

Professor Angela Brand

Essay: “Health care faces a paradigm shift”

Professor Angela Brand, Director of the European Center for Public Health Genomics, is convinced that personalized medicine offers great opportunities for improving human health. In her essay, the physician and public health specialist explains the impending paradigm shift: our changing understanding of health and disease calls for new guidelines and framework conditions; new genome-based knowledge will be integrated more heavily into health care.



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The life sciences have already worked their way through this revolution. For our public health care system, it still lies ahead: the decoding of the human genome in the year 2000 ushered in a new era in molecular biology. Doctors and cell biologists understand in ever greater detail the fundamental molecular principles of disease. This knowledge is transforming medicine, and consequently our health care system. In other words, public health care is seeing a paradigm shift, with the so-called “Four Ps” as the **basic building blocks of future medicine**: anticipating (predictive) and preventing (preemptive) disease in the future will involve highly precise, personalized diagnosis and corresponding treatment (personalized). Furthermore, patients will gradually play a more active decision-making role in their health care (participatory).

Patients differ in terms of their genetic profiles, environments and individual lifestyles

This new form of personalized health care will take into account genetic differences between patients, and make use not only of lifestyle and environmental factors, but also genome-based knowledge. In concrete terms, this means that doctors in the future will apply new diagnostic methods to choose the right medication. Biomarkers will provide increasingly detailed information as to which therapy, under what circumstances, at what point in time and in what dosage achieves a positive outcome.

Apart from therapy, changes will be seen above all in prevention. Vaccines are an impressive example of public health care in the future. To avert epidemics, vaccinations will only be administered in the future to those people who are susceptible to a certain virus on account of their genetic makeup, and are therefore potential carriers. The same vaccine would then be unnecessary for all other people. At present, it has no benefits, either to the individual or society. In other words, if we want to operate a sound system of prevention, we must know the unique genetic profile of each and every individual.

Today, for instance, newborns are already tested routinely for metabolic disorders. Infants could just as easily be tested by means of genetic diagnostics for other diseases and genetic predispositions. In this connection, however, it is clear that genomics alone will never be capable of making accurate predictions. The other critical factor is environment, meaning that we also need the science of epigenetics. This field is increasingly showing us the influence of stress, diet, toxic substances and viruses on genes. The approach taken in public health genomics therefore combines genomic information with the environmental and social aspects of our personal lifestyles – not only for prevention, but also for early detection and treatment.

The reason is that this century’s diseases are complex and usually have their origins in a combination of individual genetic predisposition, environmental factors and lifestyle: genes and external factors interact in a close interplay

between molecules and signal pathways. This interaction is similar to a social network in a state of continuous flux. We know today that specific genetic variations play a critical role in the development of cancer, asthma and cardiovascular disease. We must exploit this knowledge. However, although hereditary genetic variations can increase the risk of disease, they can also fulfill a protective function. A mutation in the ACE (Angiotensin-Converting Enzyme) enzyme, for instance, which regulates water balance and blood pressure in humans, increases the risk of stroke, but reduces the risk of contracting Alzheimer's. These findings in systems biology pose a tremendous challenge, and not only for drug development. They will also fundamentally change our understanding of disease and call into question our current system of disease classification.

In the future, genetic tests could help to better predict an individual's risk of disease and take preventive action. But whether a disease ultimately breaks out, or whether a certain therapy is effective, ultimately depends on the complex and highly dynamic interaction between genes and environment. Cancer researchers, for example, have discovered that even small quantities of soy milk can trigger early-stage breast cancer in women with specific genetic sequences. In general, however, the legume is considered a healthy food: soybeans deliver high-quality protein and minerals. In this case, early identification of such a genetic predisposition could save lives.

Personalized medicine will treat diseases more efficiently and selectively

Thanks to epigenetics and systems biology, our understanding of the development and progression of disease is much more comprehensive today. The letter-for-letter decoding of the human genome will enable tailored strategies for the prevention, early detection and treatment of disease, with advantages for each individual patient: personalized medicine will help to treat disease more efficiently, use innovative therapies in more targeted fashion and reduce the risk of side effects. At present, personalized medicine is at its most advanced stage in the field of cancer therapy, because every tumor is unique and must be treated in accordance with its individual characteristics and history of growth. In the future, blood tests may make it possible to take the genetic "fingerprint" of a cancer right in the doctor's office, thereby improving both diagnostics and the analysis of therapy effects.

Yet another entirely new challenge for personalized medicine results from the combination of systems biology and innovative information and communications technologies (ICT). It will become possible to generate computer models of each individual, and to simulate the direct effect of drugs or food on this "virtual me". Previously unimagined possibilities will emerge as a result in terms of tailoring prevention and treatment to an individual.

Genome-based information, however, will do more than just improve people's health and quality of life and extend their life expectancy. The goal is to apply this information not only to personal, but also to public health. The paradigm shift towards personalized medicine therefore impacts health policy in particular: we need specific strategies to determine how we can best evaluate new genome-based findings and technologies, and how they can be exploited to benefit society.

New genome-based knowledge must be integrated into health care systems

It also affects economic issues. For example, a balance must be found between protecting individuals and their personal interests, and the social benefit resulting from genomic innovations. No one can be forced to discover more about themselves than they would like. At the same time, this "right not to know" must stand up to moral obligation, because a person aware of his predisposition can take preventive measures and possibly reduce the cost burden on society. Each individual therefore has a responsibility to society and to others with the same genetic disposition.

Basic building blocks of future medicine

Predictive	<i>Predicting diseases</i>
Preemptive	<i>Preventing diseases</i>
Personalized	<i>Highly precise, personalized diagnosis and treatment</i>
Participatory	<i>Patients play an active, decision-making role in their health care</i>

In view of these facts, a discussion of legal and political framework conditions is essential. The Public Health Genomics European Network, with the support of the European Commission and all Member States, is currently drawing up European framework conditions that today give health policy recommendations for future challenges. After all, individual patient groups are growing smaller, respective diseases rarer and each person ultimately is one of a kind. Genome-based knowledge is expanding, and we can no longer ignore it: we must incorporate it into public health care, just as we do other biological, social and environmental factors.



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