New Opportunities in Cancer Research

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Cancer is a Current Healthcare Crisis in the U.S.

- ~ 560,000 Americans will die of cancer this year
- ~ 1.4 million Americans will be diagnosed with cancer this year
- ~ $213 billion in 2005 for cancer healthcare costs
- Numbers of new cancer cases will increase by 30-50% as we approach 2020 (Aging of the baby boomers)

Unlike Other Major Disease Killers, Cancer Continues to Take Nearly the Same Toll as it did in 1950

Source for 2006 deaths and diagnoses: American Cancer Society (ACS) 2006 Cancer Facts & Figures; Atlanta, Georgia
A Looming Global Healthcare Crisis

By 2020, cancer could kill 10.3 million people per year unless we act

Percentage increase in cancer deaths since 2002

Source: World Health Organization
“Global Action Against Cancer” 2005
The Vision for 21\textsuperscript{st} Century Personalized Medicine

<table>
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<th>20\textsuperscript{th} Century</th>
<th>21\textsuperscript{st} Century</th>
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<tr>
<td>♦ Focus on treatment</td>
<td>♦ Focus on understanding genetic predisposition, early detection</td>
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<tr>
<td>♦ Diagnosis based on morphologic and pathologic analysis</td>
<td>♦ Diagnosis based on molecular characterization and biological processes</td>
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<td>♦ Expensive; perpetuates unsuccessful approaches</td>
<td>♦ Evidence-based; continually assesses standard of care</td>
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<td>♦ Lack of robust connection between science- healthcare</td>
<td>♦ Connects bench $\Delta$ bedside $\Delta$ bench in seamless \textit{feedback loop}</td>
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<td>♦ Not Sustainable</td>
<td>♦ \textit{Sustainable}</td>
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## NCI’s Strategic Initiatives to Enable Personalized Cancer Medicine

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<td><strong>Biorespositories</strong></td>
<td>• Cancer Human BioBank (caHUB)</td>
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<td><strong>Bioinformatics</strong></td>
<td>• Cancer Bioinformatics Grid (caBIG)</td>
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<td><strong>Genomics</strong></td>
<td>• The Cancer Genome Atlas (TCGA)</td>
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<td><strong>Proteomics</strong></td>
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The “S” Curve of Cancer Science

From Qualitative to Quantitative

Search for Unifying Theories

Rise of Partial Theories On Complex Systems

Data explosion

Growing Understanding Of Subsystems

Empirical Observations

Adapted from E. Zerhouni
Biospecimens: The Foundation for Personalized Medicine

Empirical → Quality SOPs → Biospecimen Research → Data-Driven

2006 NCI First Generation Guidelines for Biorepositories

Medical/Surgical Procedures
Acquisition
Handling/Processing
Storage
Distribution
QC/QA
Restocking Unused Sample
caBIG™ is an open source and open access information (grid enabled) network enabling all constituencies across the cancer enterprise – researchers, clinicians, patients – to share data and knowledge to accelerate the discovery of new cancer interventions and deliver them to patients.
The Cancer Genome Atlas (TCGA) is a unprecedented collaborative project between the NCI and the NHGRI that is designed to develop a complete “atlas” of all of the genomic changes in cancer – and increase our comprehensive understanding of the genetic basis of cancer.

TCGA is large-scale – high throughput - and will undertake the complete characterization of 20 tumors in the next 5 years.

It is anticipated that TCGA’s integrated database of molecular and clinical information will provide unprecedented opportunities to discover and develop a new generation of targeted diagnostics, therapies, and preventives for cancer.
Three forms of cancer

- Glioblastoma multiforme (brain)
- Squamous carcinoma (lung)
- Serous cystadenocarcinoma (ovarian)

Multiple data types

- Clinical diagnosis
- Treatment history
- Histologic diagnosis
- Pathologic status
- Tissue anatomic site
- Surgical history
- Gene expression
- Chromosomal copy number
- Loss of heterozygosity
- Methylation patterns
- miRNA expression
- DNA sequence
The Cancer Genome Atlas

Tissue Sample

Pathology QC

DNA & RNA Isolation, QC

Analysis

Sequencing

Expression, CNA & LOH, Epigenetics

Data and Results Storage & QC

Integrative Analysis

Comprehensive Multi-Dimensional Integrated Data Set

= Process

= Data

= Results

= BCR

= GSCs

= CGCCs

= DCC

= Collaborators
Physical Sciences in Oncology

Integrating and Leveraging the Physical Sciences to Open a New Frontier in Oncology

Diagram:
- De-convoluting Complexity
- Coding/Decoding/Transfer Of Information
- Evolution and Evolutionary
- Physics (Physical Laws and Principles)

Investigators tend to work in ‘length-scale’ silos. In order to have a clearer picture of cancer, these barriers need to be broken.

Length Scale – In Reference to Size (Ranging from 1 nm – 1 mm)
Critical to Think in Terms of Space and Time
Nanotechnology: A New Frontier to Drive Innovation in Medicine

The Alliance for Nanotechnology in Cancer:

- To ignite nano-product development and commercialization
- Encompasses public and private sectors
- Six key areas of focus:
  - Molecular Imaging and Early Detection
  - In Vivo Imaging
  - Reporters of Efficacy
  - Multifunctional Therapeutics
  - Prevention and Control
  - Research Enablers

Nanodevices:

- Nanopores
- Dendrimers
- Nanotubes
- Quantum dots
- Nanoshells
Unprecedented knowledge of nearly every cancer – most certainly an affordable cancer genome

Real diagnostic and predictive biomarkers

A connected bioinformatics enterprise - searchable databases that are evolving toward in silico discovery – new development (clinical trials models)

Evidence based cancer risk prediction models

Very early detection technologies – (chip based – biosensors – advanced imaging technologies)

Large numbers of evidence-based cancer interventions in development

Electronic medical records to support personalized cancer medicine