Medical Physics in the Era of Genomic Medicine

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If you don’t like change, you are going to like irrelevance even less.

General Eric Shinseki, Secretary of Veterans Affairs

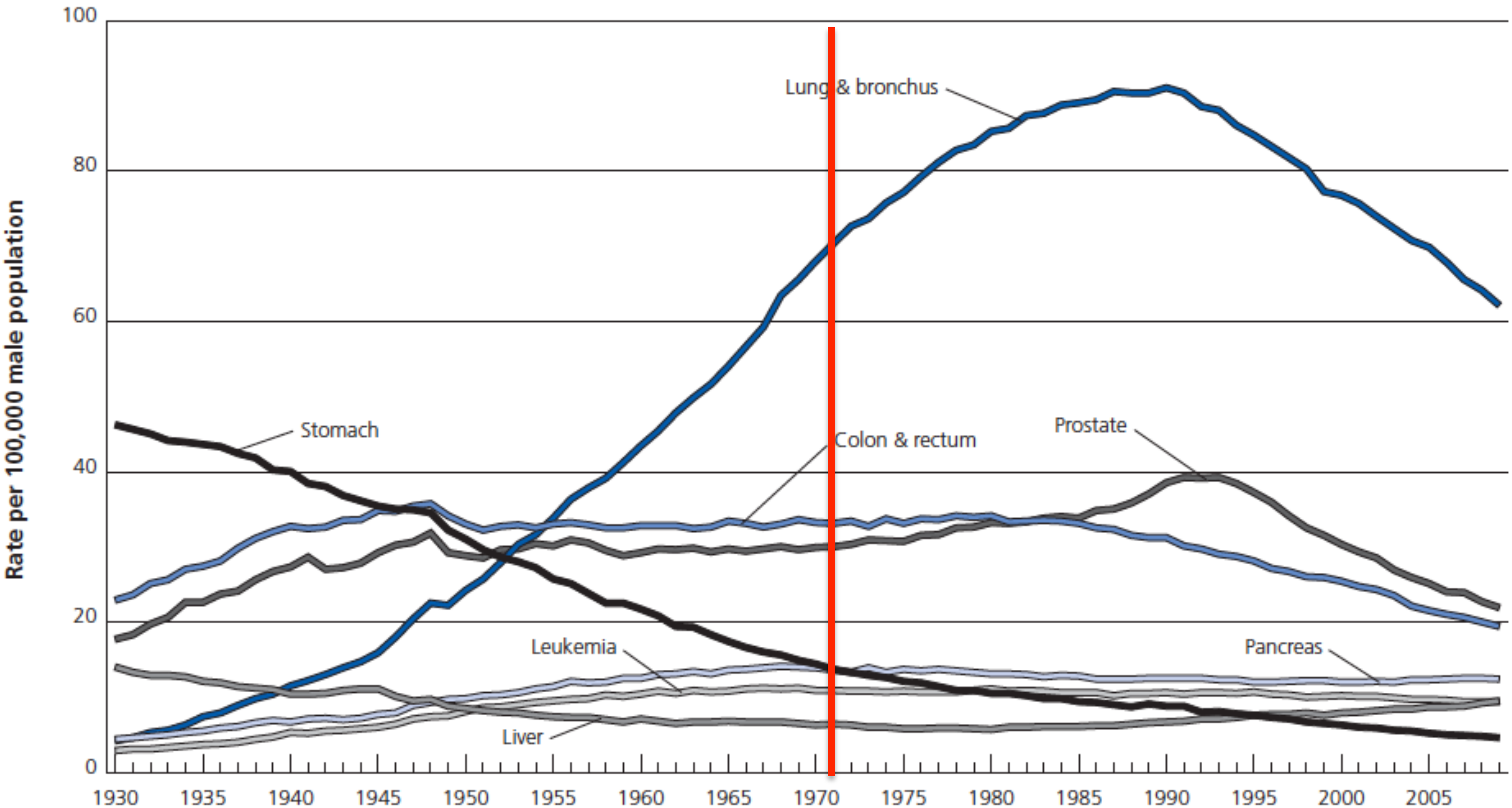
What's driving cancer research?

- **GOOD NEWS**
  - Death rates for the four most common cancers (prostate, breast, lung, colorectal), and all cancers combined, continue to decline.
  - The rate of cancer incidence has declined since the early 2000s.
  - Length of cancer survival has increased for all cancers combined.
- **BAD NEWS**
  - Incidence rates of some cancers are rising including melanoma, non-Hodgkin lymphoma, childhood cancer, leukemia, thyroid, pancreas, liver, testis.
  - Death rates for pancreas, esophagus, thyroid, and liver are increasing.
- **Cancer treatment spending continues to rise.**
- **Research funding is flat from all sources!**
- **Few *cures*…**

National Cancer Act of 1971

- Signed into law by President Richard M. Nixon
- The act was created as a mechanism to make the elimination of cancer a national priority
- The press dubbed this the *War on Cancer*
- In 2003, NCI Director Andrew von Eschenbach issued a challenge to cure cancer by 2015
  - This position was supported by AACR in 2005
- **We are not close yet and it's 2013!!!**

Age-adjusted Cancer Death Rates*, Males by Site, US, 1930-2009

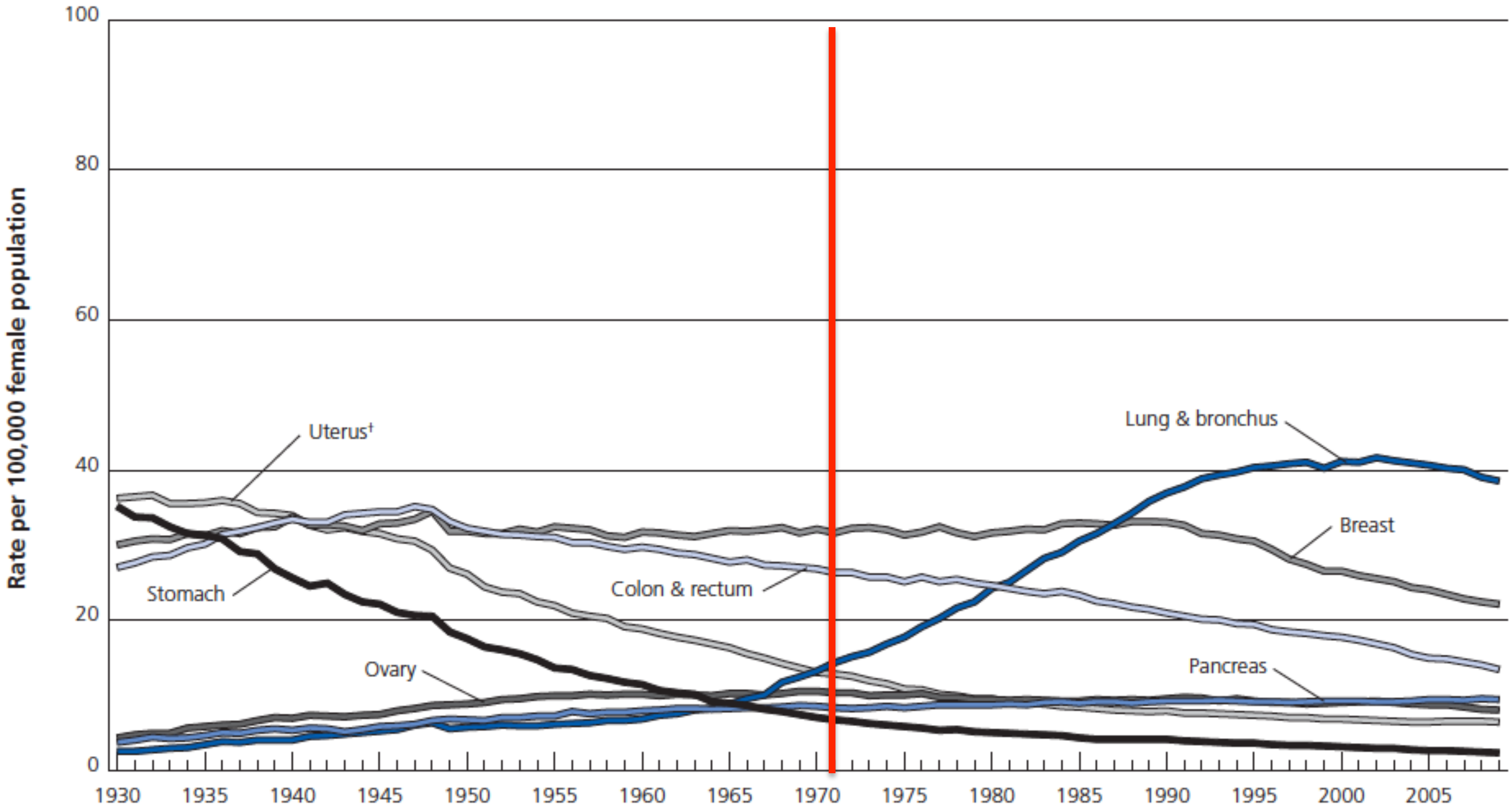


*Per 100,000, age adjusted to the 2000 US standard population.

Note: Due to changes in ICD coding, numerator information has changed over time. Rates for cancer of the liver, lung and bronchus, and colon and rectum are affected by these coding changes.

Source: US Mortality Volumes 1930 to 1959, US Mortality Data 1960 to 2009, National Center for Health Statistics, Centers for Disease Control and Prevention.

Age-adjusted Cancer Death Rates*, Females by Site, US, 1930-2009



*Per 100,000, age adjusted to the 2000 US standard population. †Uterus refers to uterine cervix and uterine corpus combined.

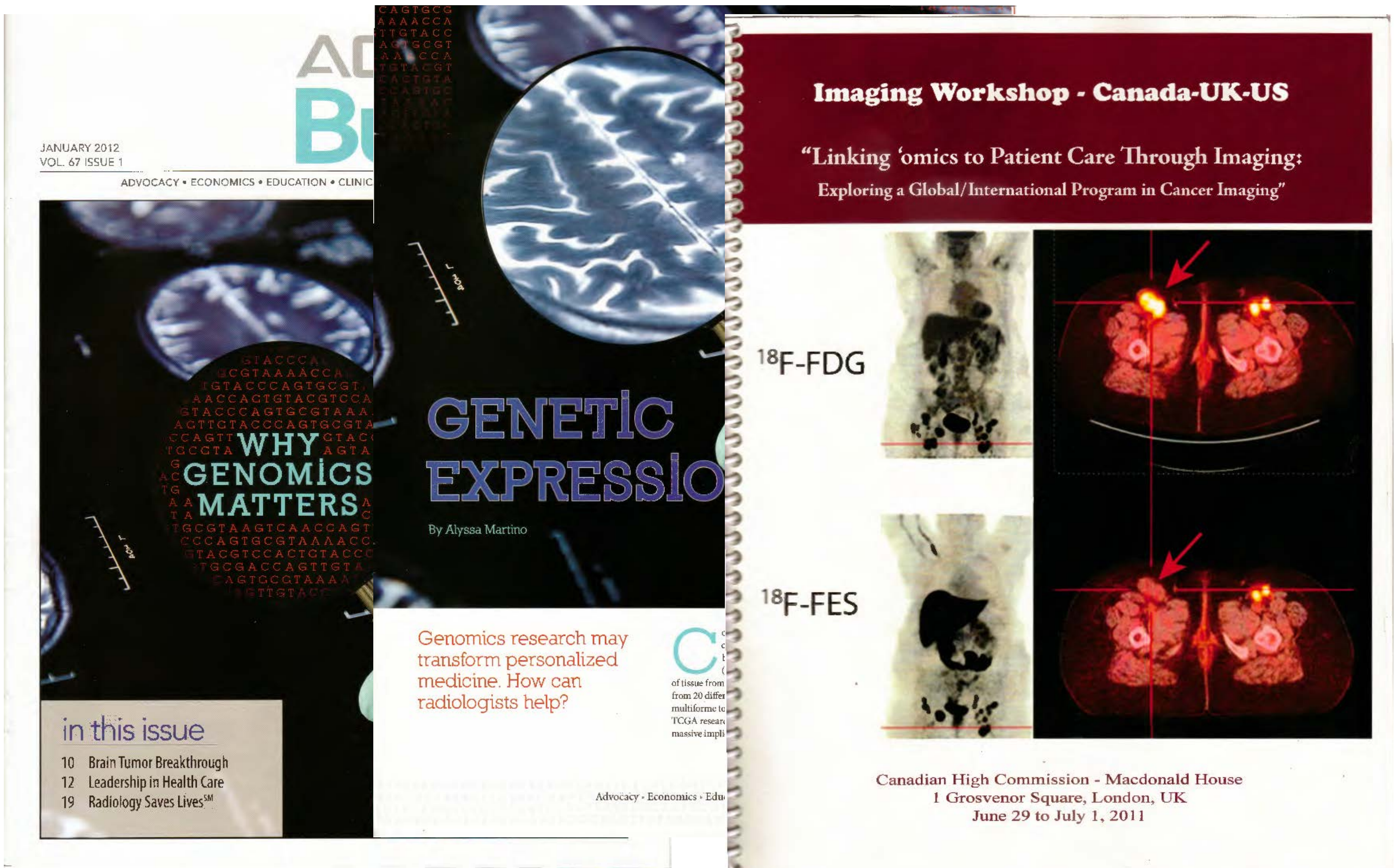
Note: Due to changes in ICD coding, numerator information has changed over time. Rates for cancer of the lung and bronchus, colon and rectum, and ovary are affected by these coding changes.

Source: US Mortality Volumes 1930 to 1959, US Mortality Data 1960 to 2009, National Center for Health Statistics, Centers for Disease Control and Prevention.

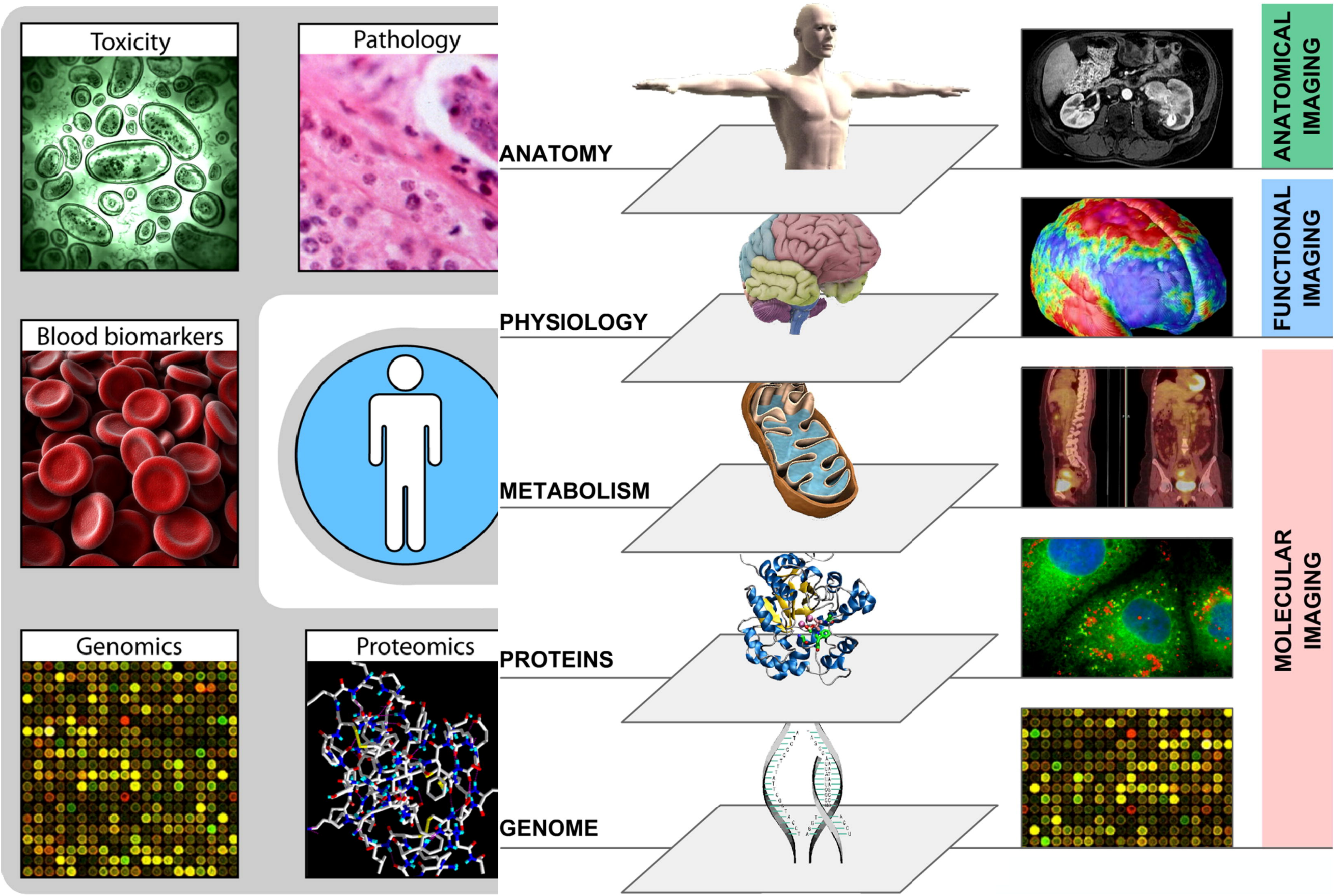
Human Genome Project

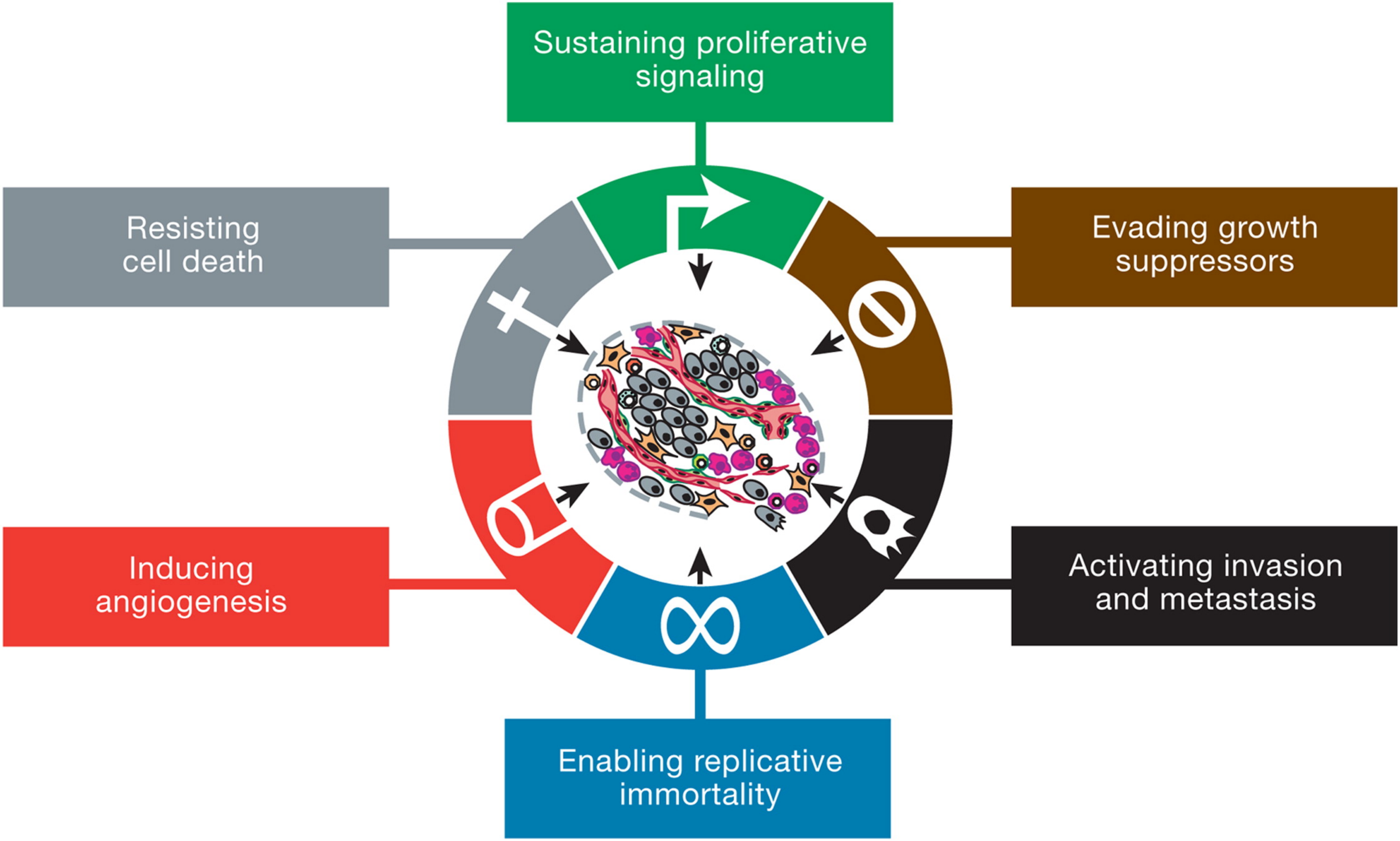
- Initiated with funding by the Reagan administration in 1987 as a consequence of a 1986 scientific meeting in Santa Fe.
- In 1990, the DOE and NIH signed an MOU coordinating their funding efforts and set 1990 as the starting point of a 15 year clock.
- The project was declared complete in 2003.
  - *99% of the genome was known to 99% accuracy*

WHAT IS THE FUTURE OF MEDICAL PHYSICS RESEARCH IN A GENOMIC WORLD?

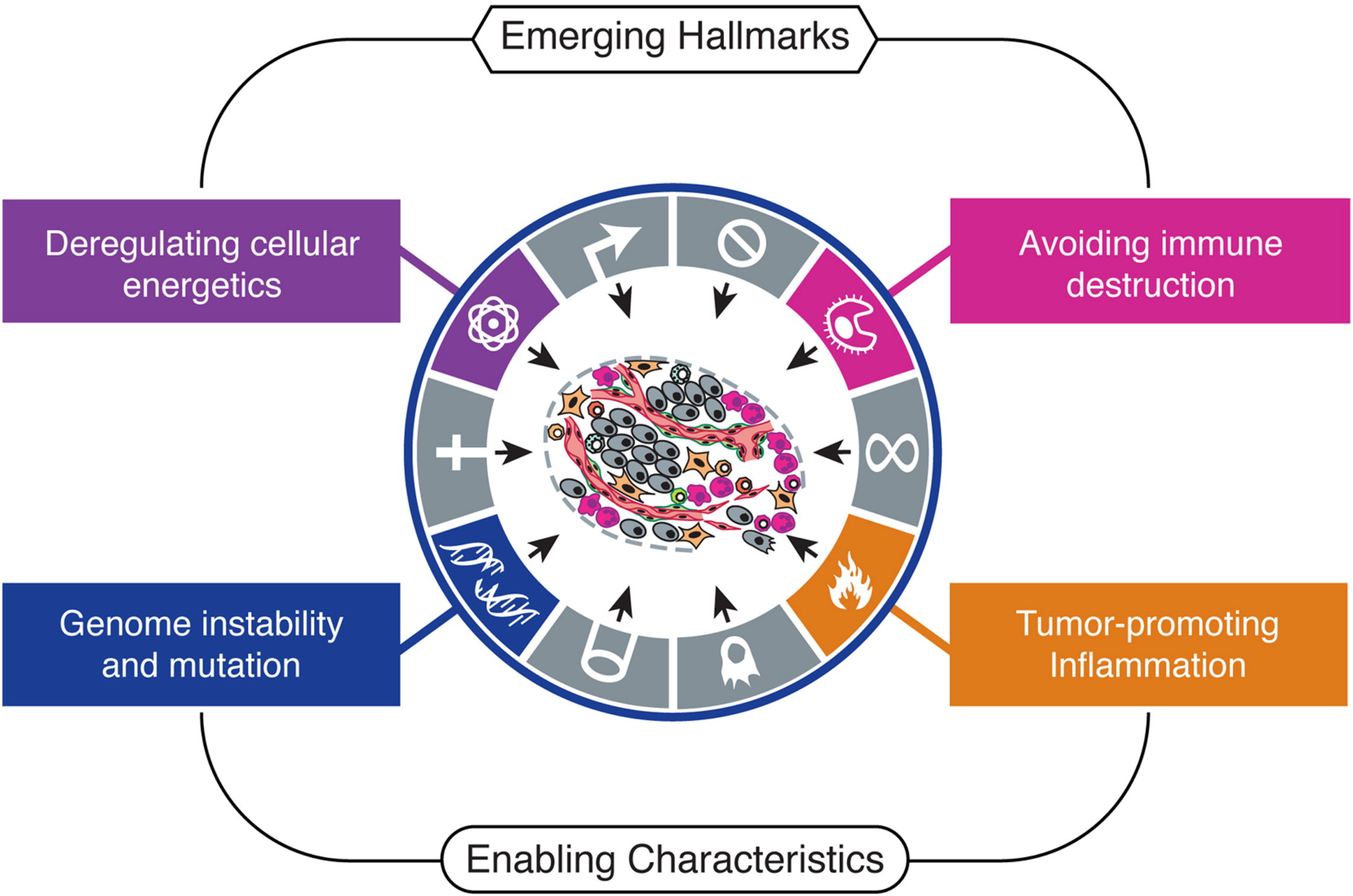


The omics of cancer





Hanahan & Weinberg, Cell 57-70, 2000



Hanahan & Weinberg, Cell 646-671, 2011

Current funding priorities at NCI

- Much more **impact** focused.
  - *So it's a great idea. If it is successful, what will be the impact on patient mortality and morbidity?*
- Biology orientation
  - ***For cancer, that's really genomics!***
- Instrumentation development will need a very well defined outlet.
  - *Difficult to get funding for platform technologies or incremental advances.*

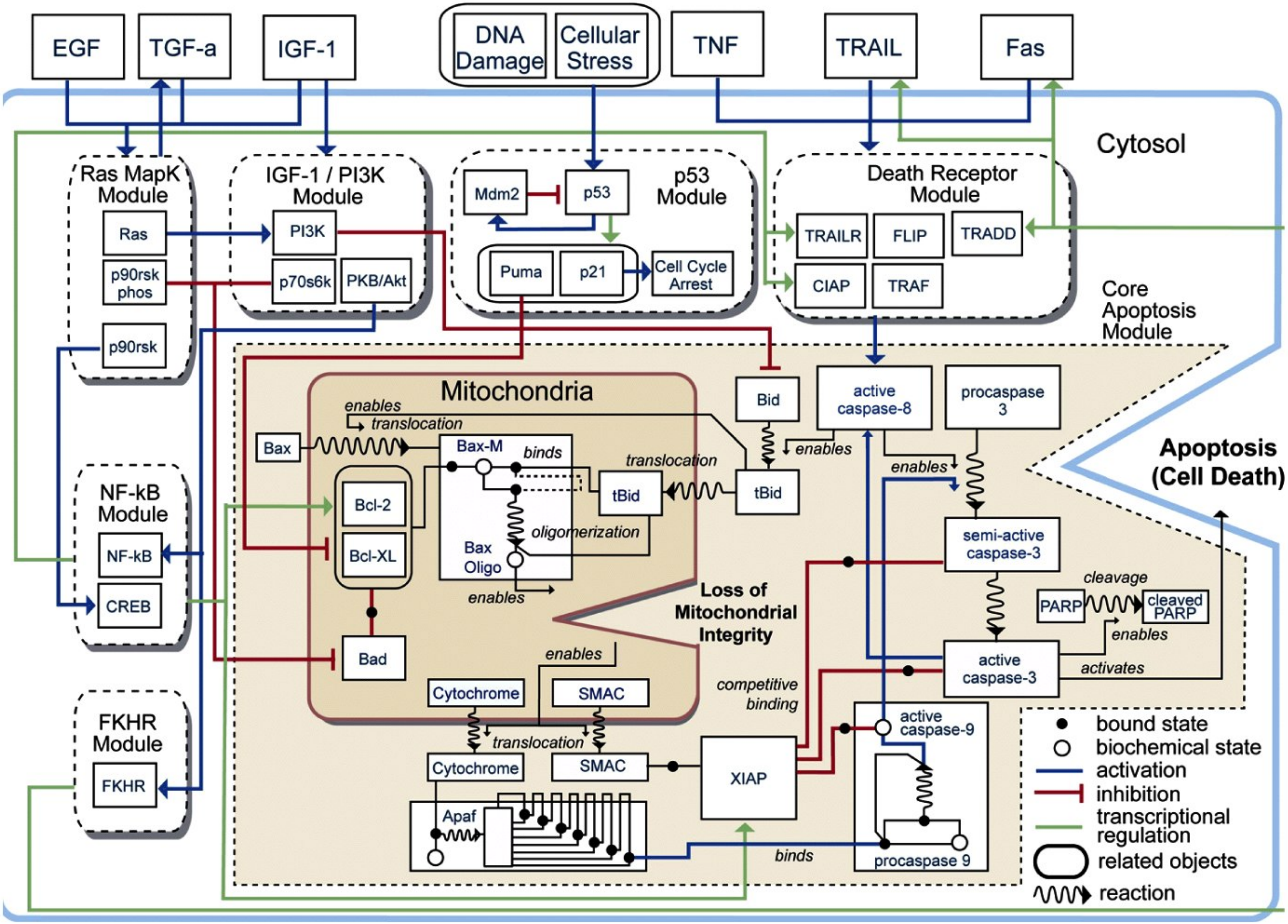


Figure 9.37 *The Biology of Cancer* (© Garland Science 2007)

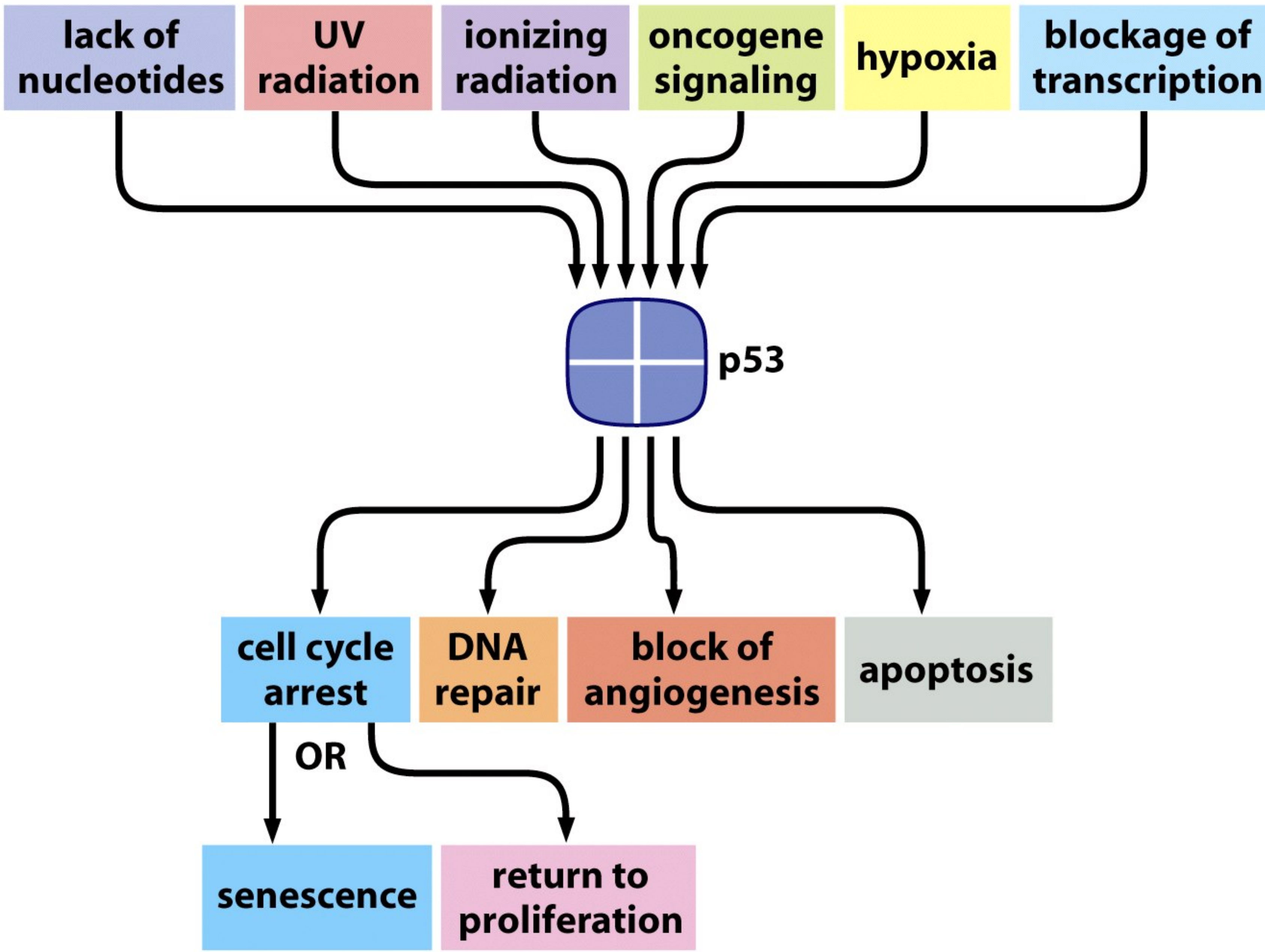


Figure 9.8 *The Biology of Cancer* (© Garland Science 2007)

NCI provocative questions project

- How does obesity contribute to cancer risk?
- Are there ways to objectively ascertain exposure to cancer risk using modern measurement technologies?
- What are the molecular and cellular mechanisms by which patients with certain chronic diseases have increased or decreased risks for developing cancer, and can these connections be exploited to develop novel preventive or therapeutic strategies?
- Why do certain mutational events promote cancer phenotypes in some tissues and not in others?
- Can tumors be detected when they are two to three orders of magnitude smaller than those currently detected with *in vivo* imaging modalities?
- Are there definable properties of a non-malignant lesion that predict the likelihood of progression to invasive or metastatic disease?

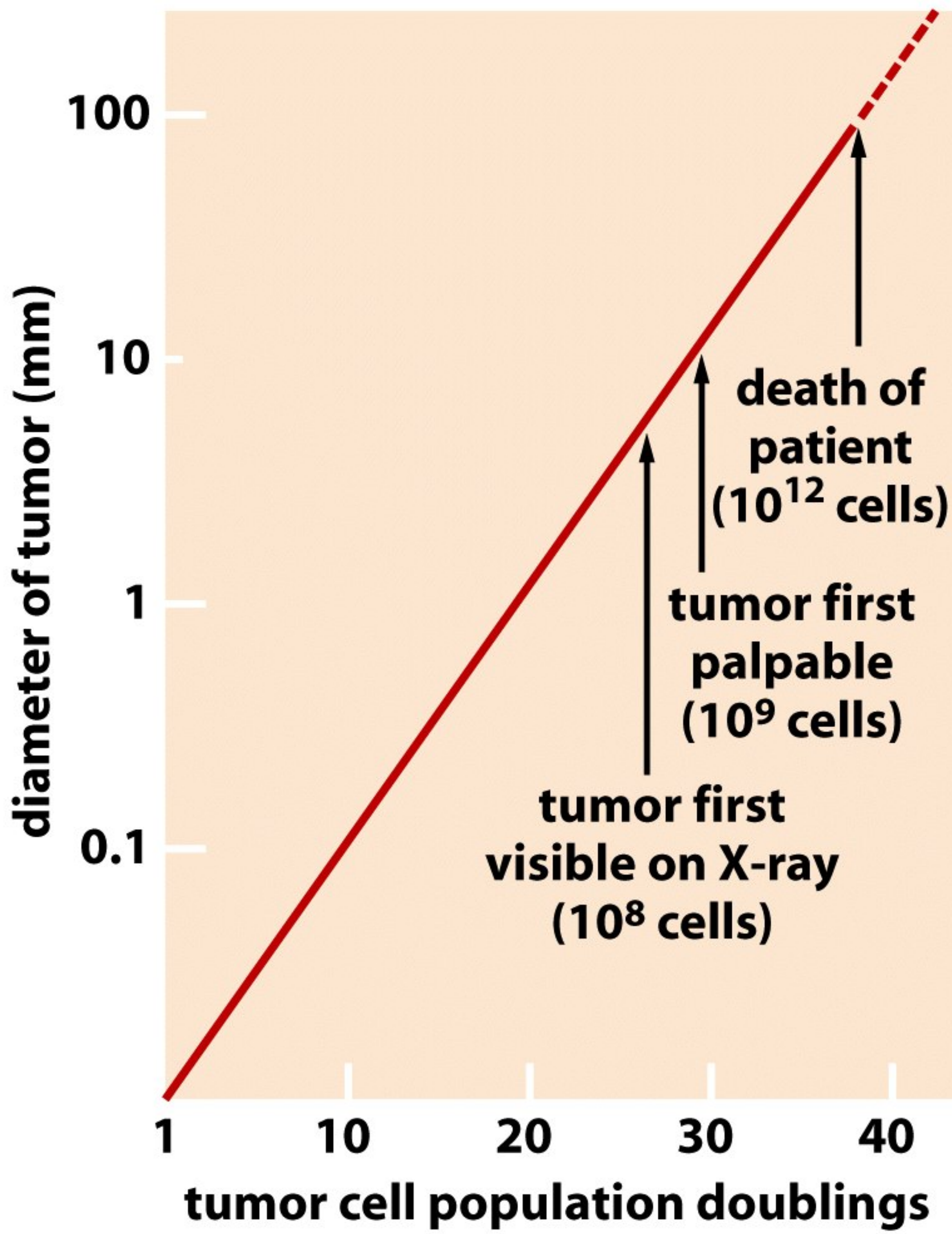


Figure 10.5a *The Biology of Cancer* (© Garland Science 2007)

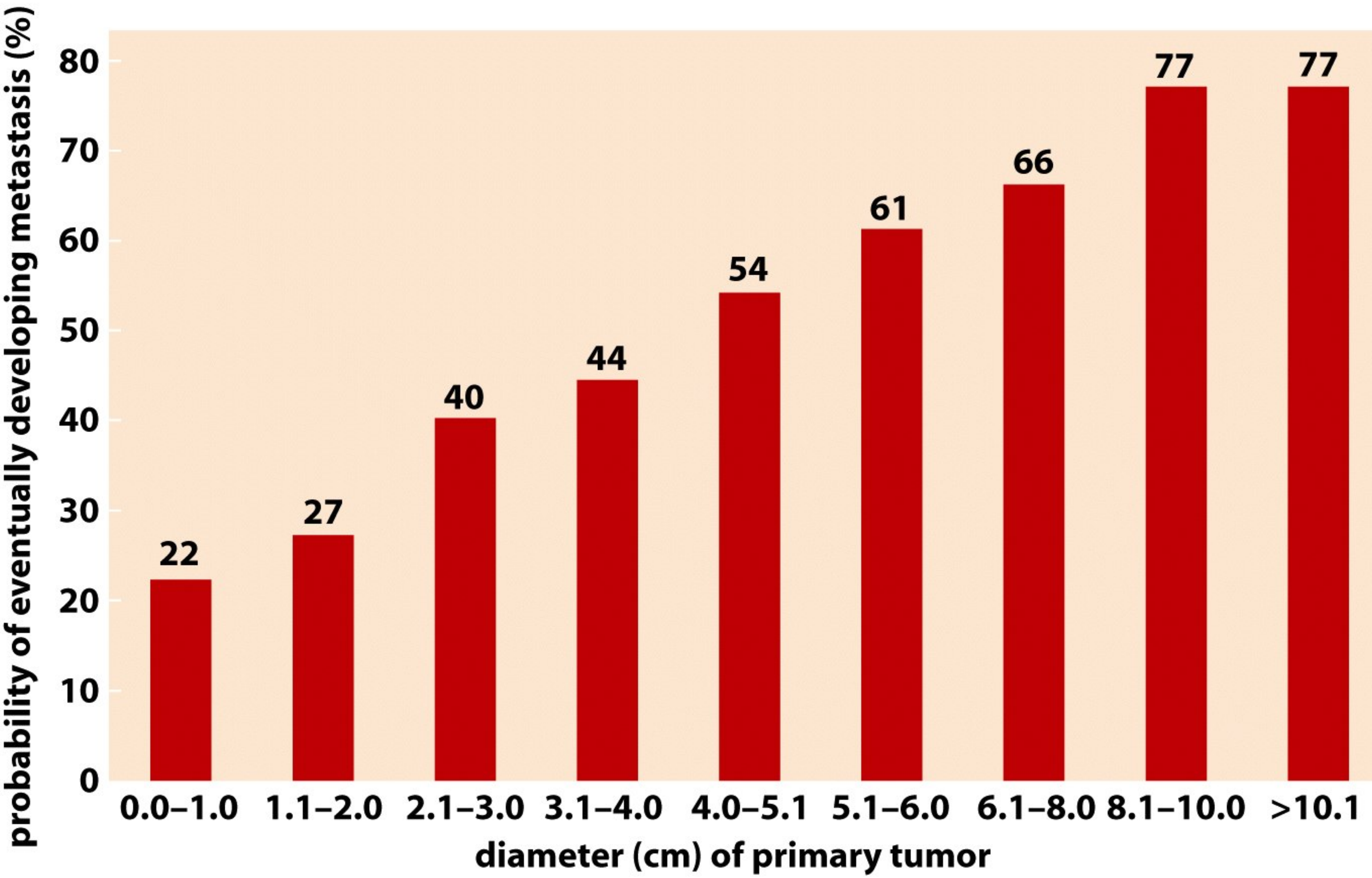


Figure 14.3 *The Biology of Cancer* (© Garland Science 2007)

What is the impact of these changes on AAPM?

- The shortest term impact will be on the types of research being funded by NIH/NCI.
  - NIH/NCI funding is currently a “zero sum” game.
  - Fundamental instrumentation related research is less likely to be funded as a stand-alone project. Most instrumentation research will likely be linked to applications of the technology to a specific cancer problem.
- The intermediate impact will be on what the educational profile should be for a medical physicist.
  - What are the evolving core competencies that will be needed to be competitive for peer-reviewed research grants in the future?
- Ultimately, this could change the face of cancer care and the role of the medical physicist in delivering that care.
  - What will be the role of the medical physicist in 10 years if the science of cancer care evolves significantly, but medical physics does not?

How should AAPM move forward?

- Do we continue to focus in the sciences and practices of radiation physics, radiological imaging physics and nuclear medicine physics as they apply to whole humans?
- Do we expand the focus of AAPM to include a broader scope of science?
- What? Who? How?
  - *Work Group on the Future of Research and Education*


We cannot solve our problems with the same thinking we used when we created them.
-Albert Einstein
visit Jim Hunt at facebook.com/huntcartoons

Changes in research focus and funding will necessitate changes in education

- We must become more efficient in the use of research funding in developing the next generation of scientists.
- Our educational programs must be sustainable.
- While we should accommodate alternate pathways to becoming a Qualified Medical Physicist (QMP), we must first make sure that students entering medical physics graduate programs are afforded the opportunity to become QMPs.

Sustainable educational programs

- We must be more efficient in the use of research funds in developing the next generation of academic scientists.
  - Graduate programs have been relatively homogeneous in educating medical physicists.
  - Ph.D. programs need to be more focused on educating academic and research oriented medical physicists, some of whom maybecome QMPs.
  - Professional degree programs (D.M.P.) should prepare clinically oriented QMPs with financial support for these programs coming from the students.

Summary

- Some reasonably obvious opportunities.
  - Quantitative imaging for therapy response assessment
  - Functional imaging to understand and sample tumor phenotype
- Team science is expected to solve the "big problems of the future. We bring an aspect of quantitative science that will enhance these teams.
- Continuing to refine our educational programs to meet the scientific needs for future in research medical physics.
- The AAPM's role is to provide a framework and infrastructure for addressing these challenges and opportunities, and to organize efforts to achieve our goals in patient care, <u>research</u> and education.