Department of Electrical Engineering (ESAT)

Faculty of Engineering
Katholieke Universiteit Leuven

ICT en eHealth

Nieuwe uitdagingen voor de wetenschap

IBBT

Bart De Moor

ESAT-SCD
Katholieke Universiteit Leuven

A: Kasteelpark Arenberg 10, B-3001 Leuven
Belgium
T: +32(0)475 2 8 7052
W: www.esat.kuleuven.be/~demoor
E: bart.demoor@esat.kuleuven.be

Inhoud

-Trends

-Context

-Opportuniteiten en uitdagingen

-De toekomst

Trends

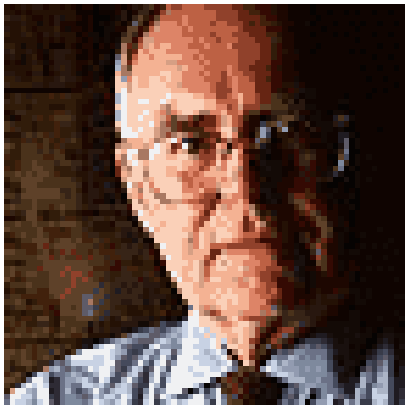
I. Exponentiele evoluties

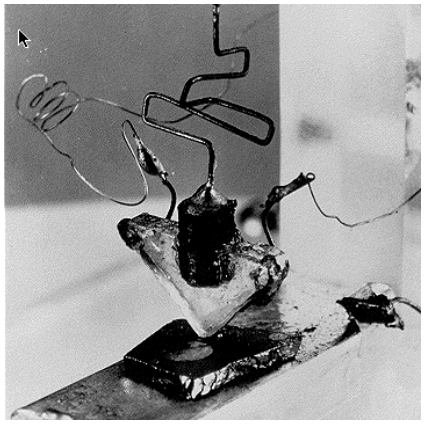
II. Tsunami van data

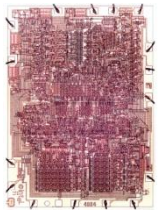
III. Inter-, cross-, and multi-disciplinariteit

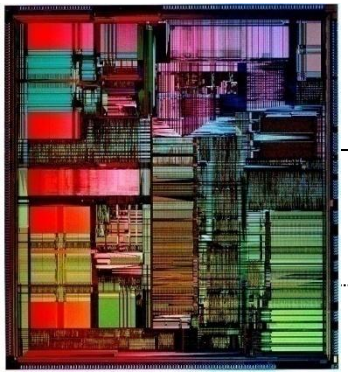
IV. De samenleving is vragende partij

De wet van Gordon Moore

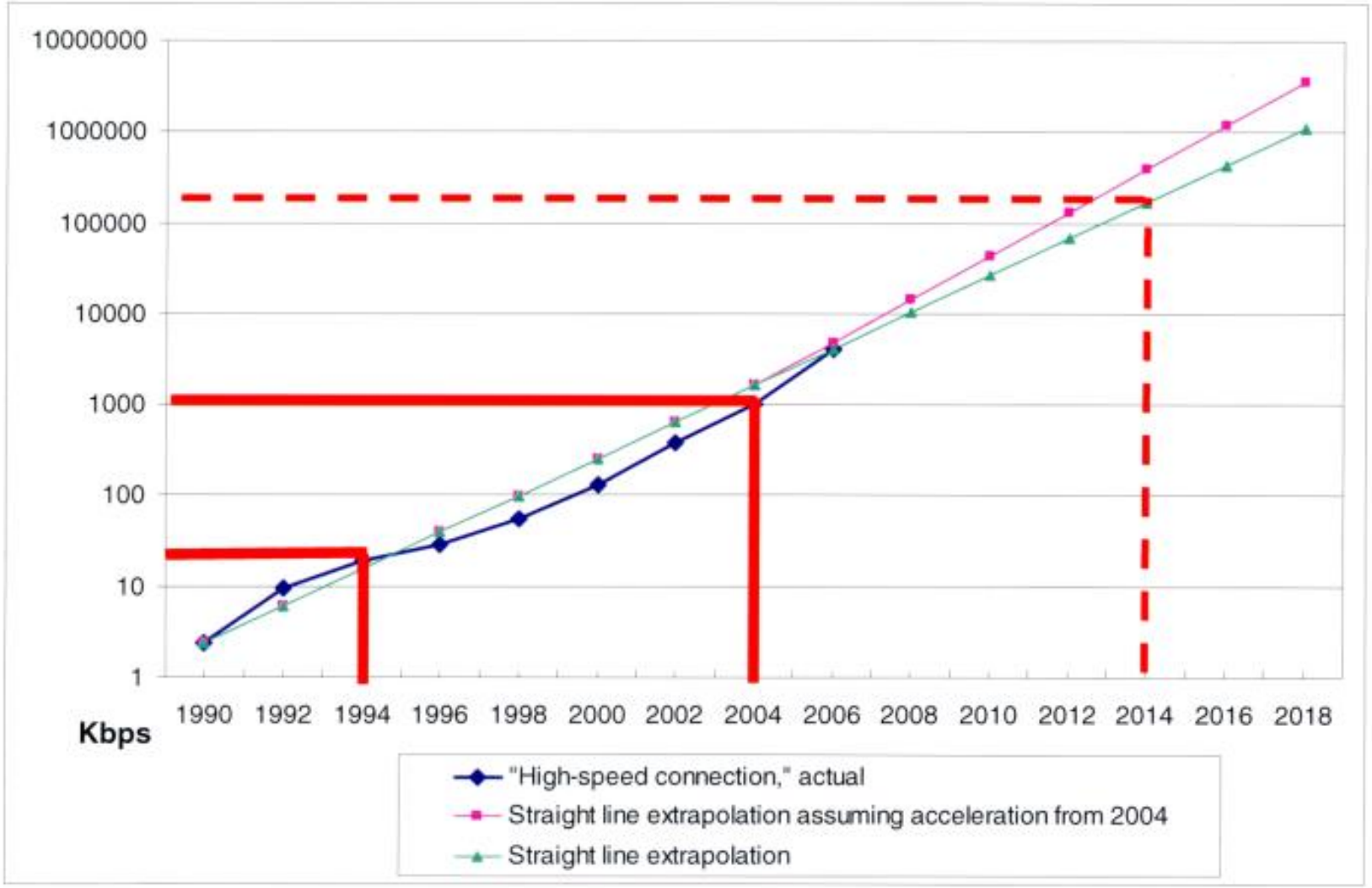




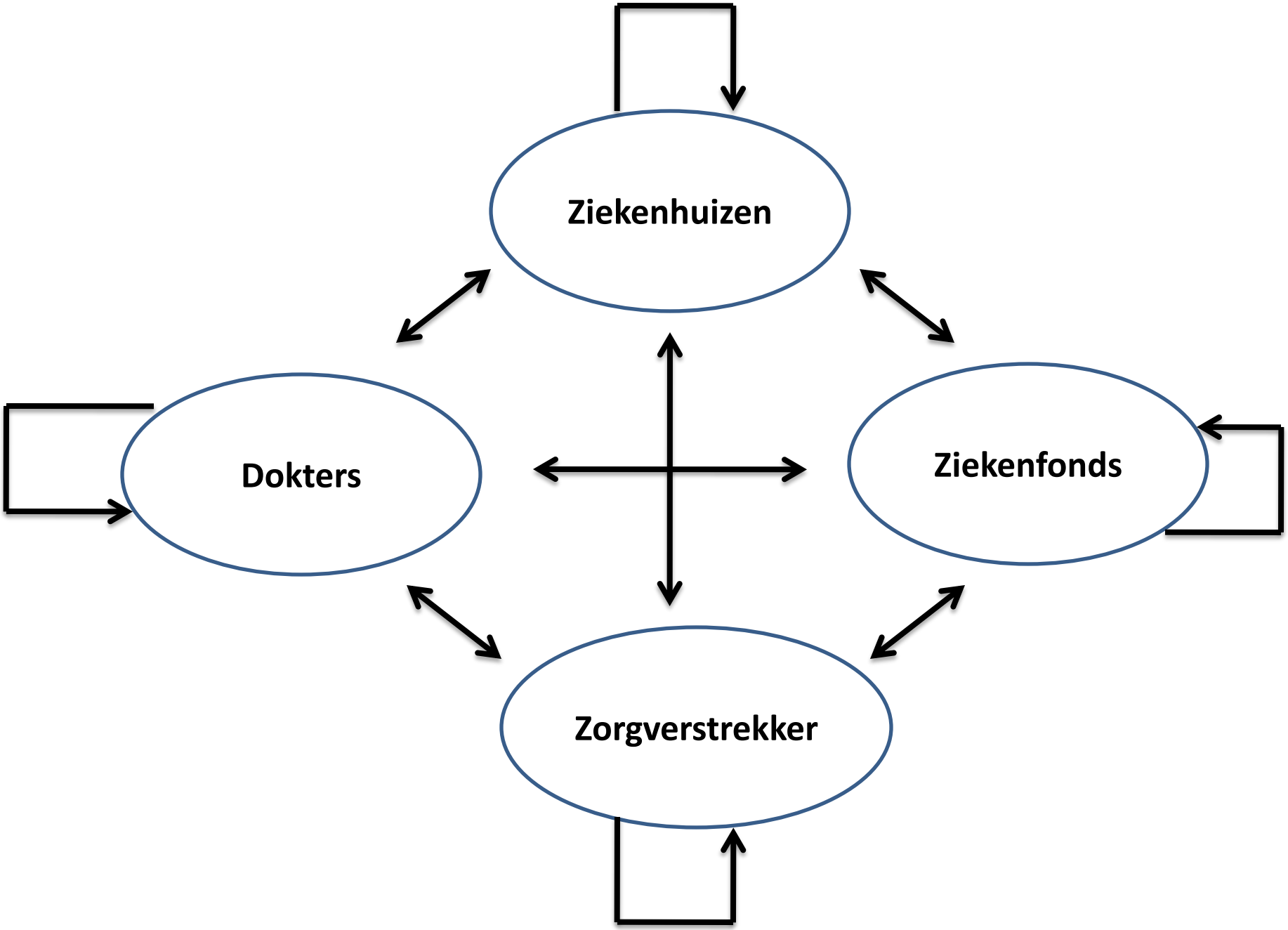




Het is een kleine wereld



Source: Heavy Reading report "FTTH Worldwide Market & Technology Forecast, 2006-2011"


Ziekenhuizen
Dokters
Ziekenfonds
Zorgverstrekker

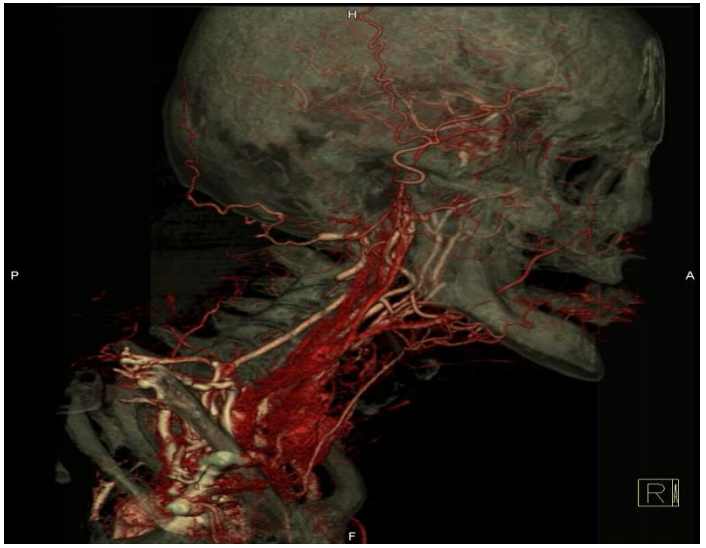
Tsunami van data

-Nieuwe technologieen genereren steeds meer data

-Resolutie en nauwkeurigheid in ruimte en tijd neemt toe

-Meer data per patient, meer patienten per databank (‘high throughput’)

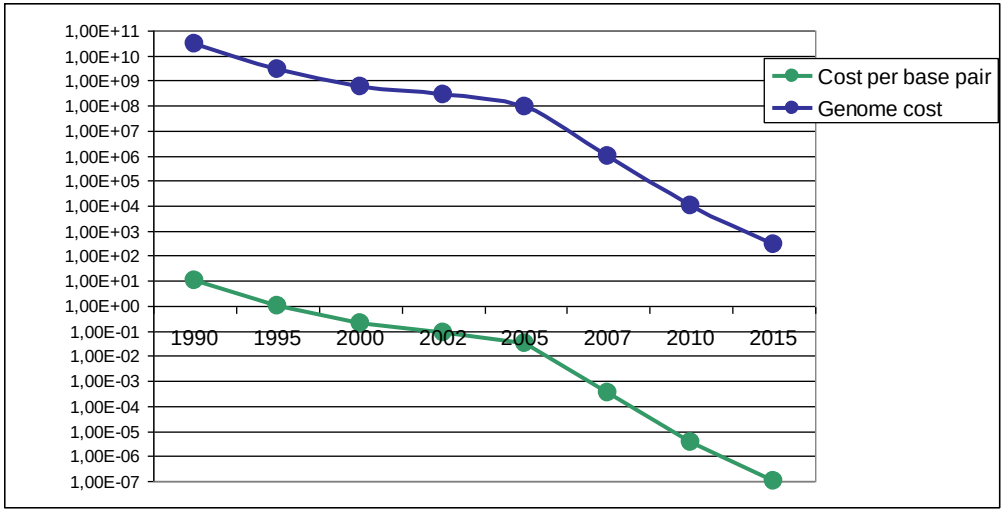
Virtual colonoscopy from CT images
with automatically detected polyps



subtraction CT angiography

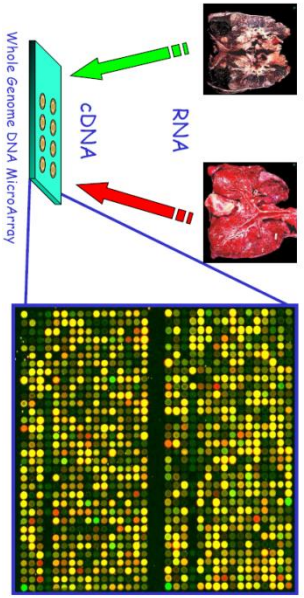
Een genoom voor 1000 dollar ?

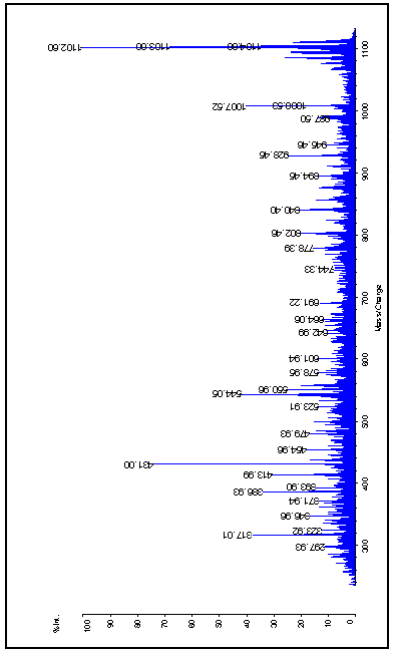
- Human genome project
  - Initial draft: June 2000
  - Final draft: April 2003
  - 13 year project
  - $300 million value with 2002 technology
- Personal genome
  - June 1, 2007
  - Genome of James Watson, co-discoverer of DNA double helix, is sequenced
    - $1.000.000
    - Two months
- €1000-genome
  - Expected 2012-2020

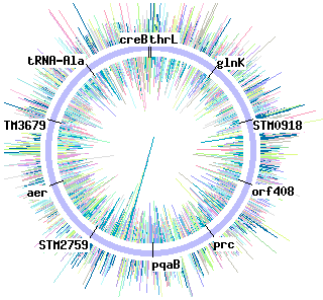


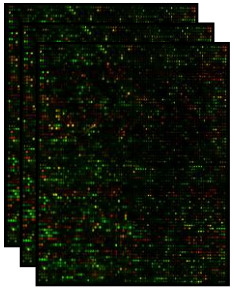
Year	Cost per base pair	Genome cost
1990	10	3E+10
1995	1	3.000.000.000
2000	0.2	600.000.000
2002	0.09	270.000.000
2005	0.03	90.000.000
2007	0.000333333	1.000.000
2010	3.33333E-06	10000
2015	0.0000001	300

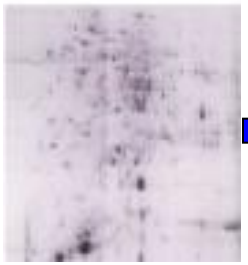
ACACATTAAATCTTATATGC
TAAAACTAGGTCTCGTTTTA
GGGATGTTTATAACCATCTT
TGAGATTATTGATGCATGGT
TATTGGTTAGAAAAAATATA
CGCTTGTTTTTCTTTCCTAG
GTTGATTGACTCATACATGT
GTTTCATTGAGGAAGGAAC
TTAACAAAACTGCACTTTTT
TCAACGTCACAGCTACTTTA
AAAGTGATCAAAGTATATCA
AGAAAGCTTAATATAAAGAC
ATTTGTTTCAAGGTTTCGTA
AGTGCACAATATCAAGAAG
ACAAAAATGACTAATTTTGT
TTTCAGGAAGCATATATATT
ACACGAACACAAATCTATTT
TTGTAATCAACACCGACCAT
GGTTCGATTACACACATTAA
ATCTTATATGCTAAAACTAG
GTCTCGTTTTAGGGATGTTT
ATAACCATCTTTGAGATTAT
TGATGCATGGTTATTGGTTA
GAAAAAATATACGCTTGTTT
TTCTTTCCTAGGTTGATTGA

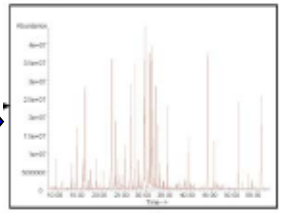


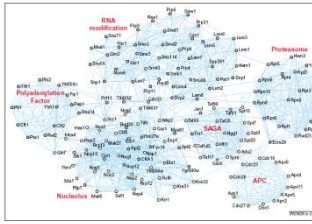












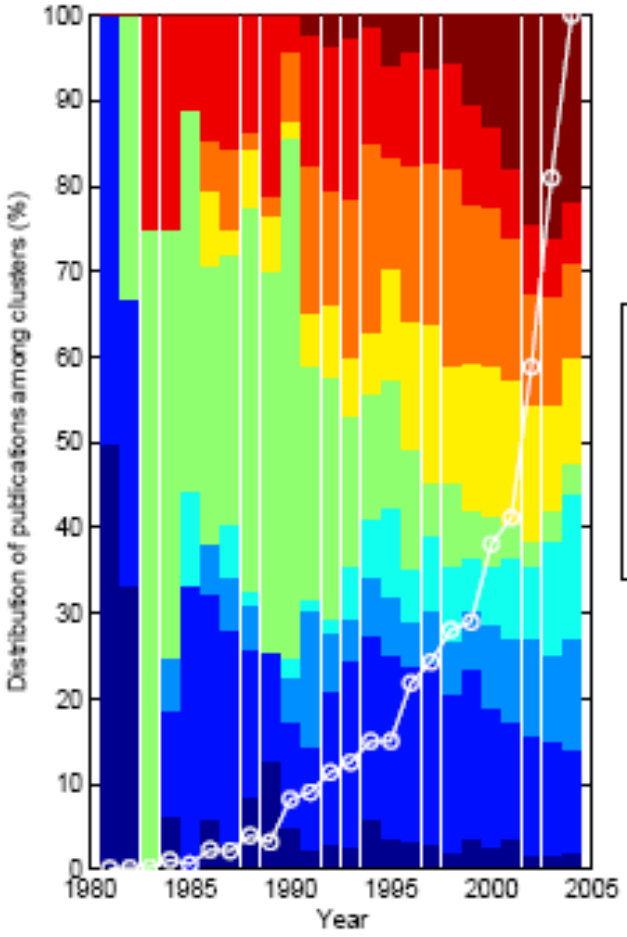
genome **transcriptome** **proteome** **metabolome** **interactome**

GS-FLX Roche
Applied Science 454

maf VIB
MicroArray Facility

Prometa

De kennis neemt snel toe



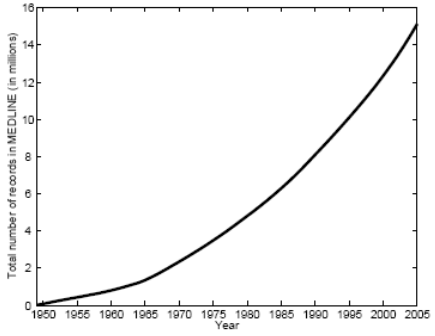


Figure 1.2: Growth of MEDLINE, the U.S. National Library of Medicine (NLM) premier bibliographic database covering the fields of medicine, nursing, dentistry, veterinary medicine, the health care system and preclinical sciences. The total number of scientific publications (in millions) is indicated for each year. Today, MEDLINE contains approximately 15 million unique records about journal articles in life sciences. This figure was constructed using data published by NLM [161].

By 2010, 1/3 of all world data bases will consist of biomedical data

Inhoud

-Trends

-Context

-Opportuniteiten en uitdagingen

-De toekomst

Context

-VRWB cluster analysis
  -Cluster 2: ICT and Health Care
  -Cluster 5: New business models

- VR 30/04/2009: Oprichting van een Centrum voor Translationele Biomedische Innovatie / m.i.v. 8 mio euro voor biobank

- IMEC (40 mio euro/jaar), VIB (40 mio euro/jaar), IBBT (20 mio euro/jaar)

-Universiteiten (KUL: 650 mio euro/jaar, waarvan 50 % onderzoek;
  De helft daarvan biomedisch; Omzet Gasthuisberg 740 mio euro/jaar)

- eHealth platform

Meer aandacht voor gezondheidszorg

- **De kwaliteit verbeteren van de gezondheidszorg**
  - Individuele dokter ondersteunen
    - Aantal medische fouten verminderen
    - ‘Evidence Based Medicine’
  - Informatie-uitwisseling tussen dokters
    - ‘doctor hopping’ vermijden
    - 1 medische dossier per patient
    - Interoperabiliteit tussen ziekenhuizen – mobiliteit van de patient
- **‘Empowerment’ van de patient**
  - 4P: personalized, preventive, predictive, participatory
  - Gepersonalizeerde therapien
  - Transparantie en consistentie verhogen
  - Steeds meer chronische patienten met welvaartziektes (hart, diabetes, kanker,…)
  - Mobiliteit van de patienten verhoogt steeds meer
- **Kosteneffectiviteit van het gezondheidszorgsysteem**
  - Verouderende bevolking
    - EU 2050: 65+ → +70%; 80+ → +180%
    - Vl. 2012: 60+ → 25 % of Vl.
  - Overconsumptie tegengaan
  - Detecteer abnormaliteiten in diagnoses, therapieen, voorschrijfgedrag,
  - Zorgprogramma’s
- **Werken in een tsunami van data**

Obama

But in order to lead in the global economy and to ensure that our businesses can grow and innovate, and our families can thrive, we're also going to have to address the shortcomings of our health care system.

The Recovery Act will support the long overdue step of ***computerizing America's medical records***, to reduce the duplication, waste and errors that cost billions of dollars and thousands of lives. But it's important to note, ***these records also hold the potential of offering patients the chance to be more active participants in the prevention and treatment of their diseases***. We must maintain patient control over these records and respect their privacy. At the same time, we have the opportunity to offer billions and ***billions of anonymous data points to medical researchers who may find in this information evidence that can help us better understand disease***.

History also teaches us the greatest advances in medicine have come from scientific breakthroughs, whether the discovery of antibiotics, or improved public health practices, vaccines for smallpox and polio and many other infectious diseases, antiretroviral drugs that can return AIDS patients to productive lives,
pills that can control certain types of blood cancers, so many others.

Because of recent progress —- ***not just in biology, genetics and medicine, but also in physics, chemistry, computer science, and engineering —- we have the potential to make enormous progress against diseases in the coming decades***. And that's why my administration is committed to increasing funding for the National Institutes of Health, including $6 billion to support cancer research -- part of a sustained, multi-year plan to double cancer research in our country. (Applause.)

http://www.whitehouse.gov/blog/09/04/27/The-Necessity-of-Science/

Inhoud

-Trends

-Context

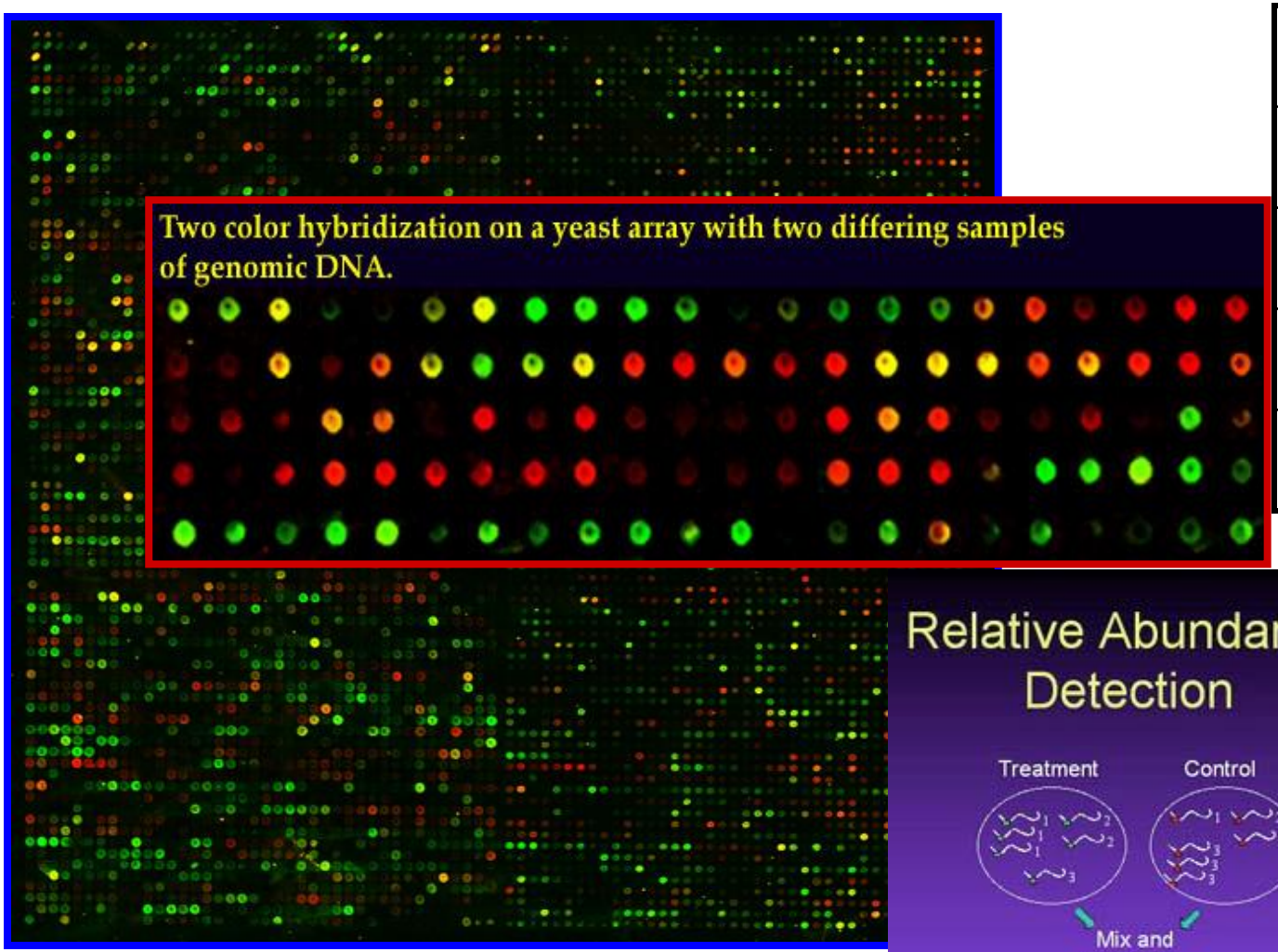
-Opportuniteiten en uitdagingen

-De toekomst

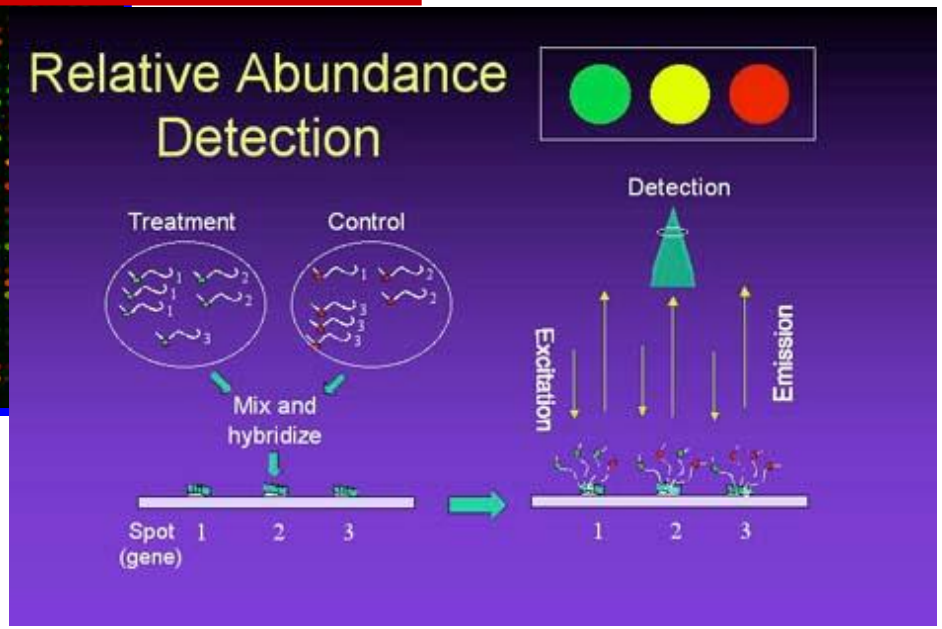
Voorbeelden van nieuwe methodes

- Diagnose via DNA-chips
- Werken met verschillende bronnen van medische meetgegevens
- Biobanken: IOTA: International Ovarian Tumor Analysis

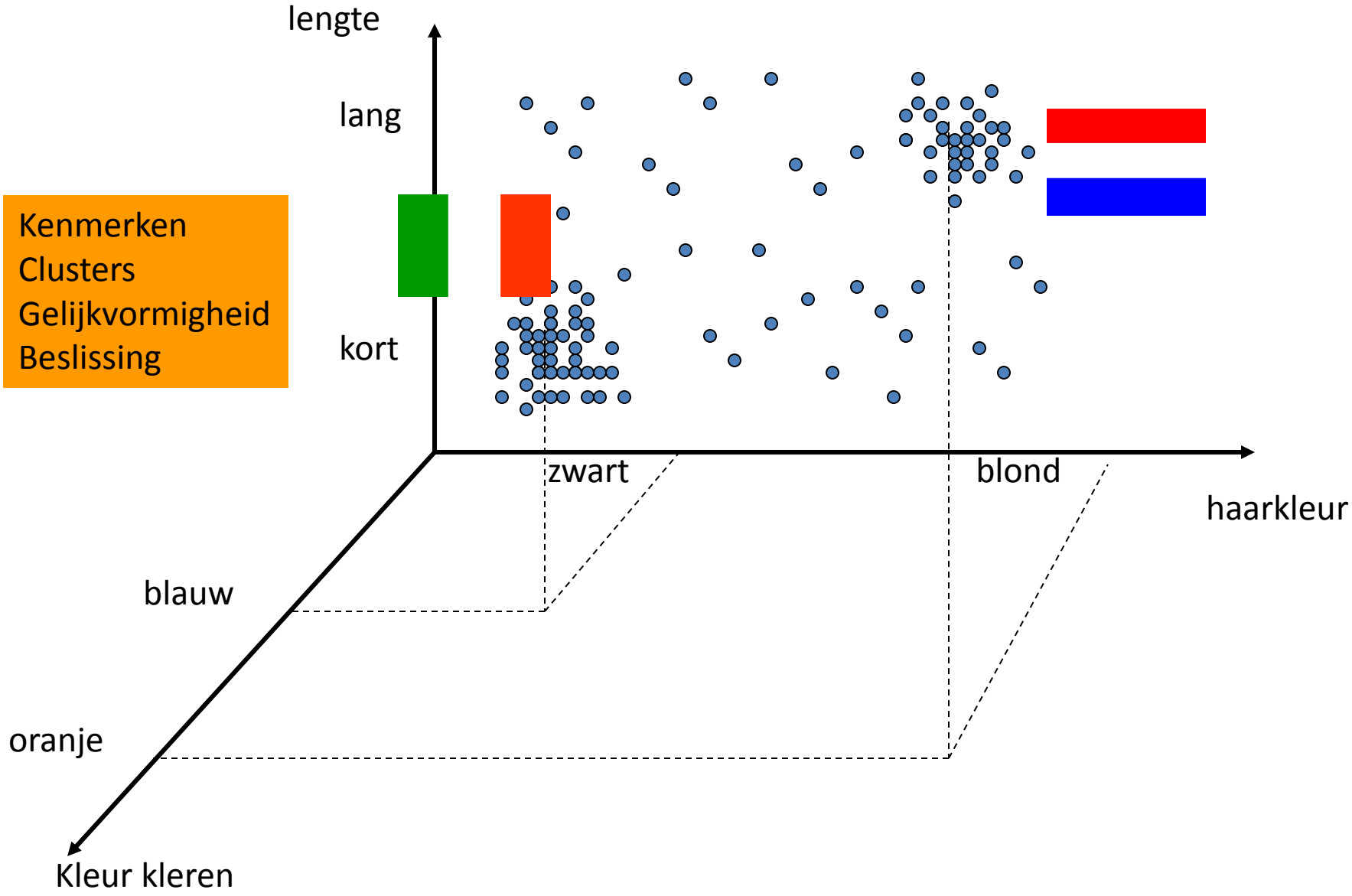
DNA-chips

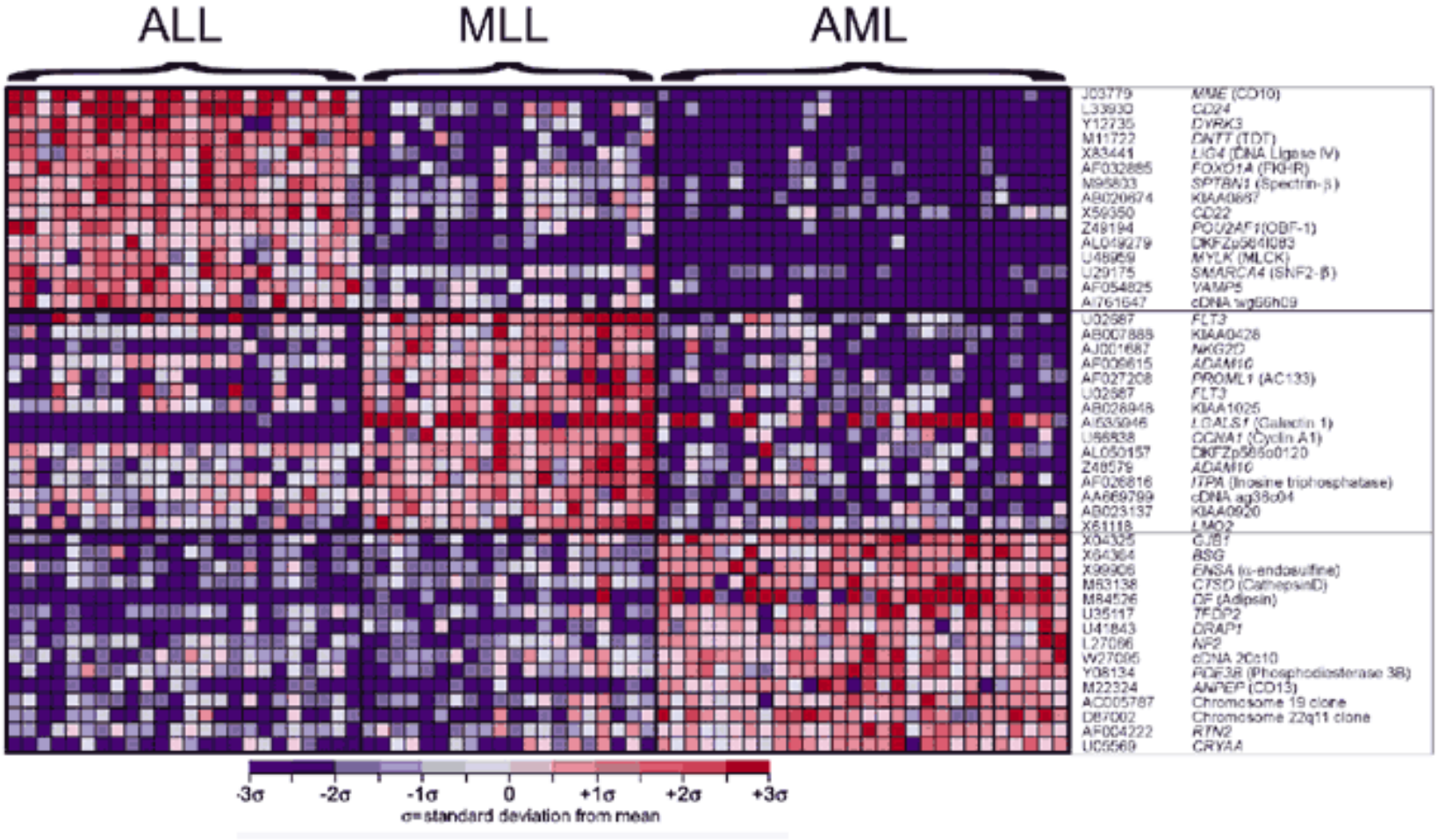


	Test	Ref.
	High	Low
	Low	High
	High	High
	Low	Low



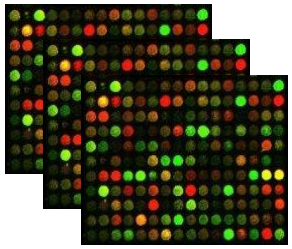
Methodes om te clusteren



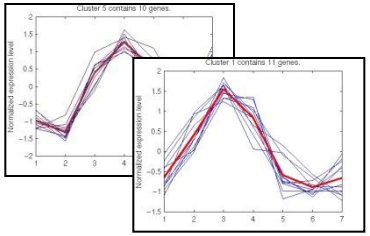

ALL
MLL
AML
J03779 MME (CD10)
L33930 CD24
Y12735 DYRK3
M11722 DNTT (TDT)
X83441 LIG4 (DNA Ligase IV)
AF032885 FOXO1A (FKHR)
M96803 SPTBN1 (Spectrin-β)
AB020674 KIAA0687
X59350 CD22
Z48194 POU2AF1(OBF-1)
AL049279 DKFZp564I083
U48959 MYLK (MLCK)
U29175 SMARCA4 (SNF2-β)
AF054825 VAMP5
AI761647 cDNA:wg66h09
U02687 FLT3
AB007885 KIAA0426
AJ001687 NKG2D
AF006615 ADAM16
AF027208 PROML1 (AC133)
U02687 FLT3
AB028948 KIAA1025
AI53946 LGALS1 (Galectin 1)
U66838 CCNA1 (Cyclin A1)
AL050157 DKFZp586o0120
Z48576 ADAM10
AF026816 ITPA (Inosine triphosphatase)
AA869799 cDNA:ag38c04
AB023137 KIAA0920
X61118 LMO2
X04325 GJB1
X64364 BSG
X99906 ENSA (α-endosulfine)
M63138 CTSD (CathepsinD)
M84526 DF (Adipsin)
U35117 TFDP2
U41843 DRAP1
L27096 AIF2
W27096 cDNA:20c10
Y08134 PDE3B (Phosphodiesterase 3B)
M22324 ANPEP (CD13)
AC005787 Chromosome 19 clone
D87002 Chromosome 22q11 clone
AF004222 RTN2
U05569 CRYAA
-3σ
-2σ
-1σ
0
+1σ
+2σ
+3σ
σ=standard deviation from mean

Verschillende databronnen combineren

High-throughput genomics



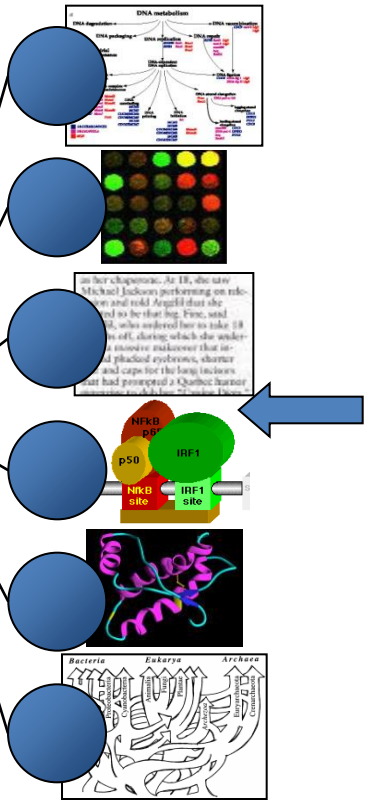
Data analysis



Candidate genes

Name	Ensembl
TTR	ENSG00000118271
PAH	ENSG00000171759
G6PC	ENSG00000131482
IGF1	ENSG00000017427
ALB	ENSG00000163631
CRP	00000132693
HABP2	00000148702
IF	00000138799
FST	00000134363
ARAF1	00000078061
HMGA2	G00000149948
C9	SG00000113600
PCBP2	ENSG00000111406
HOXB6	SG00000108511
RERE	ENSG00000142599
HOXA11	ENSG00000005073
CLIC1	ENSG00000096238
ERCC3	ENSG00000163161
ERCC3	ENSG00000163161
TLL2	ENSG00000095587
SYT4	ENSG00000132872
SYT4	ENSG00000132872
PIK4CB	ENSG00000143393
PKD2	ENSG00000118762
	ENSG00000081026
ANKRD3	ENSG00000183421
F13A1	ENSG00000124491
BPAG1	ENSG00000151914
KCNN3	ENSG00000143603
GRIN2A|GRIN2B	ENSG00000150086
SIM1	ENSG00000112246
	G00000174891
	SG00000089195
C14orf10	G00000092020
STX8	00000170310
	ENSG00000107671
MSH5	00000096474
CRH	G00000147571
MID1	G00000101871
	00000184508
	00000113460
TGFB3	ENSG0000
C1QR1	EN
N	EN
PDC	ENS
PD	
NR	
NFYA	
T...	ENSG 106537
MMP3|MMP1	ENSG00000149968

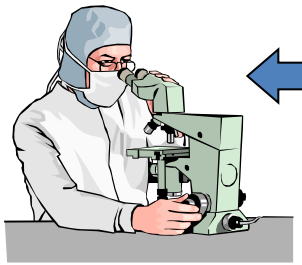
Information sources



Candidate prioritization

Rank	En	Ex	Ip	Ke	GO	Te Avg	Pval
1	TTR	G6PC	PAH	G6PC	IGF1	TTR		TTR
2	IGF1	TTR	IGF1	PAH	PAH	IGF1		PAH
3	CRP	ALB	TTR	RERE	G6PC	CRP		G6PC
4	HOXB6	HABP2	ALB	ERCC3	TTR	HOXB6		IGF1
5	ALB	PAH	HDC	ERCC3		ALB		ALB
6	NR4A2	IF	TLL2	ANKRD3		HMGA2		CRP
7	PAH		C1QR1	ARAF1	HDC	NR4A2		
8	HOXA11	IGF1	G6PC	PKD2	F13A1	PAH		IF
9	NFYA	CRP	HABP2	MTMR1	KCNN3	HOXA11	C13orf7	FST
10	C9	ARAF1	IF	HDC	CLIC1	NFYA	TTR	ARAF1

Validation



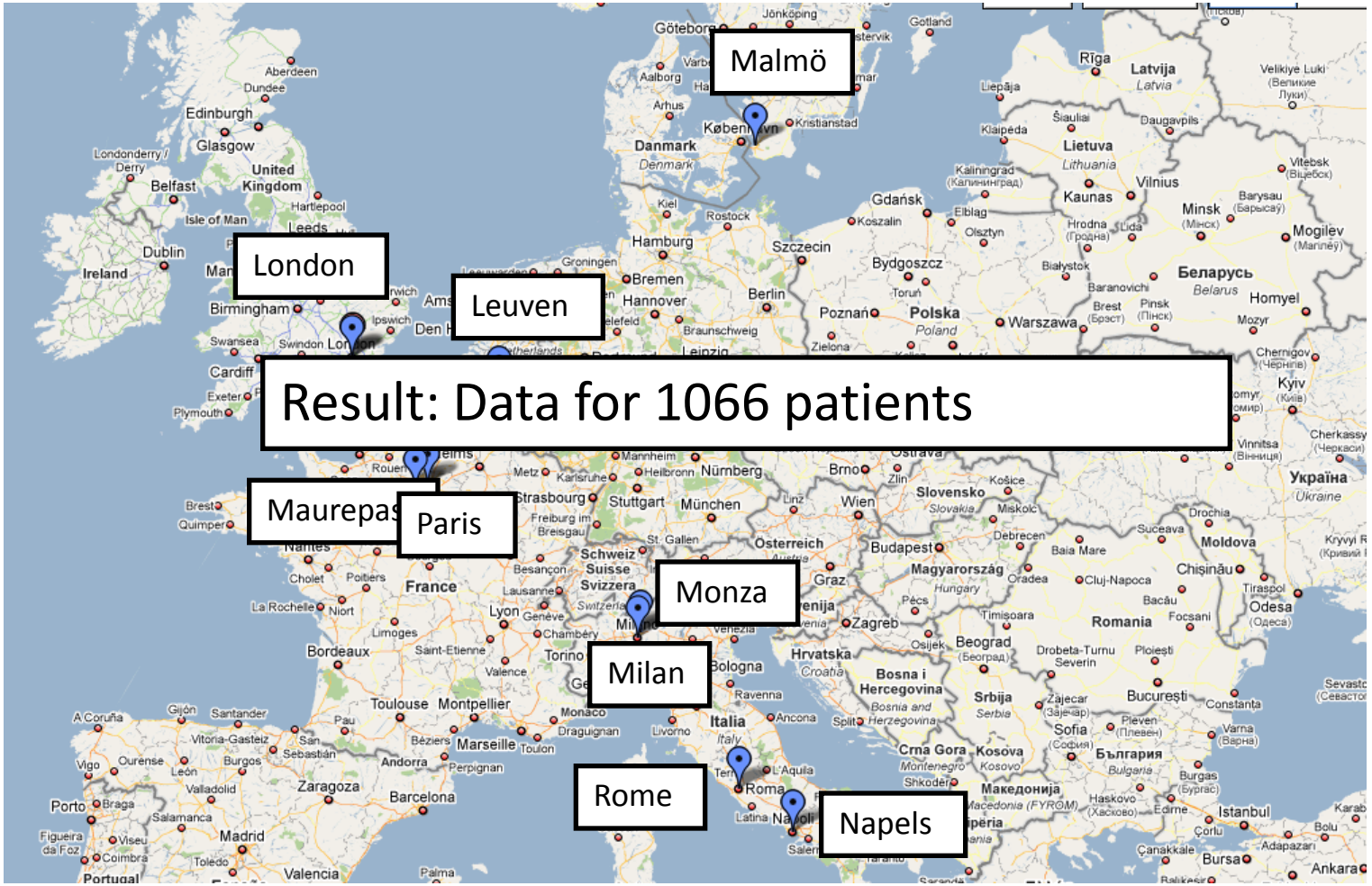
Aerts et al, Nature Biotechnology, 2006

International Ovarian Tumor Analysis Group (IOTA)

Making it easier to diagnose ovarian cancer

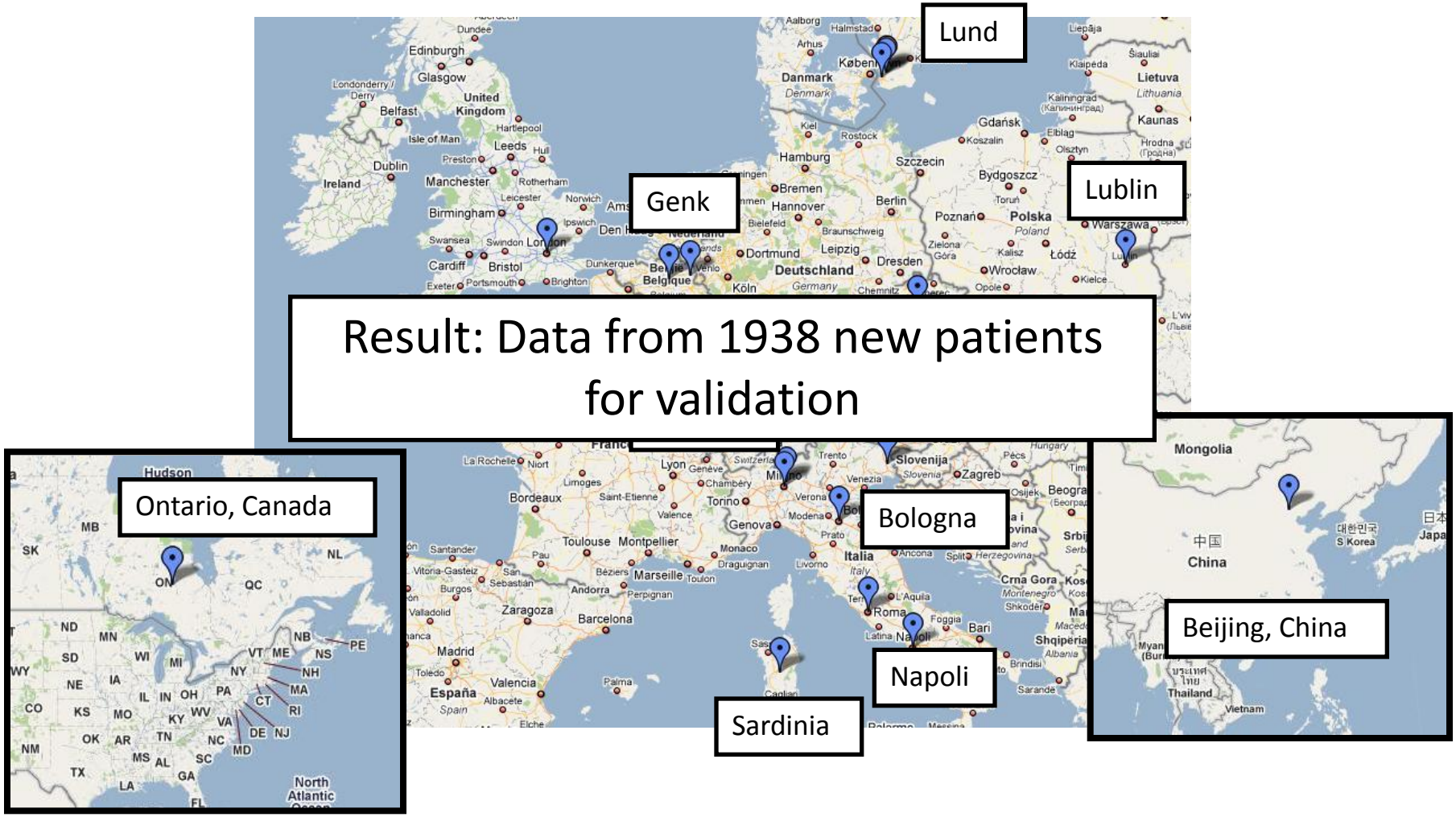
IOTA phase 1 centers

9 centers, 60 variabelen/patient



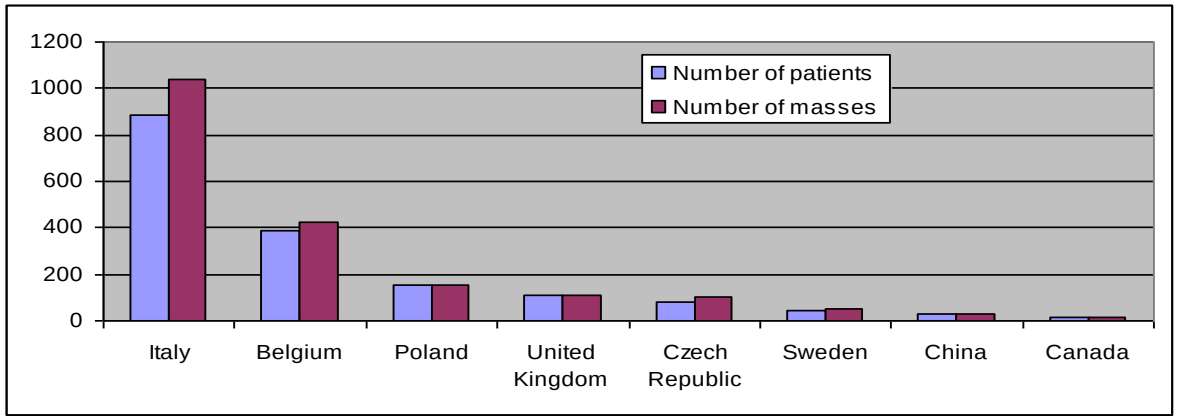
IOTA phase 2 centers

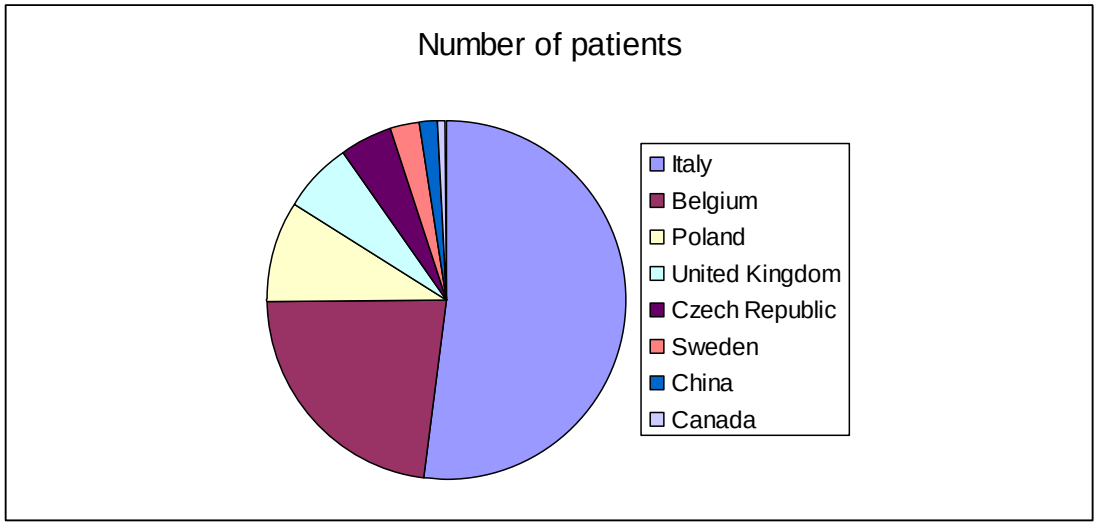
12 new centers



IOTA phase 2

numbers

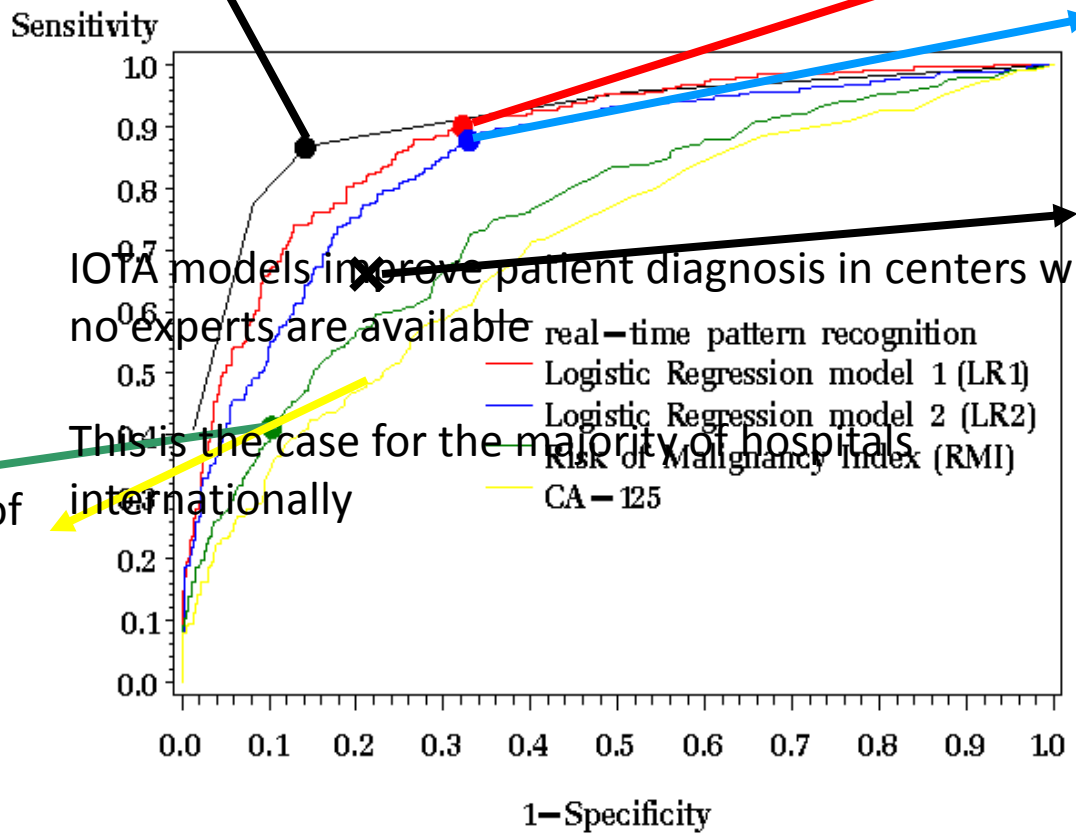




Performance comparison

Performance of an expert

Performance of IOTA models



Performance of non-experts

IOTA models improve patient diagnosis in centers where no experts are available

This is the case for the majority of hospitals internationally

Performance of old models

You share, we care !

Inhoud

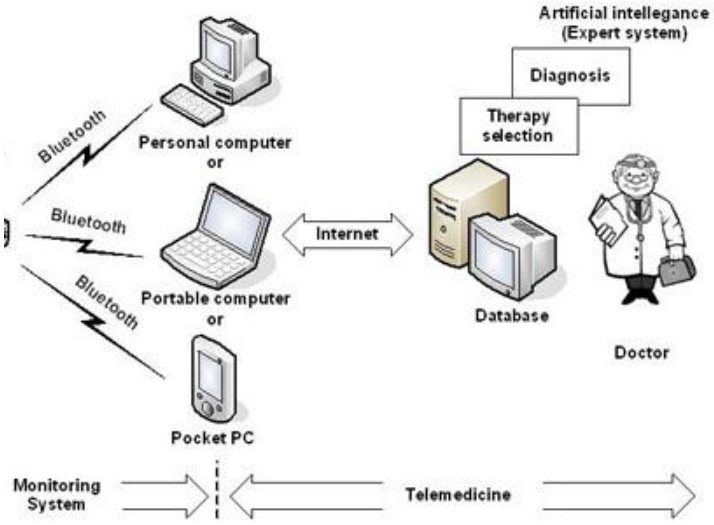
-Trends

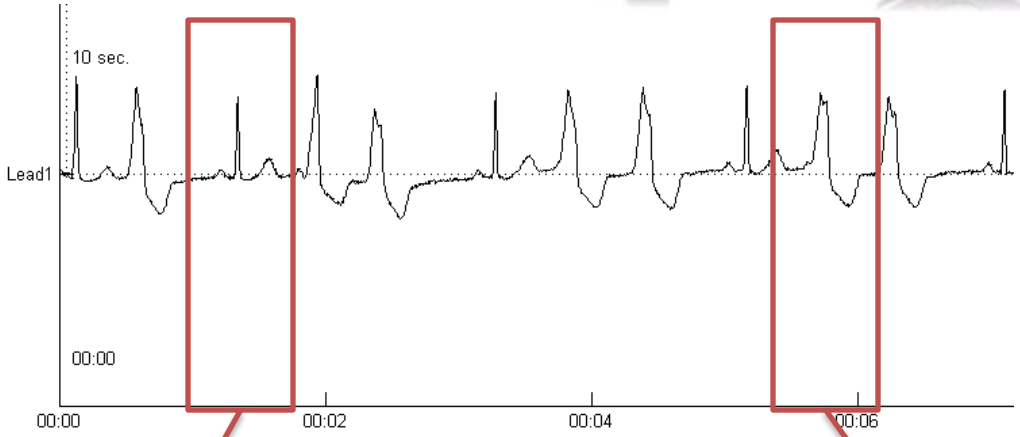
-Context

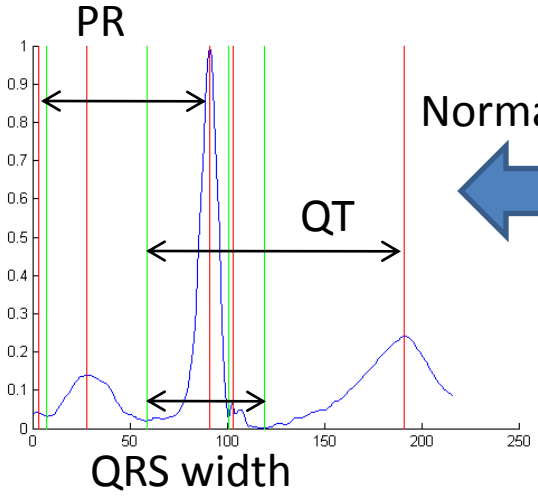
-Opportuniteiten en uitdagingen

-De toekomst

Draagbare monitors

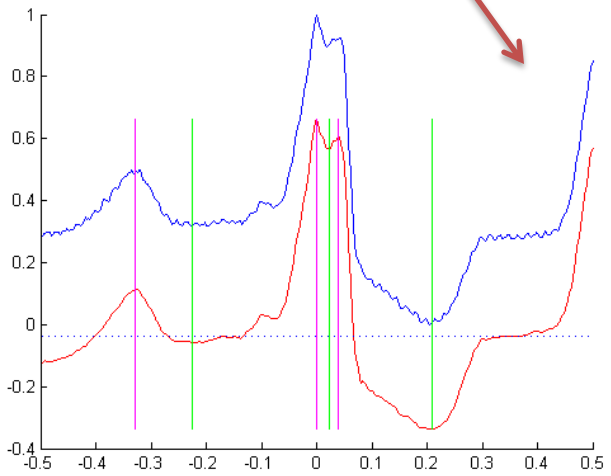




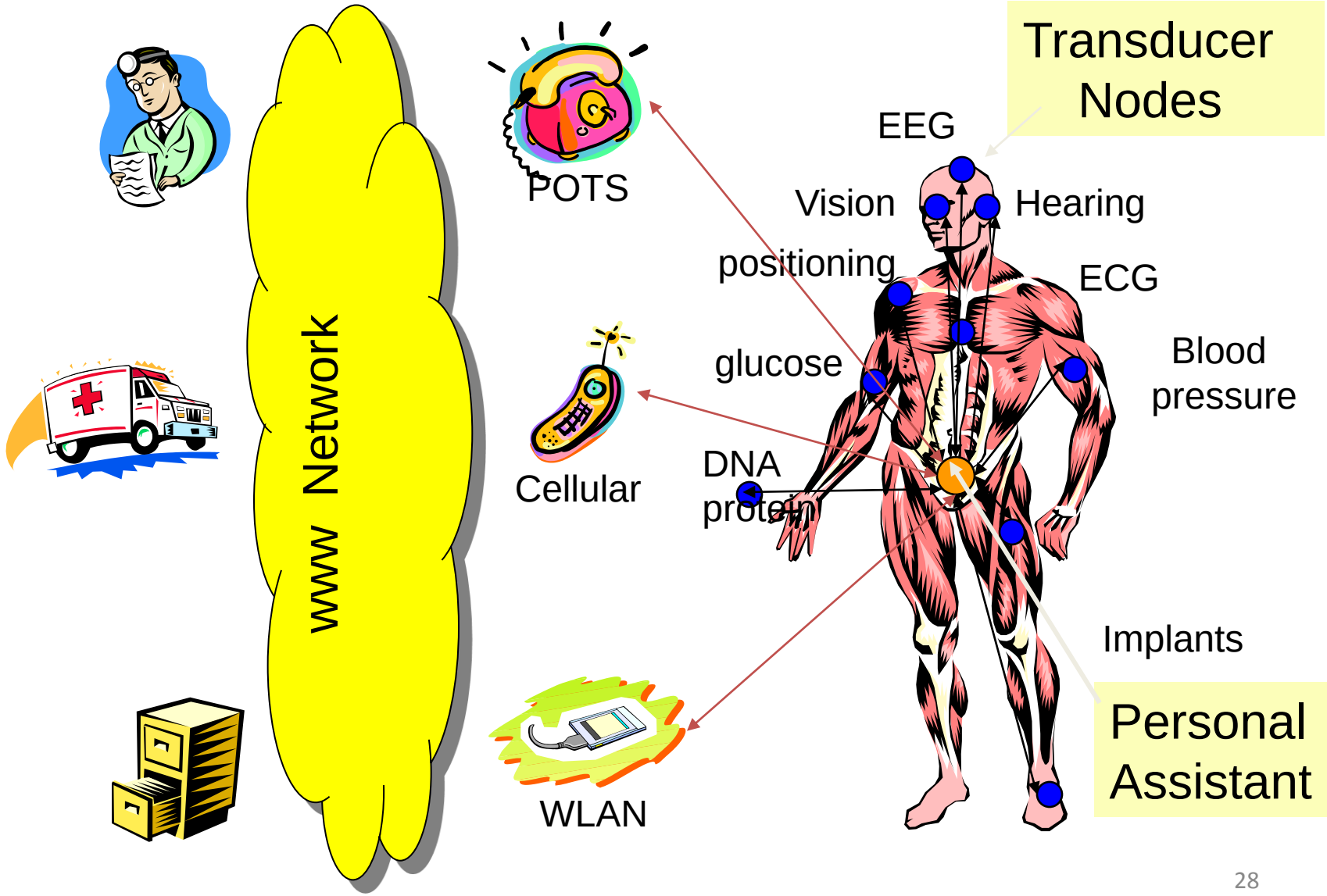


Normal QRS

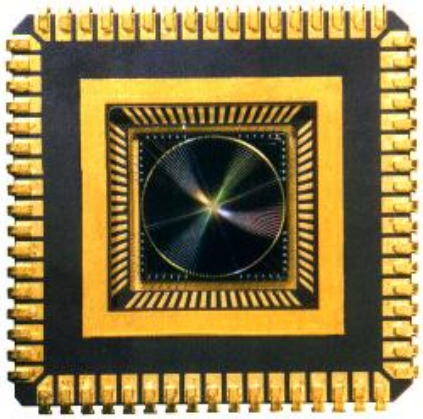
Left Bundle
Branch Block



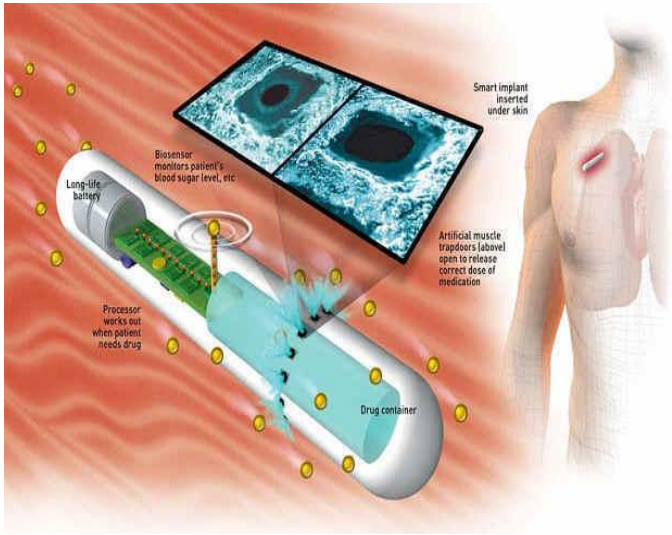
Human++ programma IMEC



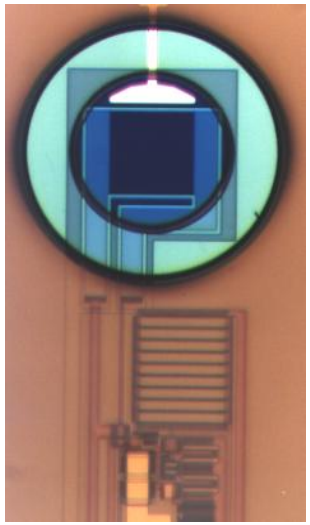
Nano-Sensoren en Actuatoren



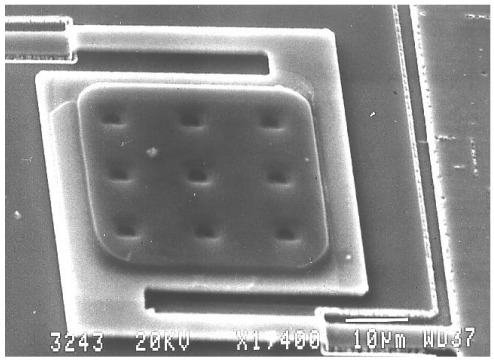
CMOS Imager



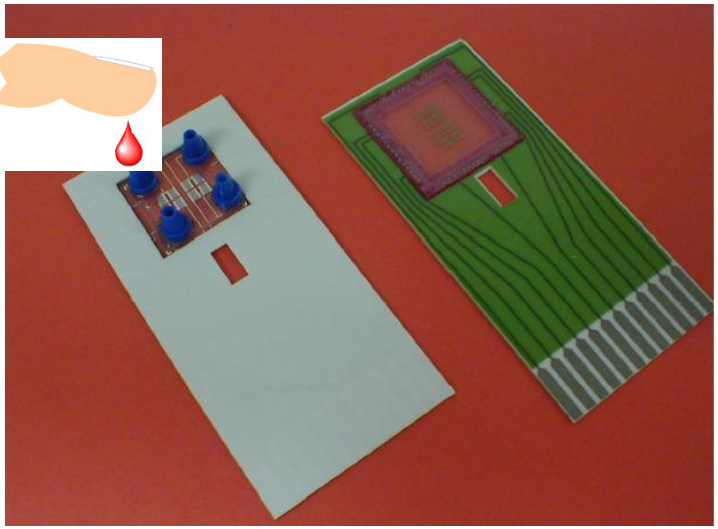
Smart Pill (Ohio State Univ)



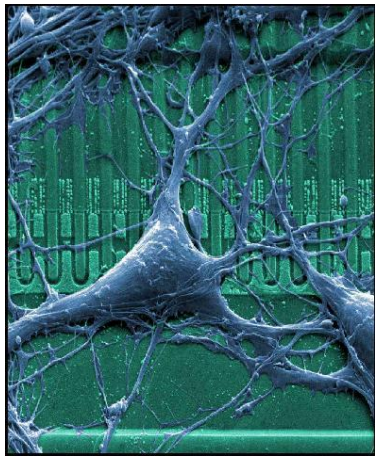
Blood gas sensor (IMEC)



IR Sensor (IMEC)



Prostate cancer diagnosis (IMEC)



NeuronSensor (KNS)

KATHOLIEKE UNIVERSITEIT LEUVEN

Synthetic Biology

Dr. Coli

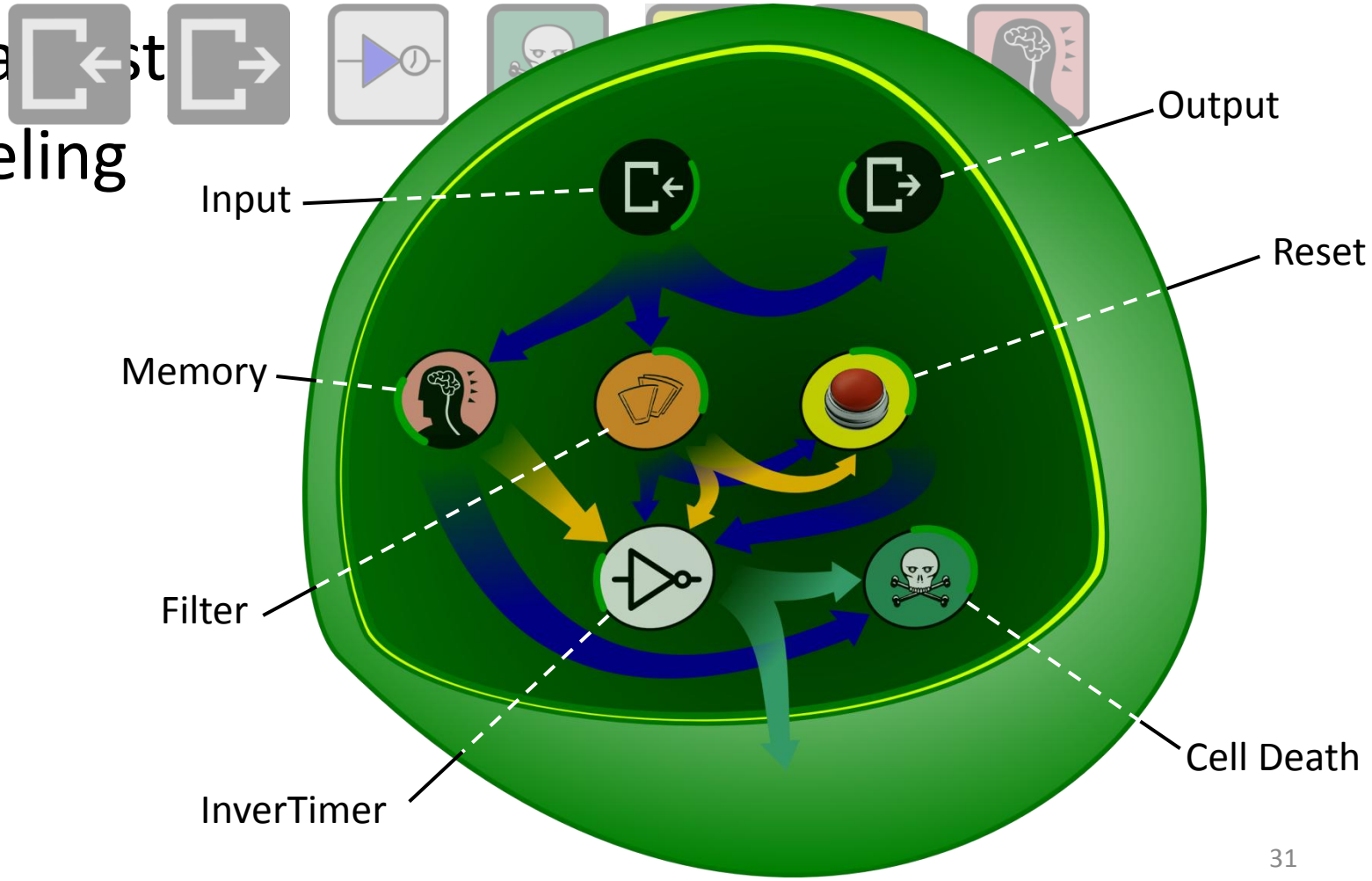
The bacterial drug delivery system

Leuven - BELGIUM

Multidisciplinary team

Slimme bacterie

- 7 subsystems
- Globa[illegible]st
- Modeling



Inhoud

-Trends

-Context

-Opportuniteiten en uitdagingen

-De toekomst