NCI Alliance for Nanotechnology in Cancer

Pre-application Meeting

RFA-CA-09-013: Cancer Nanotechnology Platform Partnerships

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Cancer is a Current and Long Term Healthcare Crisis

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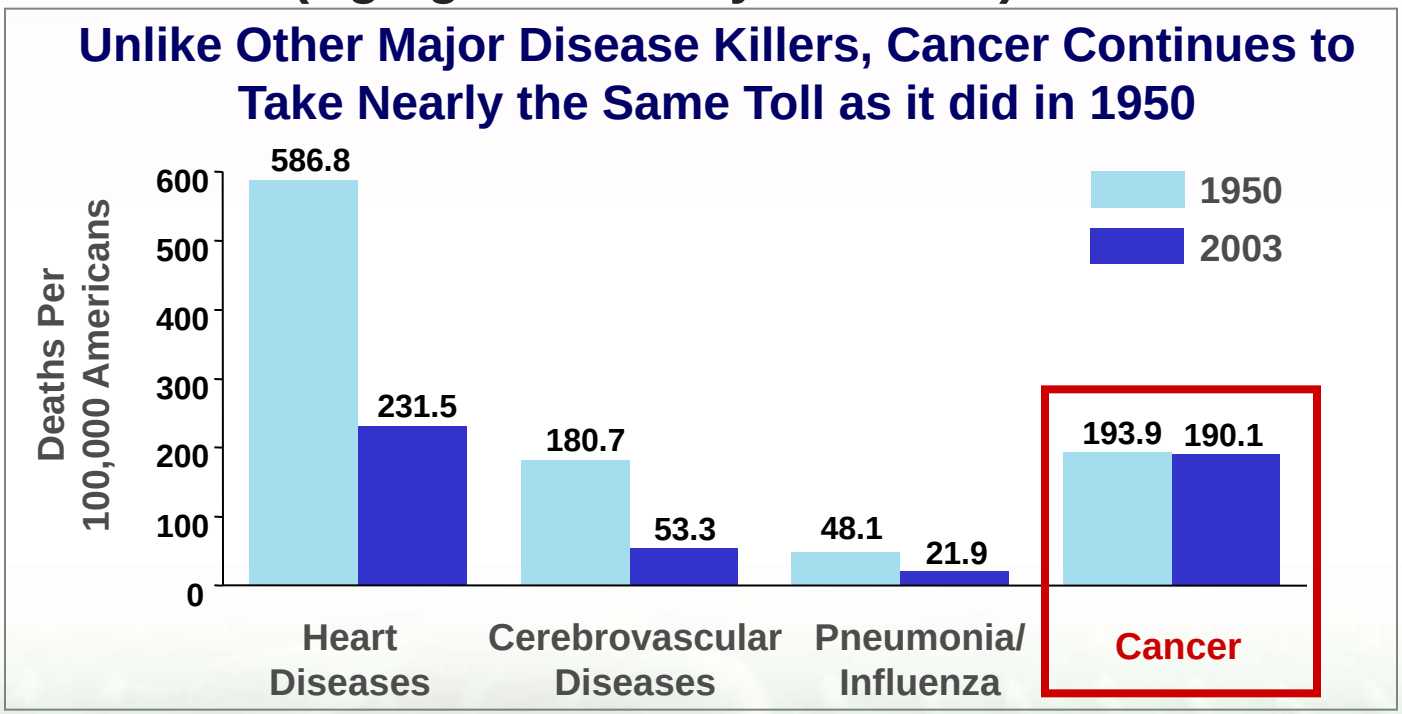
- ~ 560,000 Americans will die of cancer this year
- ~ 1.4 million Americans will be diagnosed with cancer this year
- ~ $213 billion in 2005 for cancer healthcare costs
- Numbers of new cancer cases will increase by 30-50% as we approach 2020 (Aging of the baby boomers)



Source for 2006 deaths and diagnoses: American Cancer Society (ACS) 2006 Cancer Facts & Figures; Atlanta, Georgia
Source for 2003 age-adjusted death rate: National Center for Health Statistics, U.S. Department of Health and Human Services, NCHS Public-use file for 2003 deaths.

Barrier: The Daunting Complexity of Cancer at Every Level

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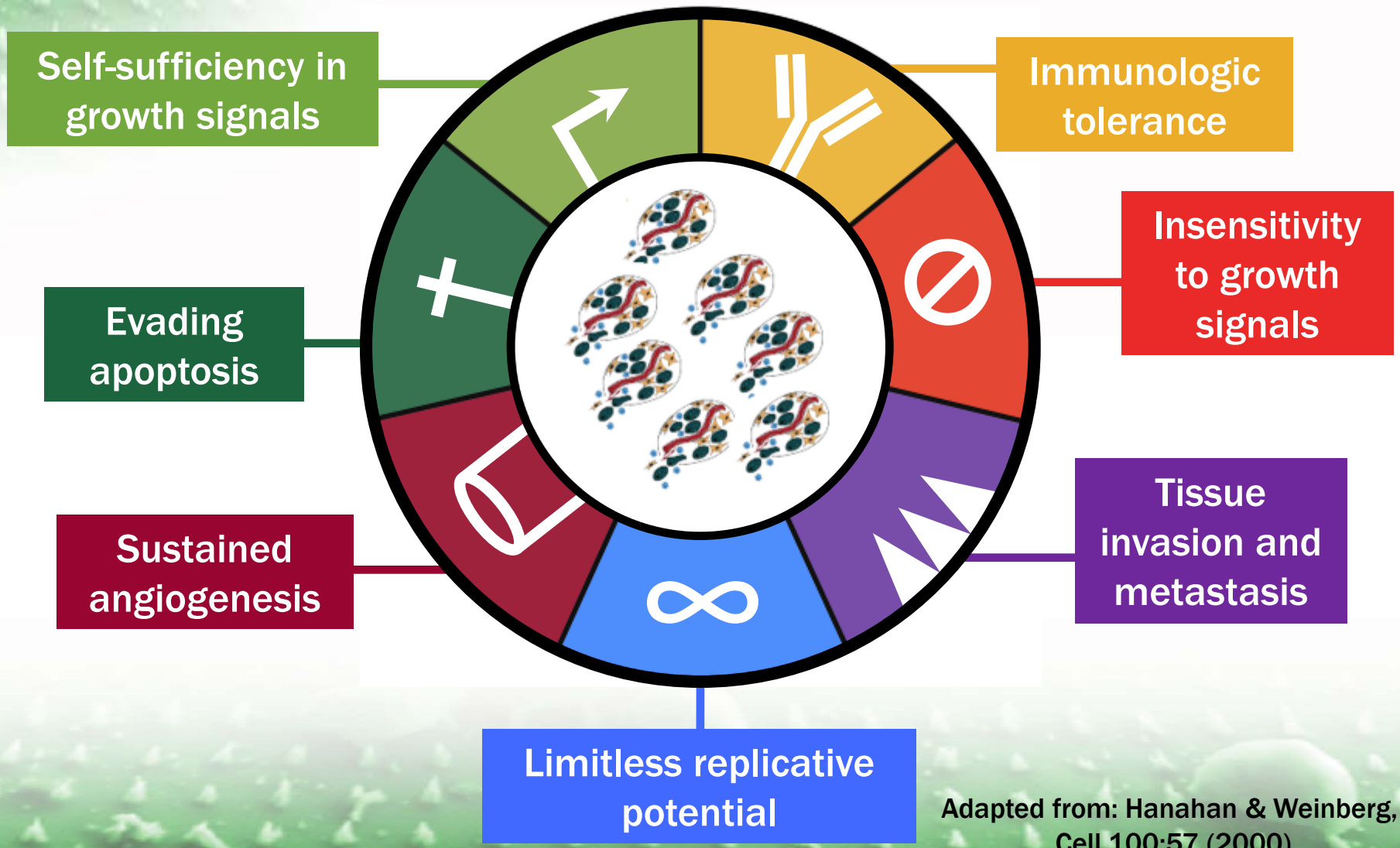

Adapted from: Hanahan & Weinberg, Cell 100:57 (2000)

Barrier: Cancer is an Evolving Emergent System

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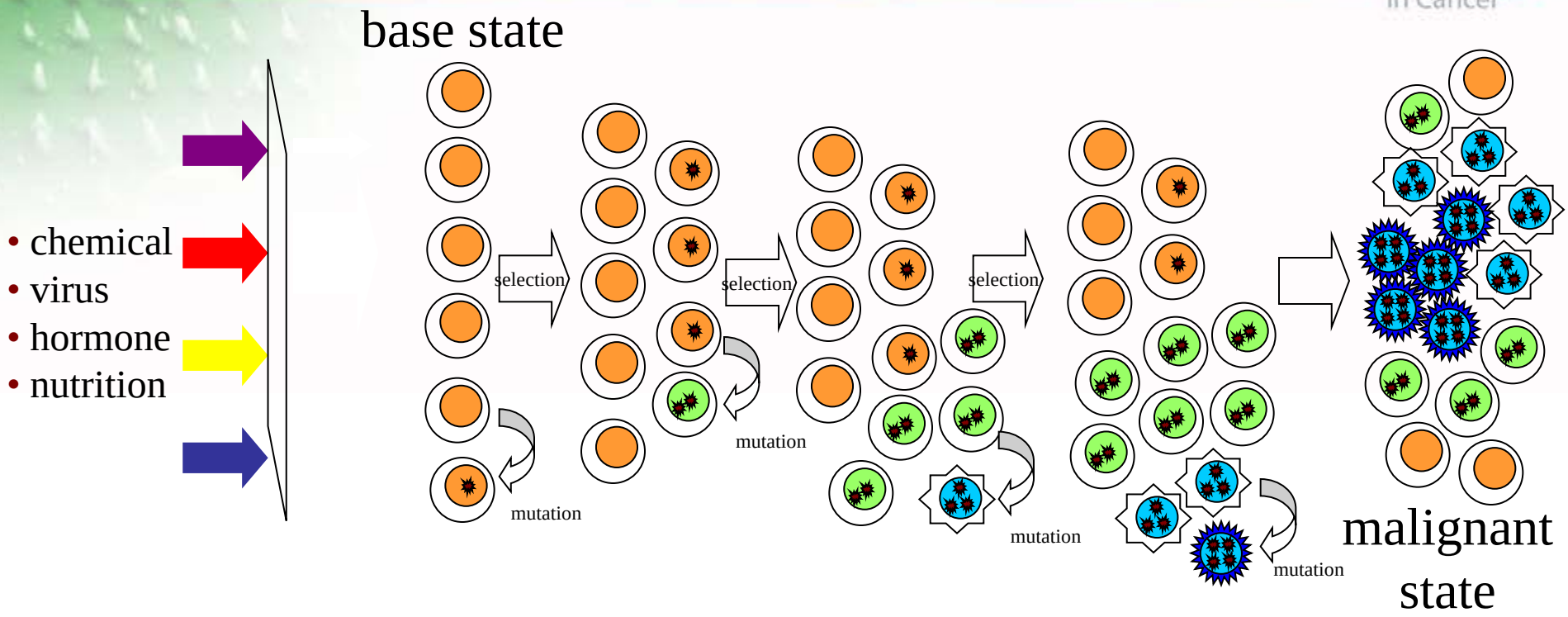

Insufficient Knowledge of Biological Space

Barrier: Tumor Heterogeneity

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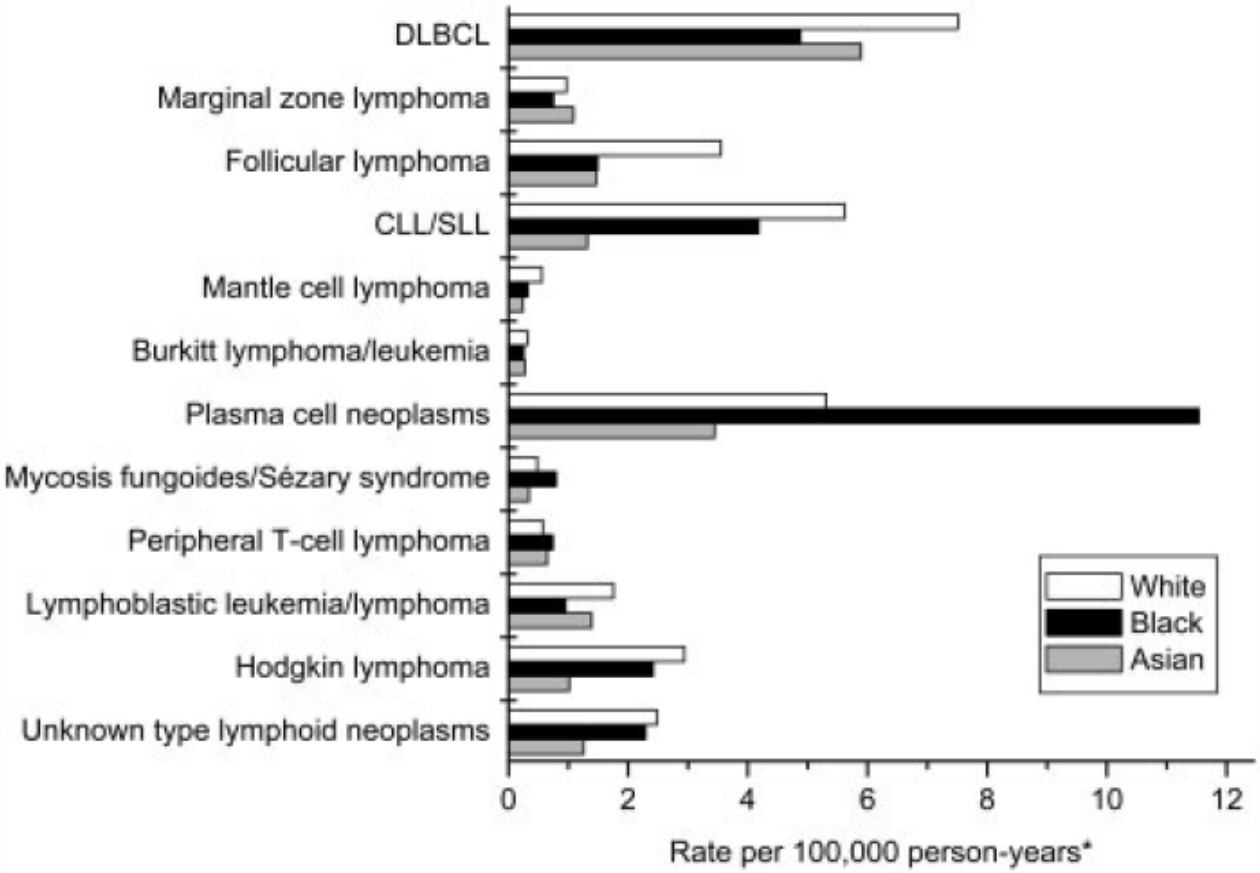

Figure 3. Incidence of lymphoid neoplasms by subtype and race, 12 SEER registries, 1992-2001. *All incidence rates are age adjusted to the 2000 United States population. Abbreviations are explained in Table 1.

Morton et al, Blood 2006

Barrier: The Oncology Drug Development Challenge

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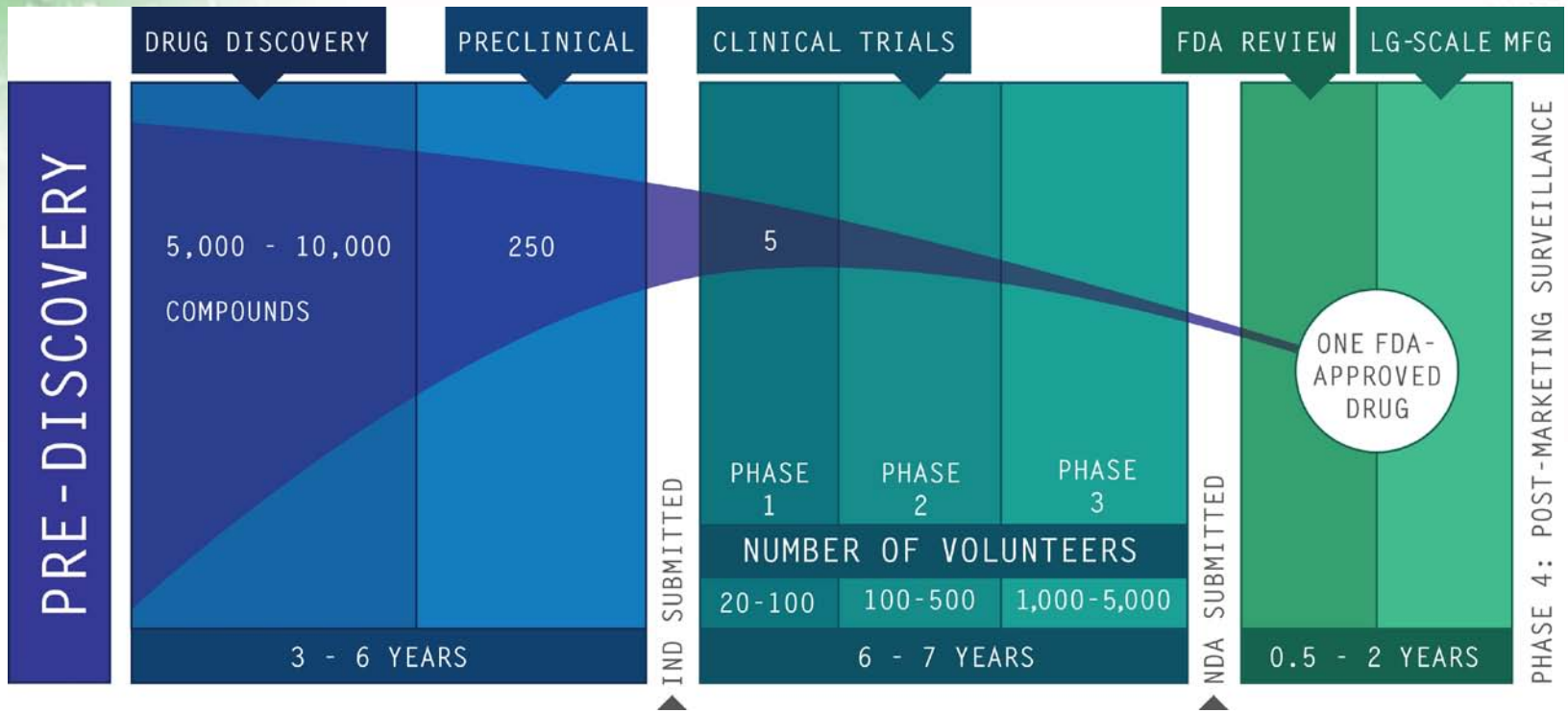

Time and attrition are both directly related to **insufficient knowledge of biological space**

~ US$ 1 Billion

So Why Nanotechnology for Cancer?

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- Cancer can generally be successfully treated – if diagnosed early
- Cancer is an exceedingly complex disease (potentially hundreds of genomic changes – possibly thousands of proteomic changes to measure for diagnosis)
- Specific delivery to the target is critical for cancer – now and in the future
- Imaging offers enormous potential for both diagnosis and therapy – especially functional imaging
- Multiplexing functions is necessary for cancer detection and treatment (need to detect – deliver – report – monitor – re-deliver)
- Sensing changes in tissues/microenvironments is early but could enable preventive strategies
- Understanding the biologic “space” will be enabled by nanotechnologies
- Nanotechnology may be our best hope for prevention

Some "Big Questions in Cancer

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- How do we knowing most/all of the relevant information that drives cancer initiation and progression – understanding the biological space?
- Can we define most of the types and subtypes of cancer?
- Can we capture enough information to diagnose cancer at the earliest possible time?
- How can we stop cancer metastasis?
- For established disease – can we define what a therapeutic target is - and direct an agent to that target – sparing normal cells?
- Is it feasible to combine cancer biomarkers that can diagnose cancer - with therapies to reach the specific molecular lesions identified by the diagnostic?
- Can we monitor the effectiveness of an intervention to identify resistance and address it early?
- Will we ultimately be able to monitor the state of cellular/tissue homeostasis – sense specific pre-neoplastic changes (genomic, physical, etc.) and estimate risk?

Current NCI Alliance for Nanotechnology in Cancer

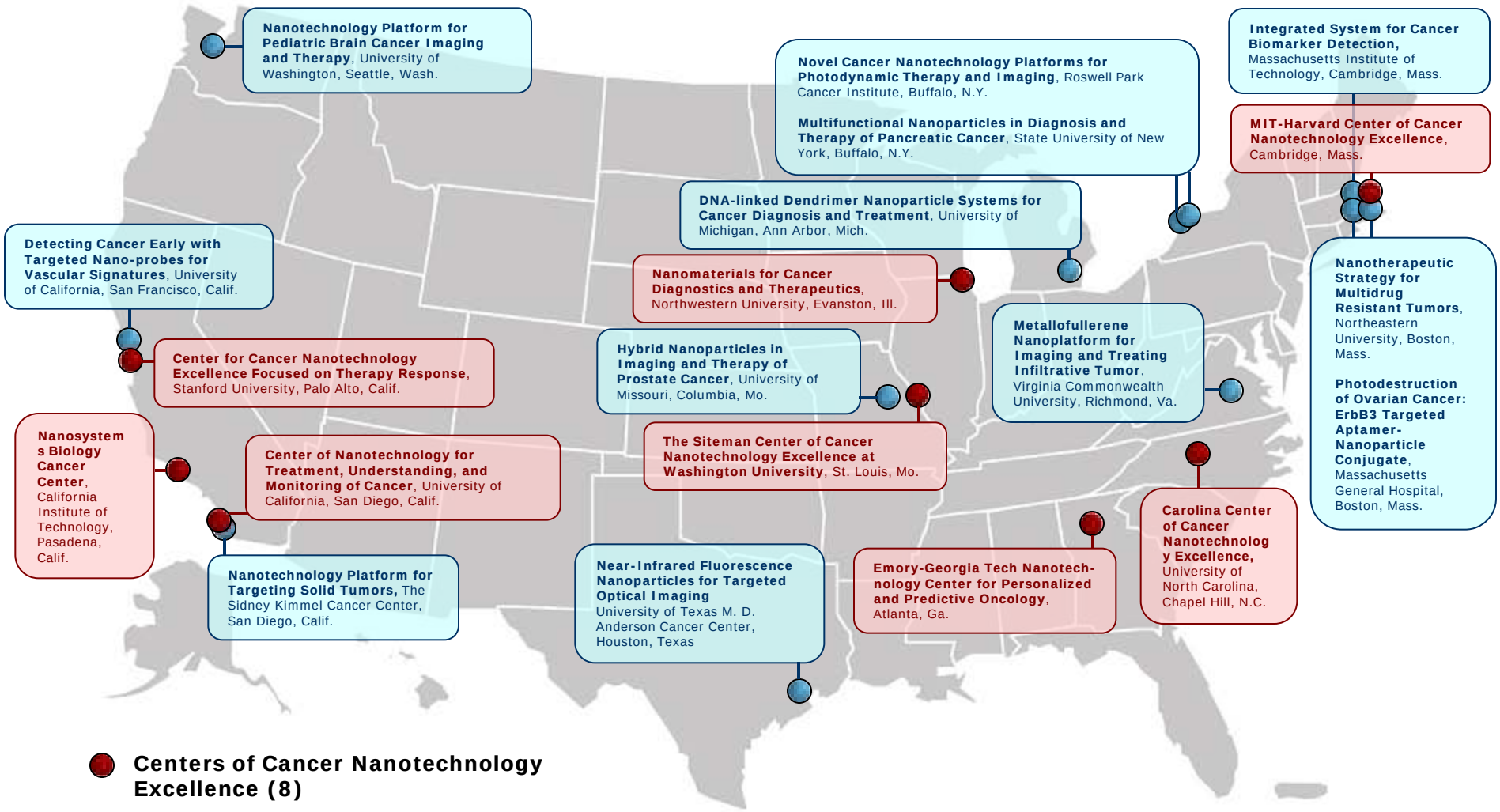
NCI Alliance for Nanotechnology in Cancer

Launched in September of 2004

- **8 Centers of Cancer Nanotechnology Excellence**
- **12 Nanotechnology Platforms for Cancer Research**
- **Multidisciplinary Research Training and Team Development**
  - Fellowships in Cancer Nanotechnology Research
  - Interagency Collaborations
- **Nanotechnology Characterization Laboratory**

NCI's Alliance for Nanotechnology in Cancer

NCI Alliance for Nanotechnology



Are We Making Progress?

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- Cancer can generally be successfully treated – if diagnosed early – Key efforts are already underway using multiple nanotechnologies to increase sensitivity of high information content assays
- Cancer is an exceedingly complex disease (potentially hundreds of genomic changes – possibly thousands of proteomic changes to measure for diagnosis) - nanotechnology is not numbers/parameters limited so attacking this issue is feasible
- Specific delivery to the target is critical for cancer – now and in the future – power of delivering therapies via nanotechnologies is virtually unlimited
- Imaging offers enormous potential for both diagnosis and therapy – especially functional imaging – well underway, and nanotechnology-enabled imaging improvements are increasing
- Multiplexing functions is necessary for cancer detection and treatment (need to detect – deliver – report – monitor – re-deliver) – Multiplexing is enabled by nanotechnology and increasingly on the horizon as a reality
- Sensing changes in tissues/microenvironments is early but could enable preventive strategies – it's early but biosensors are in development – realistic possibilities

Future Challenges for Nanotechnology in Cancer

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- Defining properties at the meso-scale in the cancer setting
- Engaging and educating the oncologists
- Numerous technical challenges: e.g., communication from the nano to macro environments; reporter systems for nano; predictive theoretical models; proof of concepts transition to products, etc.
- Developing new clinical trials models
- Regulatory hurdles
- Limitations of numbers of trained scientists and new training models
- Building the right teams
- Building networks that work – one lab can not do it all
- Public perception (nano-bots to invisibility) vs. real promise for medicine

Nanotechnology – Reasons for Optimism - Interrogating Cancer's Complexity

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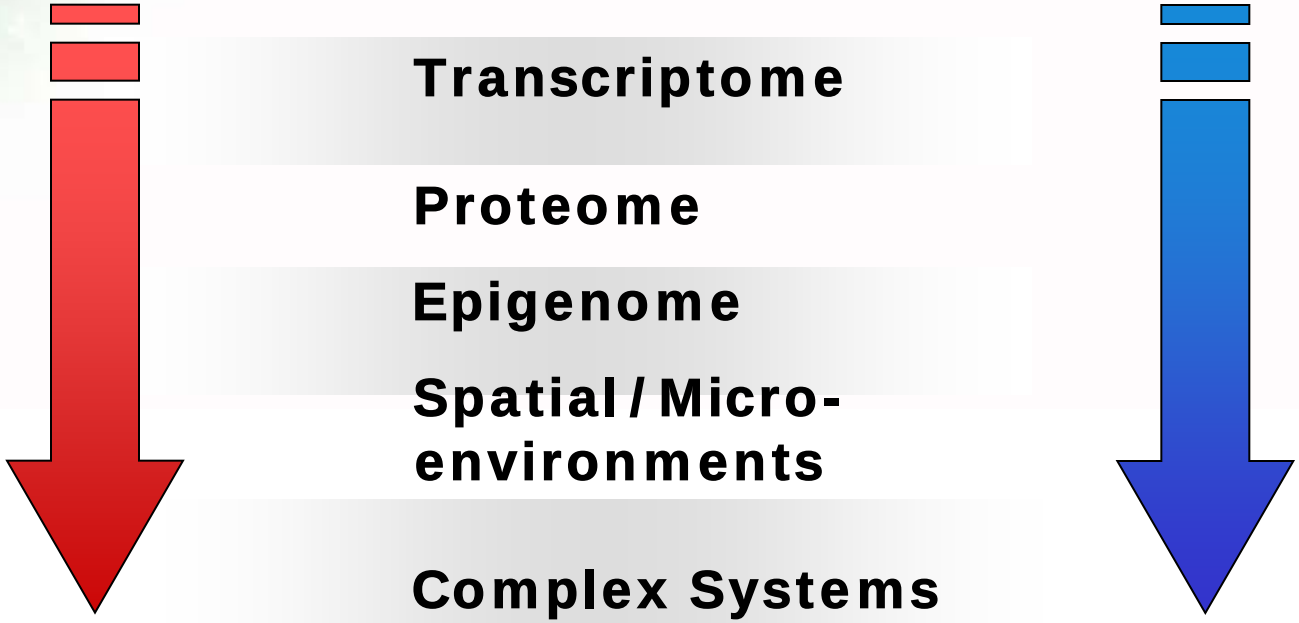

Increasing layers of complexity (Ability to detect, transcribe, Interpret and report information)

Decreasing / limiting power of current Technologies (Promise of Nanotechnology)