IT Future of Medicine

Setting the Scene
IT Future of Medicine

Content

• Rationale
• Needs
• Market
• The Model
• Example: Cancer
• What we can do already now!

• Components/ Technology
• Flagship Goals
• Partners
• Structure
• Relation to Infrastructure
• ICT Industry involvement
Data-rich, individualised medicine poses unprecedented challenges for ICT, in hardware, software solutions.

We propose a data-driven, individualised medicine of the future, based on molecular/physiological/anatomical/environment data from individual patients.

We shall make general models of human pathways, tissues, diseases and ultimately of the human as a whole.

Individualised versions of the models, produced for each patient, will then be used to identify personalised prevention/therapy schedules and side effects of drugs.
IT Future of Medicine

Needs

World wide ~12 million new cancer cases/year increasing dramatically.

Cure rates for most common forms of cancer have hardly changed over the last decades.

Even the most advanced targeted therapies are typically only effective for a small fraction of the patients.

Pharma development costs have dramatically increased, while the number of new drugs keeps dropping.
“NEW YORK, Dec. 8, 2010 /PRNewswire/ -- Spending on healthcare among the OECD (i) countries and BRIC nations of Brazil, Russia, India and China will grow by 51 percent between 2010 and 2020, amounting to a cumulative total of more than $71 trillion, according to estimates from PwC's Health Research Institute. Health spending in these areas is rising faster than gross domestic product, magnifying gaps in budget deficits and spurring governments to look to the private sector for ways to get a better value for taxpayers' money.”

“Worldwide IT Spending outperformed expectations in 2010, reaching $1.5 Trillion”, according to IDC's Worldwide Black Book from February 09, 2011 08:03 AM Eastern Time
IT Future of Medicine

The –omics Era

Factors of 10 since 2005 for genomics

Moore’s law 1.5x/yr for electronics
Life is the translation of the information in the genome into the phenotype of the organism:

The organism ‘computes’ this phenotype from its genotype, given a specific environment.
IT Future of Medicine

Genome

(PentiumV)

Phenotype

(neuronal net visualisation)
Hanahan / Weinberg Cancer Model


Pathways of the model

- IGF-1 signaling
- Cytokine signaling
- BMP signaling
- TGFbeta signaling
- Hedgehog signaling
- Notch signaling
- TNF-alpha signaling
- Fas signaling
- TRAIL signaling

- E-cadherin pathway
- Wnt signaling
- PLC signaling
- EGF signaling
- TLR3/TLR10 signaling
- GPCR pathway
- NGFR signaling
- Rb/E2F pathway
- DNA repair

- kinetic parameters
- reactions
- components
Many colon cancer patients with tumors without K-ras wild type will respond positively to treatment with EGFR receptor antagonists.
Patients with tumors with K-ras mutations do not: a €30,000 treatment will show no effect on the tumour (but will cause significant side effects on the patient)

Zalcberg et al, NEJM 2008
IT Future of Medicine

Make out of Data Models
IT Future of Medicine

Make out of Data Models

fet11 The European Future Technologies Conference and Exhibition
4-6 May 2011 Budapest, Hungary
The model of patient 1
IT Future of Medicine

Finding a Patient 1 Specific Optimal Drug Treatment

Round 1
Round 2
Round 3
Round 4
Round 5
Round 6

Single Drugs
Double Drugs
Triple Drugs
Quad Drugs
Fiver Drugs

Various Modell Components

Stepwise optimisation of the therapy for an individual patient

Drugs / Drug Combinations

MYC

1
2
3
4
5
6

10
20
30
40
50

fet11 The European Future Technologies Conference and Exhibition
4-6 May 2011 Budapest, Hungary

Science beyond fiction
IT Future of Medicine

12 Million new cancer cases every year ~1 genome/second?

Computing requirements:
Sequence analysis: 100 cores ~1 day/genome: 1e7 core seconds
Modelling: 1000 conditions, 1000 positions in the body, 1000 MC runs, 1000 core seconds/run: 10e12 core seconds
1 Blue Gene L: ~10e5 cores (up to 65,536 nodes with 2 Power PC processors)
~1 Blue Gene L equivalent per patient?

Storage:
~1 Terabyte per genome
30-100 Exabytes for data storage for all cancer patients?
Multi-Zetabytes to Yottabytes for ITFoM?

As of May 2009, the size of the world's total digital content has been roughly estimated to be 500 billion Gigabytes (500 Exabytes) (From the Wiki Exabyte entry)
Genomics:
The complete blueprint of an individual. In perspective the time for sequencing the whole genome of an individual is less and less, and the genome of more and more individuals will be available (Kurt Zatloukal, Hans Lehrach).

Proteomics:
About 100 thousand proteins from ~22000 genes. The expression of proteins is tissue/cell dependent. Well being corresponds to the correct amount of proteins in a tissue/cell.

Metabolomics:
Genomics tells you what could happen. Metabolomics of biological fluids and tissues/cells tells you what has happened. The metabolites are only a few thousand.
IT Future of Medicine

Metabolomics

NMR-based metabolomics

Metabolic fingerprint
Years 1-5

Establishment of integrated molecular/anatomical prototype models of man, development of IT techniques to individualise these models based on high throughput data sources.

Years 5-10

Development of infrastructure for model-based individualized medicine.

Interaction with relevant stakeholders/governments/healthcare and insurance systems to implement this approach throughout the healthcare system.
**IT Future of Medicine**

**24 Partners**

<table>
<thead>
<tr>
<th>Partners</th>
<th>Partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Plank Institut for Molecular Genetics</td>
<td>Uppsala University</td>
</tr>
<tr>
<td>Medical University Graz</td>
<td>University of Luxembourg</td>
</tr>
<tr>
<td>University College London</td>
<td>University of Leicester</td>
</tr>
<tr>
<td>Free University of Amsterdam</td>
<td>HARVARD Medical School</td>
</tr>
<tr>
<td>University of Manchester</td>
<td>University of Auckland</td>
</tr>
<tr>
<td>Maastricht University</td>
<td>Universite de Geneve</td>
</tr>
<tr>
<td>EMBL</td>
<td>Centro Nacional De Análisis Genómico</td>
</tr>
<tr>
<td>Wellcome Trust Sanger Institute</td>
<td>Siemens</td>
</tr>
<tr>
<td>Kungliga Tekniska högskolan</td>
<td>Alacris Theranostics GmbH</td>
</tr>
<tr>
<td>Imperial College London</td>
<td>Charite Universitätsmedizin Berlin</td>
</tr>
<tr>
<td>CIRMMP</td>
<td>Illumina</td>
</tr>
<tr>
<td>International Prevention Research Institute</td>
<td>Commissariat a l'energie atomique et aux energies alternatives</td>
</tr>
</tbody>
</table>
IT Future of Medicine

Structure

5 Platforms:

- Information Technology Platform (Mark Girolami)
- Analytical Platform (Hans Lehrach)
- Medical Platform (Kurt Zatloukal)
- Integration Platform (Hans Westerhoff)
- Coordination Platform (Hans Lehrach)
IT Future of Medicine
IT Future of Medicine

Relations to Infrastructures

- Barcelona Supercomputing Center
- European Sequencing and Genotyping Infrastructure
- Infrastructure for Systems Biology – Europe
- EATRIS
- Partnership for Advanced Computing in Europe
- Jülich Supercomputing Centre
- Biobanking and Biomolecular Resources Research Infrastructure
- Integrated Structural Biology Infrastructure
- ELIXIR: European Life Sciences Infrastructure for Biological Information

fet11 The European Future Technologies Conference and Exhibition
4-6 May 2011 Budapest, Hungary
Science beyond fiction
IT Future of Medicine

ICT Industry Involvement

- The Microsoft Research - University of Trento COSBI (Corrado Priami)
  *Computational tools for large scale Systems Biology*
- Xerox (Cedric Archambeau)
  *New machine learning and mechanism*
- IBM Research Zurich (Eleni Pratsini)
  *Integration of large scale legacy systems with novel system architectures*
- Intel Germany (Andrea Cato)
  *Future generation processor architectures - beyond vectorised GPU*
- Amazon.com
  *Multi-Peta Scale Data Storage and retrieval*
- Siemens
  *Biomedical Solutions and Bioinformatics*
- Oracle
  *Future Databases*
The project outcomes will enable the prediction of health, disease, therapy and its effects for individual patients and through application in the clinic will change the future of medicine.

For more information:
Website: http://www.itfom.eu
Email: info@itfom.eu
Twitter: @itfom
Facebook: I.T. Future of Medicine
LinkedIn: IT Future of Medicine