

## HEALTH AND GENE SCIENCES

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### Summary

Gene science, including genomics, which is the study of all the genes in living organisms, and genetic engineering, is playing an increasing role in the promotion and maintenance of health. The human genome, as well as those of microbial and other species which affect the state of human health, provides information from which new and powerful diagnostic tools, drugs and vaccines and, in the near future, gene therapy are derived. From genomics spring many applications such as gene-based diagnosis, which involves detection at very high sensitivity of disease genes of the patients or those from infectious pathogens, based on specific binding between the genes in the test samples and the complementary sequences present in the diagnostic. It can predict potential genetic diseases, or diseases resulting from interaction between genetic and environmental factors, even prior to the onset of the diseases. Many drugs and vaccines are produced from genetic engineering. These are sometimes referred to as biotechnology-derived, and are mostly proteins or peptides that are products of genes from human or other organisms, transplanted into appropriate microorganisms or cultured cell lines. Proteins are the results of gene expression, and the total proteins derived from the genome, constituting what is called the proteome, include many biological targets of drugs, vaccines and diagnostics. Genetic engineering is used to make such targets of drugs, vaccines and diagnostics as enzymes and receptors, towards which these agents are directed. It is also a tool for identification and validation of the targets themselves, as used for example in knocking out specific genes in order to observe the consequences, and thereby to deduce the functions of the genes. Individuals have different genetic make-ups, which can now be differentiated to give individual basis for treatments, forming the core of a new science of pharmacogenomics. Gene

therapy is a form of genetic engineering which delivers a specific gene into the patient directly, in order to correct the defect resulting from the malfunctioning of the patient's own gene.

## **1. Introduction**

Gene science, including genomics and genetic engineering, has made major contributions towards health, and will become even more important in this aspect in the near future. The power of genomics, genetic engineering, and biotechnology in general, lies in the application of knowledge about the genetic make-up of living organisms, and in the engineering of the organisms for useful purposes through that knowledge. In the health area, this leads to the ability to diagnose and prevent diseases, to design and make new drugs against diseases and promoting health, and even to modify the genetic make-up of individuals to prevent or correct hereditary abnormalities. The total genetic make-up of an organism—the genome—contains all the information which determines all its characteristics. The characteristics are derived from genetic expression, which results in proteins and other molecular components assembled together to form cells, tissues and organs. For humans as for other species, such characteristics are different among all individuals, each of whom has a unique genome slightly, but significantly, different from those of the others. Individuals respond differently to drugs, foods as well as to other environmental factors. Pharmacogenomics, the science which deals with individual interactions with drugs, is an important part of the budding field of individual medicine, as so is nutrigenomics, which deals with individual interactions with foods.

## **2. Relevance of genomes to human health**

The clues to human health and diseases lie in the knowledge about the human genome and its interaction with the environment. The human genome can be studied by sequencing some three billion units, called nucleotides, present as strings of four different characters arranged as letters in a message. The nucleotide string is called deoxyribonucleic acid (DNA) [see also— *DNA as genetic material and nucleic acid*] and is packed together with proteins into each of the 46 chromosomes, which are arranged as pairs with one set from each parent. The 30 000 or so genes of the human being form a part of these sequences. The genome of a person [see also— *The Human Genome*] contains all genetic information which, through interaction with the environment, determines the status of health throughout his or her life. This is so because many genes are expressed as proteins responsible for the forms and functions of cells and organs, while others act as controlling elements in the gene expression. Malfunctioning genes or abnormal interactions among them can therefore lead to the state of disease. For example, aberrant genes may be present which predispose a person to diabetes, stroke, Alzheimer's disease, asthma, autoimmune diseases and some types of cancer. Whether or when the diseases due to the aberrant genes will occur often depends on the lifestyle and the environment to which the individual is exposed. Genes predisposing a person to high blood cholesterol will lead to a high risk of stroke, but the stroke may not occur if the person maintains a healthy low-fat diet. Knowledge of the human genome is therefore vital to prediction of risk to diseases, diagnosis, and finding of preventive and therapeutic measures for the diseases.

In addition to the human genome, the genomes of various infectious organisms, and other organisms interacting with man in other ways, are also important in determining the state of health and diseases. When an infectious organism infects a person, it uses specific genes to its advantage, but resulting in the disease state of the infected person. Hence, a human immunodeficiency virus (HIV) uses a component of its coat protein, which is its gene product, to interact specifically with the membrane of the lymphocyte human cell which is its target, thereby gaining entry into the cell. In other cases, the infectious organisms create toxins as products of their genes, which interact specifically with the target cells to cause damage. Knowledge of the genomes of infectious organisms is therefore vital in diagnosis, prevention, and therapy of the diseases they cause. In addition, knowledge of the genomes of other organisms interacting with the human being in other ways is also very useful, since they may help in maintaining the state of health, or may exacerbate the state of disease. Some diseases not previously suspected to be infectious are now known to be caused, or greatly influenced, by microorganisms. For example, infection with *Helicobacter pylori* is a causal factor for peptic ulcer. Finally, knowledge of the genomes of other organisms, the gene products of which may serve as medicines, such as antibiotics from microorganisms or natural products from plants, is very important to the drug industry and therefore in the maintenance of health.

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### Biographical Sketch

**Professor Yongyuth Yuthavong** is a scientist with interest in biochemistry and chemotherapy of malaria, and in the broad issues of science and technology. He was awarded a Thai Government scholarship to study in the UK, where he obtained a bachelor degree in chemistry with first class honours

from University of London, and a doctoral degree from University of Oxford. After a long research and teaching career at Mahidol University, where he was appointed Professor, he was appointed the first Director of the National Science and Technology Development Agency (NSTDA) of Thailand, where he served for two terms. In 1998 he returned to the research career to work on development of antimalarial drugs at the NSTDA's National Centre for Genetic Engineering and Biotechnology. He has published more than 110 research papers in international journals, and has authored and co-authored 10 books on technical and broad issues of science and technology. In 1984, he was given the "Outstanding Scientist of Thailand" Award by the Foundation for Promotion of Science and Technology. In 2004, he was given the Nikkei Asia Award for Science, Technology and Innovation.

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