
- Accounts for 38% of all deaths (2004)
- Significant impact on life quality and quantity
- Substantial cost to healthcare system

- **BDI Approach:**

- Simple, low cost, early monitoring of cardiac 'wellness' markers
- Early intervention; lifestyle changes
- Better patient outcomes
- Significant cost and health benefits



Fluorescence-based biochip array

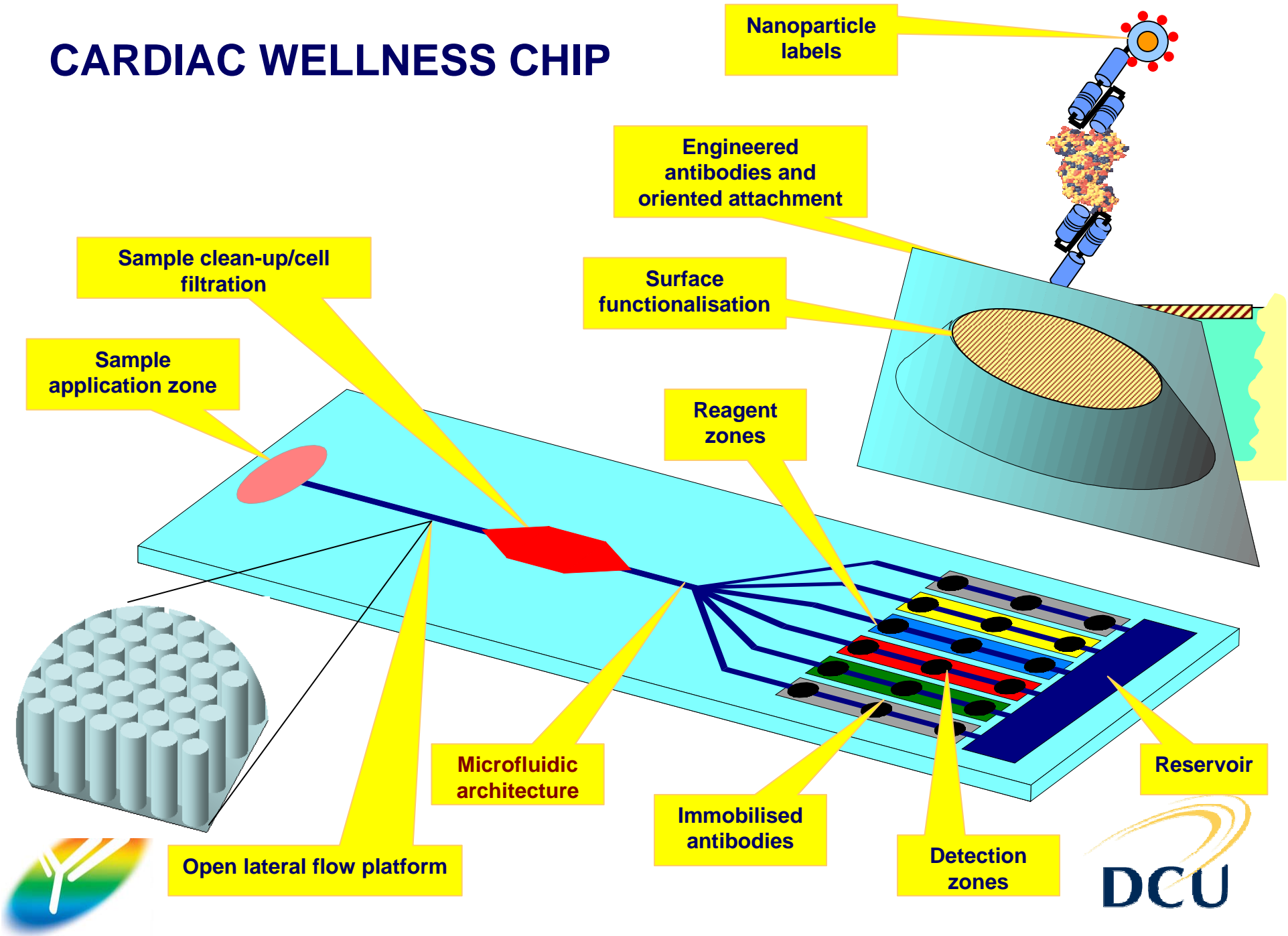


Enhancements in Fluorescence-based Biochips

- 1. Enhanced Fluorescence Capture Efficiency**
- 2. Plasmonic Amplification** (*Metal-enhanced Fluorescence*)
- 3. High Brightness Labels**
 - **1+2+3**  **1000-fold enhancement**

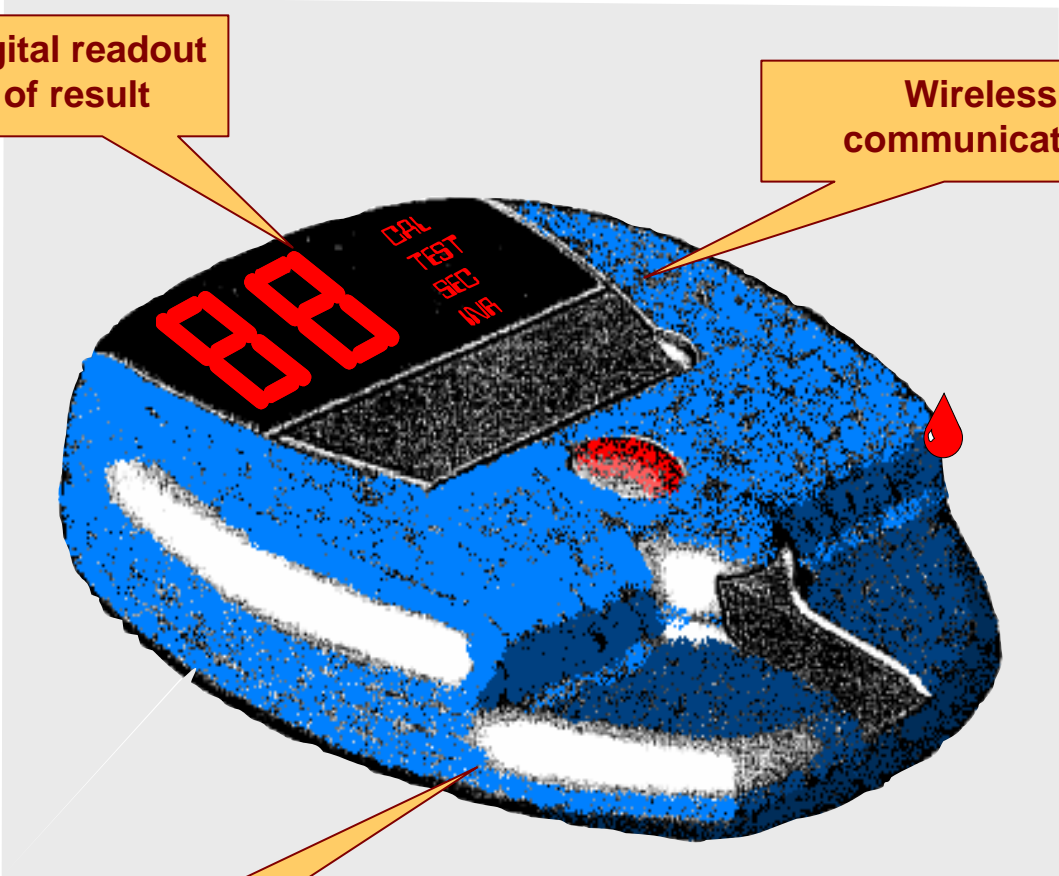


CARDIAC WELLNESS CHIP

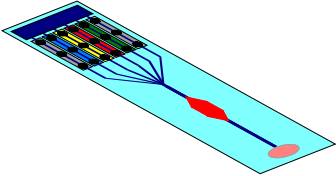


Digital readout
of result

Wireless
communication



Detection



DIABETES

- **Major healthcare challenge**
 - 4th major cause of premature death
 - 1 in 25  1 in 13
 - 9% of NHS budget in UK
 - 300m worldwide diabetics
- **Glucose Monitoring**
 - >25% of Diagnostics Market (€25bn)
 - €10bn by 2010



DIABETES: Trends in Glucose Monitoring

In-vitro Wearable Minimally Invasive...



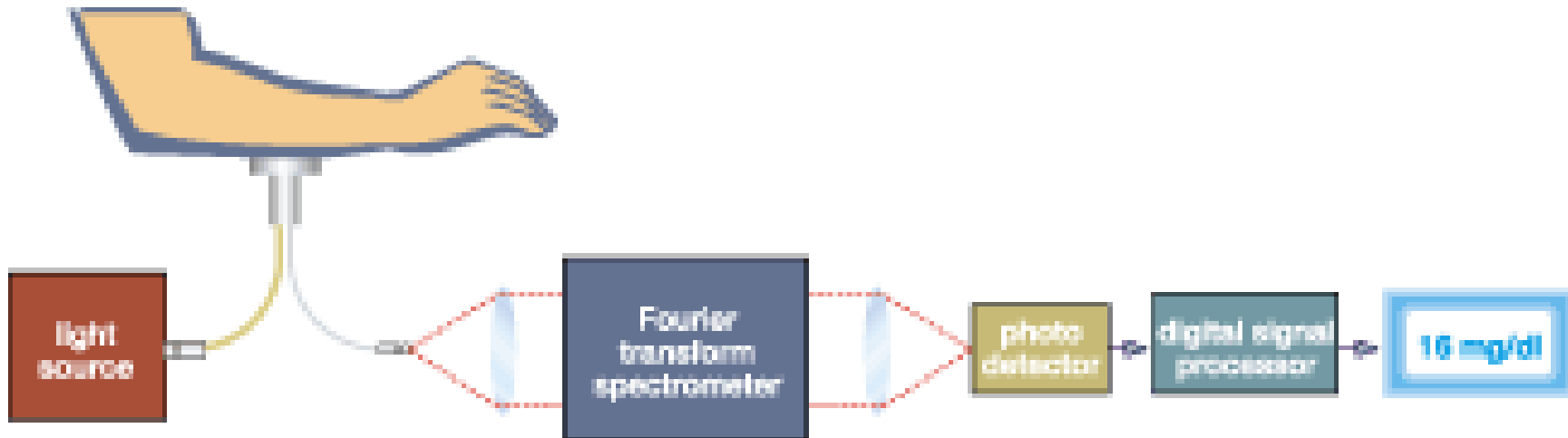
..... 'In-vivo' ??

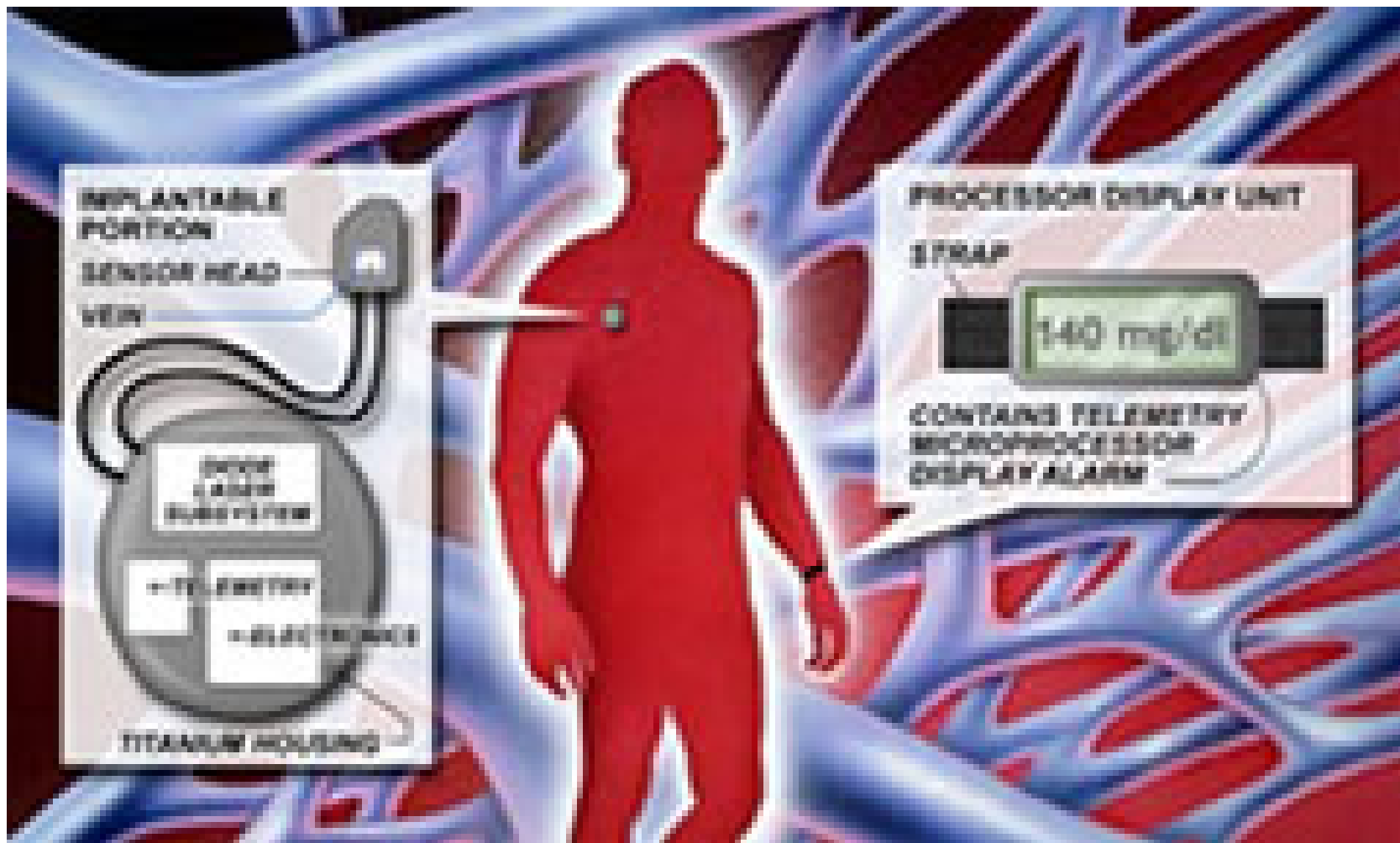


Trends in Diabetes Monitoring

- **Traditional meters will disappear**
- **Patch and disposable / Implanted minimally invasive devices**
- **Non-invasive devices**
- **Closed-loop systems (sense & insulin dose)**



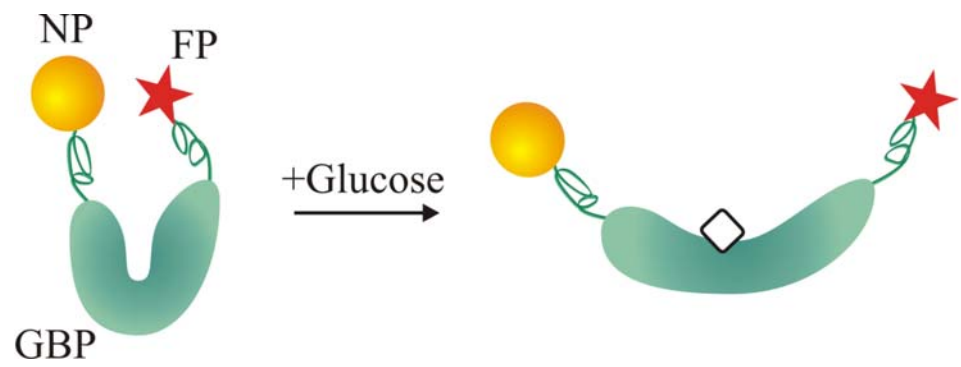




***Animas Corp: IR laser; C-clamp
around 5mm blood vessel***



In-vivo Glucose Monitoring using Glucose-Binding Protein (GBP)



FP: Environment-sensitive Fluorophore



Biomarker Discovery: Colon Cancer

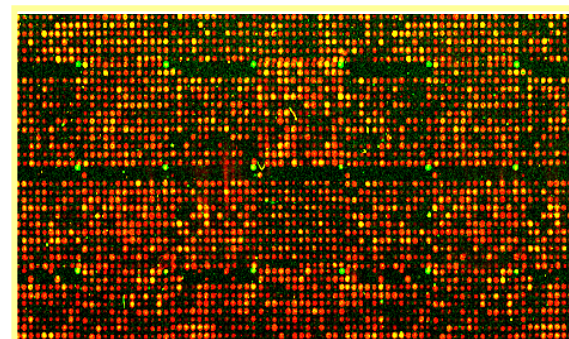
- **Major Killer**
- **Current Tests are crude and unreliable**
- **Objective:**
 - Develop new, rapid test for early detection**

Strategy: New Biomarker(s) + Biochip



Biomarker Discovery

- ***Patient profiling*** at Clinical Research Centre at Beaumont Hospital, Dublin.
- ***Sample collection***, analysis and banking (e.g. blood serum)
- ***Biomarker discovery*** using protein arrays



KEY DRIVERS FOR BIOSENSORS

- **Miniaturisation** (Microsystems / Nanotechnology)
- **Integration** (Lab-on-a-chip; MEMS; μ TAS ..)
- **Multi-analyte sensing** (Panels)
- **Mass-production / disposability**
- **Sensing & wireless comms combined**
- **Convergence** (Micro – Nano – Bio – ICT - ...)

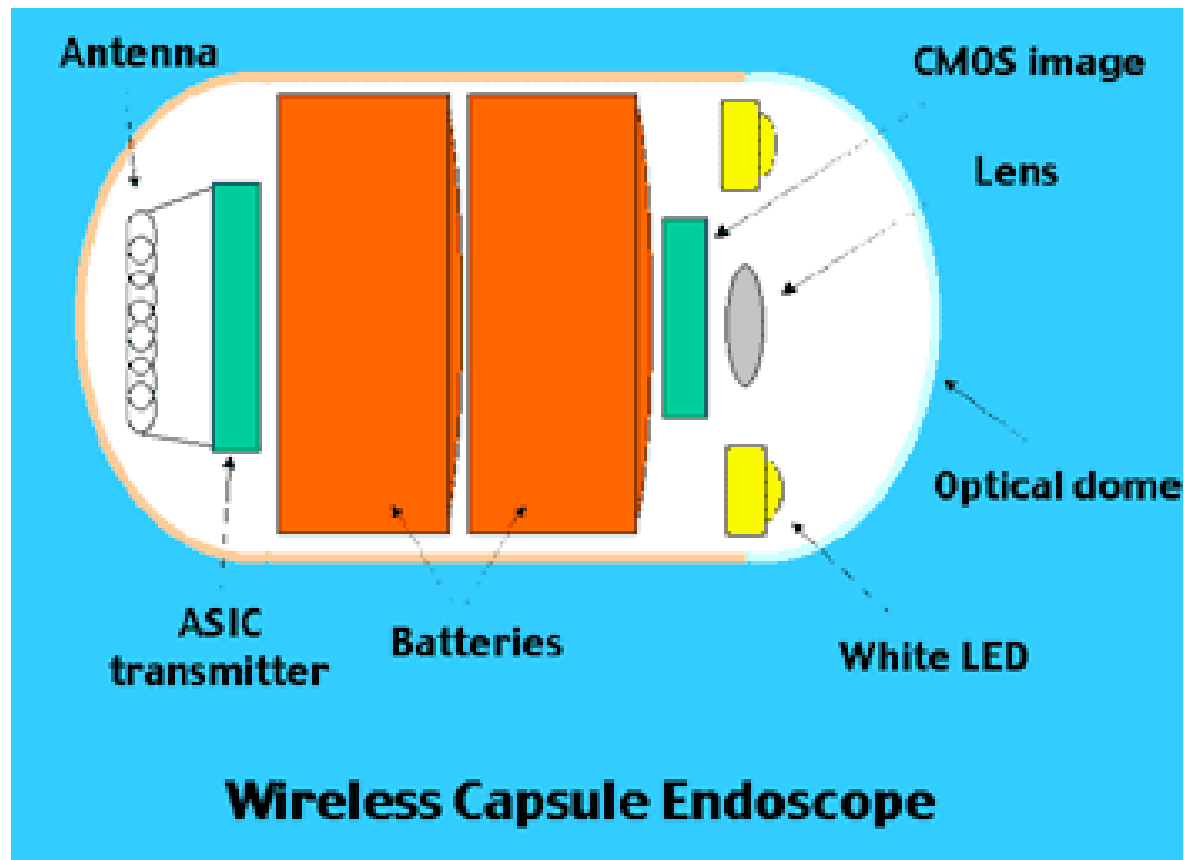


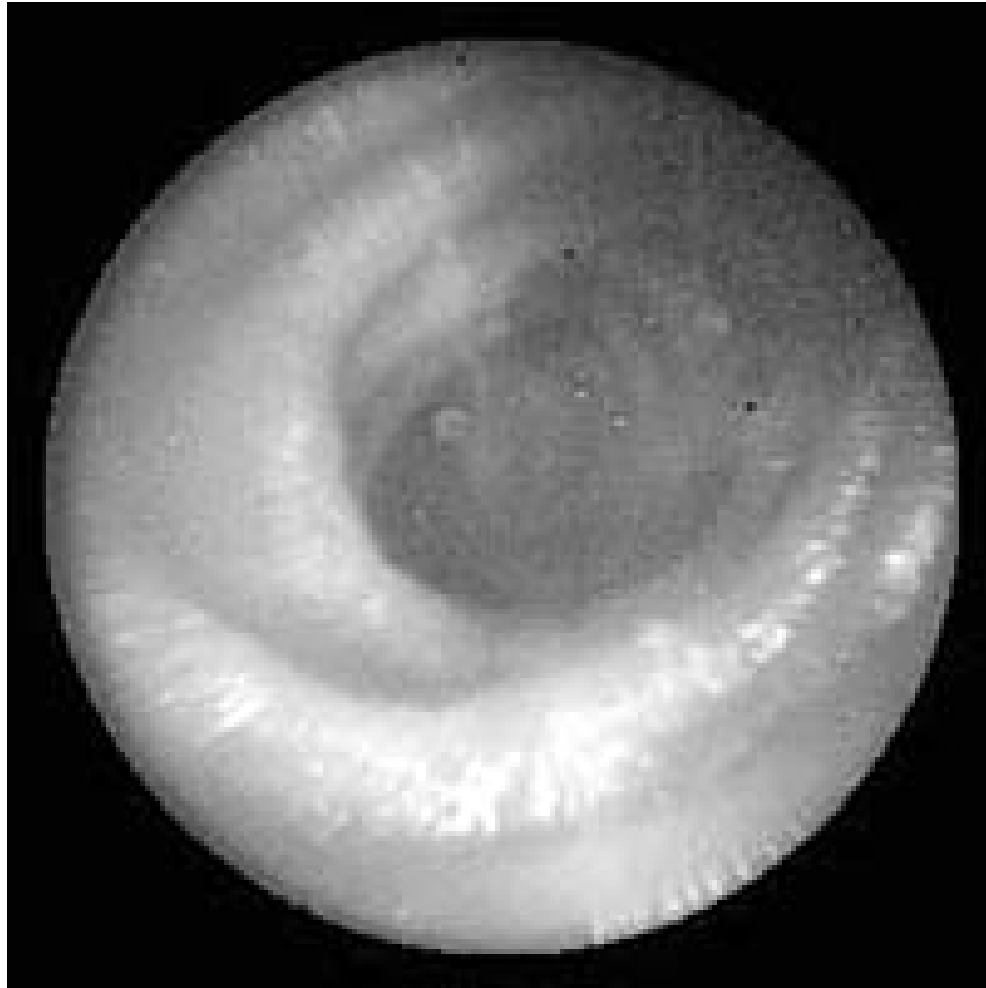
Biomedical Sensors – Technology trends

- **Smart bandages (microneedles; sensing + drug delivery)**
- **In-vivo modules**
- **Breath monitoring**
- **Spectroscopic monitoring + Chemometrics**
- **Wearable sensors**
- **.....**









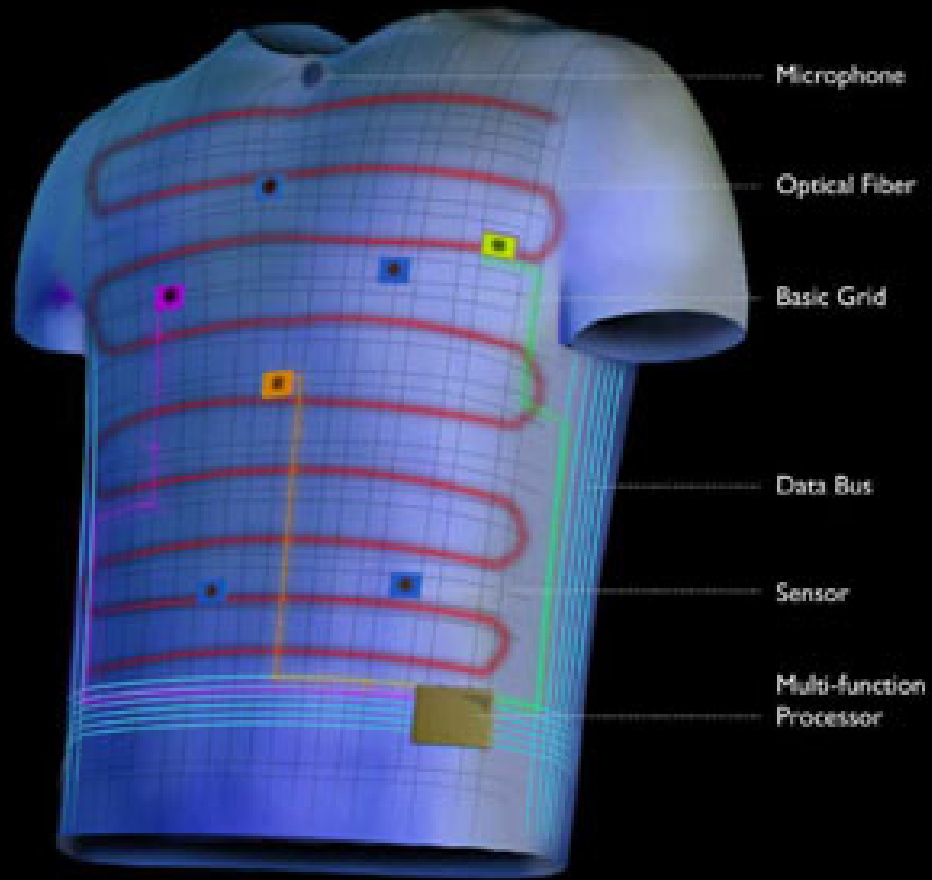
Nanobot Biosensors ?



Smart Bandages -- RFID



Smart Shirt Sensory Architecture



Breath Monitoring

| <i>Breath constituent</i> | <i>Level</i> |
|---------------------------|--------------|
| Methane | 2 – 10 ppm |
| Ethane | 0 – 10 ppb |
| Pentane | 0 – 10 ppb |
| Nitric Oxide | 10 – 50 ppb |
| Carbon Monoxide | 1 – 10 ppm |
| Carbonyl Sulfide | 0 – 10 ppb |
| Nitrous Oxide | 1 – 20 ppb |
| Isoprene | 50 – 200 ppb |
| Ammonia | 0 – 1 ppm |
| Acetone | 0 – 1 ppm |

| <i>Disease</i> | <i>Marker</i> | <i>Level</i> |
|----------------|---------------|----------------|
| Renal Failure | Ammonia | 150 – 2000 ppb |
| Breast Cancer | Ethane | 0 – 10 ppb |
| Asthma | Nitric Oxide | 10 – 100 ppb |



Trends

- Diagnostics will become more **predictive**
- Therapeutic interventions will become more **preventive**
- Healthcare will become more **personalised** and tailored to the individual



*'Futurewatch: Biotechnologies for 2025', New Zealand
Ministry of Research, Science & Technology, 2005*



Nanomedicine

Role for Nanomedicine:

- **Genomics & Proteomics rapidly elucidating molecular basis of many diseases**
- **Powerful diagnostic tools to identify genetic predisposition to disease**
- **Use of POC diagnostics to**
 - **Identify patients requiring preventative medication**
 - **Select most appropriate medication for individuals**
 - **Monitor response to treatment**



ESF-European Medical Research Councils Forward Look Report on 'Nanomedicine' 2005



Priority Areas in Nanomedicine (~Biosensors)

- **Next 5 years:**
 - **Engineering technology for immobilising cells/molecules on surfaces**
 - **Non-invasive, in-vivo diagnostic systems**
 - **Improved sensitivity for in-vivo methods**
 - **Implantable/injectable nanodevices for diagnosis**



*ESF-European Medical Research Councils Forward Look
Report on 'Nanomedicine' 2005*



Priority Areas in Nanomedicine (~Biosensors)

- **Next 10 years:**
 - **Single molecule analysis**
 - **Nanosensing of multiple, complicated analytics *in-vitro***
 - **Nanosensing in vivo with telemetrically-controlled, functional mobile sensors**
 - **Rapid fingerprinting of all components in blood samples**



***ESF-European Medical Research Councils Forward Look
Report on 'Nanomedicine' 2005***



Conclusions: Trends

- **Self-test; Home-use**
- **Personalised medicine**
- **Theranostics**
- **Pharmacogenomics ---- Nutrigenomics!!**
- **Personal responsibility for health**
- **Sensors + eHealth**
- **Closed loop systems**
- **Wearable / in-vivo**
- **Nanomedicine**
- **Complexity of disease – multi-gene – need for highly sensitive arrays**



Conclusions: Key Technical Areas

- **Biorecognition – receptors**
- **Immobilisation / low NSB**
- **High sensitivity transduction (arrays)**
- **Calibration stability**
- **In-vivo: Biomaterials, batteries etc**
- **Glucose!!**
- **Etc.**



Conclusions

- *Major growth area*
- *Some trends predictable*
- *Academic – Industry – Clinical Partnerships*
- *Multidisciplinary – incentivise*
- *Need for high-quality underpinning science*
- *Need to consider total situation: government, health insurance, ethics, ‘who pays?’*
- *Impact on the quality of people’s lives*
- **FOCUS**



‘The future has already happened, it just isn’t very well distributed.’

William Gibson



Thank you!

