

THE **2029**
PROJECT

ACHIEVING AN ETHICAL FUTURE
FOR BIOMEDICAL R&D



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Jonathan C. Peck
Futurist



EXECUTIVE SUMMARY

Introduction

In *The 2029 Project: Achieving an Ethical Future for Biomedical R&D*, the Institute for Alternative Futures (IAF) provides a sweeping preview of the greatest advances coming through biomedical R&D. The report forecasts that a wide array of achievements in science will be enabled by an ethical evolution. After scanning the scientific literature, interviewing dozens of scientists and holding meetings focused on 2029, IAF anticipates a culture change. An emerging ethical concern for global health will create the context for medical science to realize its full potential, which will culminate in a Health Advocate Avatar.¹ IAF offers seven recommendations to bring science and ethics together through the Avatar.

The 2029 project explicitly pushes the boundary of optimism because an accelerating rate of change can deliver a cascade of surprising successes in science. IAF contends that scientists who can imagine such success will be all the more likely to achieve it over the next twenty-four years. As a rule scientists want their work to improve the quality of life in this world, and this report shows how such a highly ethical endeavor can unfold.

¹ In this report the term avatar refers to a computer interface that personifies collective knowledge. The word has been adapted in computer game cultures from a Sanskrit term referring to the incarnation of a Hindu God. (See http://en.wikipedia.org/wiki/Avatar_%28disambiguation%29.)




Futures Methodology

IAF began this project in 2004 using a forecasting method to help scientists imagine success in 2029. The project used literature scans to develop forecasts describing the breadth of change that biomedical R&D promises. IAF used its provocative forecasts to interview dozens of leading scientists who explored the most promising areas for improving health. IAF organized workshops with selected scientists from various disciplines and interest areas to develop further foresight across different fields. To help scientists share common ground in this exploration, IAF prepared multiple briefing papers on potential breakthrough areas.² IAF then revised its forecasts after working with farsighted scientists on February 10, 2005 to develop timelines showing how biomedical R&D can develop its greatest contributions to global health.

Health Advocate Avatar

The most exciting forecast is the Avatar. The scientists at the February meeting concluded that IAF should bring them back together with others who have the expertise and capability to help create this Avatar. Basically the Avatar is a knowledge interface that can mediate interactions between individuals and the world of medical knowledge. The Health Advocate Avatar is envisioned as a secure and discreet agent for the individual that also represents a highly ethical learning technology for collective knowledge. A variety of developments and new technologies will be required to provide components for the Avatar, including natural language search engines, truly effective voice recognition, haptic devices and high resolution displays. The Avatar is envisioned to be a coach, educator

²See <http://www.alfutures.com/2029.asp>.



and health manager that draws on the experience of large populations. The Avatar can provide individuals with control and personalized advice while serving health worldwide. More than just a technological wonder, the Avatar is an ethical development that can facilitate the health of both individuals and society.

Four Timelines

The promise of the Health Advocate Avatar is supported by a large number of forecasts IAF arrayed along four timelines. They anticipate short term (2005-2010), mid term (2011-2020) and long term (2021-2029) developments in biomedical R&D. Each timeline is thematically distinct, yet they flow together to offer patterns of opportunity that the Avatar can synthesize into a growing capability to achieve health. The four timelines are:

- Turning data into information, knowledge and wisdom: Science will have extraordinary tools and immense amounts of data to support knowledge creation.
- The union between East and West: Bringing together Eastern and western ways of understanding will lead to a unifying theory of biology.
- Moving beyond boundaries: Greater connectivity will accelerate learning around the globe, into communities and by individuals.
- Shift from disease to health potential: Medicine will shift from managing the risks of disease to promoting the potential for health for individuals and society.



Turning Data into Information, Knowledge and Wisdom

Knowledge is power, and more people will gain access to this power. Over the next five years, the flood of data from genetics, proteomics and electronic medical records will be converted into an overwhelming amount of health information. Scientists will use new knowledge tools, such as intelligent agents, to create the context that converts this information into knowledge. By the mid-term the accelerating spread of knowledge will include biomarkers that illuminate cellular pathways. Systems biology will take these pathways into new assessments of individual health potential based on signals of pre-disease. By the 2020s, a prognostic system will emerge and begin to replace the diagnostic systems of the past. Remarkable knowledge tools, such as immersive interactive environments and virtual brains will support the creation and dissemination of knowledge. By 2029 more people will be looking beyond knowledge and asking how to create wisdom.

The Union between East and West

Wisdom can arise from different cultures that will bring their particular gifts together in the decades ahead. Over the next five years Eastern philosophies and practices will be further adopted in the West, complemented by a growing base of Asian scientists bringing their worldview to biomedical R&D. By 2020, this combined knowledge will merge science and ancient beliefs into a new understanding of health that recognizes subtle effects, chaos theory and energy fields. At all levels prevention will become the favored intervention, with pre-disease displacing disease as the focal point for research. Death will become another focal point, bringing the idea of spiritual health to the fore. By 2029, systems biology with advanced models and simulations will fuse with Eastern philosophies to achieve a unifying theory of biology no less significant than the breakthroughs in physics of the early 20th century.



Moving Beyond Boundaries

Learning will accelerate worldwide over the next twenty-four years as networks grow across such divisions as country, sector, institution and discipline. By 2010, boundaries will blur as open source networks rapidly create and spread knowledge. Fed by a major short-term success against malaria, grid communities and distributed research projects will help open source science create continuous risk assessment for individuals, families and communities. By 2029, complete connectivity between researchers and patients who actively collaborate in science will reinforce a global ethic. The political impact of this ethic will be clear in new intellectual property rules negotiated to speed innovation and diffusion. Biomedical R&D will serve the poor as well as the rich, worldwide. Healthcare can be fully personalized by 2029 to achieve gains in individual and population health that will also create greater wealth.

Shift from Disease to Health Potential

When more disease can be prevented, interest will grow in how health can be created. The shift starts in the near term with regulators accepting the validity of surrogate markers and suites of biomarkers that individuals will use for continuous risk monitoring. As more people learn to interpret biological signals, prevention will take center stage. A low-dose combination therapy will prove successful against heart disease by 2010. This success will lead to a “predict and prevent” approach that fosters global learning cooperatives as people with shared risk factors pool their knowledge. By 2020, risk research will identify indicators for families, communities and societies showing their health potential. Healthy communities will grow in number, and will focus on the role of compassion in creating health. The global health agenda created by these healthy communities will be supported by science and ethics.



Biomedical Research and Development Advances

IAF's 2029 forecasts propose a preferred future for biomedical R&D that is based on what scientists currently recognize as the probable future. The 21st century is poised for many potential advances to improve health, quality of life and longevity that will change how people live and die by 2029. These probable advances include:

Using Knowledge Technologies to Transform Healthcare

Researchers and patients will gain access to greater computing power, new user interfaces and miniature biomonitors that continuously collect data. Knowledge will be created, challenged and changed at a faster rate to “support a purity of thought we’ve not had before.” Key technologies will include:

- Grid computing to supply the power and the storage capacity, enabling endeavors such as the Human Proteome Folding Project.
- Data management tools that mine the vast repositories that can be made available on the “deep web” of dynamic web pages opening up to information retrieval systems.
- Natural language processing that helps computers “understand” human languages at the same time it democratizes scientific knowledge.
- Intelligent agents with increasingly friendly, intuitive interfaces that help both scientists and citizens engage in research.



Developing Knowledge of Health and Disease

Remarkable advances in diagnostics provide new insights into the biology of the mind and the nature of disease. Medical science will predict changes in health status and prevent many illnesses through developments that include:

- Diagnostics capable of distinguishing between sub-classes of diseases and identifying pre-disease states to create new categories of health, including “super healthy.”
- Molecular imaging that peers into cellular processes, and uses probes that can be armed with therapeutic agents to address problems such as cancer.
- ‘Omics sciences focused on the study of genes (genomics), proteins (proteomics), sugars (glycomics) and other biologically crucial molecules.
- Systems biology that understands the dynamics within cells based on cross-disciplinary research building up systems knowledge from the cell to tissues, organs and organisms.

Developing an Infrastructure for Personalizing Risk

The ability to continually monitor individuals and create personal risk assessments will lead to individualized therapy. The platforms for assessing risk will define therapeutic selection, meaning the platforms will prove more valuable than the medicines, thanks to:

- Measuring risk using new methods such as adaptive trials with Bayesian statistics used in environments with electronic personal health records.
- Modeling and simulations that work at different levels, from digital models of “virtual patients” down to the more granular levels of genes and



proteins. Computer models and simulations will speed experimentation and help predict safety and efficacy for each patient.

- Open source research which increases collaboration across organizational structures and geographies to develop new research tools and incentives for addressing the health needs of the developing world.
- Biomonitors that make it cheaper and easier to continuously measure change in health status so that healthcare is addressed in the home through risk reduction.
- Developing “N of 1” clinical trials which incorporate bioengineered tissue scaffolds identical to a patient for pre-clinical safety assessment as well as combinations of therapies given in low dose to identify the best therapeutic effect for a given patient.

Looking at Potential Breakthroughs

Four specific advances hold the greatest breakthrough potential that will create new hope for patients and new pressures for healthcare systems. Progress on these new therapies will come from both East and West:

- Stem Cells hold the potential for decisively addressing heart disease, diabetes, cancer and neurological diseases such as Alzheimer’s and Parkinson’s.
- Gene Therapy/Silencing therapeutics are emerging as new delivery technologies target specific cells. A number of Eastern countries are pursuing this promising technology. If scientists can comprehend the complexity of cellular systems there is great potential for RNAi drugs across many diseases.
- Nanomedicine has achieved initial successes in medical devices and diagnostic tests, but a far larger number of applications could come



within the decade. Nanotechnology is bringing valuable research tools and clinically useful devices. A breakthrough could come from implantable devices that diagnose, deliver therapies and monitor effects.

- Implants and Drug Delivery devices will improve dramatically as new advances in microelectromechanical systems (MEMS), nanotechnology and other technologies are combined to create new ways of delivering drugs that improve patient care and mobility.

The Evolution of Ethics and Healthcare

While the 2029 project intended all along to forecast scientific breakthroughs, the cultural breakthrough in ethics surprised both the scientists and futurists exploring future possibilities. A global ethic of concern for life worldwide will evolve over the next twenty-four years. Natural selection will favor this ethical position in healthcare, economics and politics. As in nature, human systems are organized as a hierarchy of systems nested in more complex systems. When healthcare creates health, it fosters economic and political advantages. Evolutionary pressure works toward higher global value propositions, and the most advanced communities and societies will adopt the highest level of ethical concern by 2029. This emerging ethical convention will direct law and economics so that science can fulfill its promise to deliver global health.



Seven Recommendations

IAF proposes seven steps to promote the most ethical advances from biomedical R&D, expand knowledge of health and disease, and improve health for everyone.

1. Set a goal for U.N. adoption of a minimum health standard for all.
2. Create personalized risk profiles.
3. Initiate a global discussion of ethical positions for intellectual property.
4. Move from healthcare focused on treating disease to promoting health.
5. Change healthcare regulations to promote information sharing and new methods beyond clinical trials.
6. Foster an open-source system for health research, including drug discovery.
7. Create a collaboration of stakeholders to design and develop the Health Advocate Avatar.

Conclusion

The report concludes that biomedical R&D can contribute more to global health in the future than history suggests is possible. Science is delivering remarkable technologies that can improve the health of billions of people around the world. Knowledge of health and disease will increase dramatically, affecting how biomedical research is performed and healthcare is delivered. The deeper question is how do we unlock the full potential of science? The answer is to evolve our ethical positions so that whole societies gain from the coming knowledge revolution. The Health Advocate Avatar is an exciting way to tie the evolution of healthcare, economics and ethics together. The 2029 Project ends with a call to enhance health, to leap beyond existing strategies and to promote the highest level of global health.