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About the Impact of Modern Knowledge, Science, and Medicine on Neurootology

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NEUROOTOLOGY

At a time when we regularly find that our surroundings and historic-cultural environment are increasingly changing, even a very well-educated academic person such as a medical doctor can no longer ignore the fact that the constant production of modern knowledge and scientific results soon overwhelm the individual capacities of even the best of us. A logical rear-guard action in modern medicine had to take place, as medical doctors maintained their intellectual and other capacities. When doctors' individual output remained the same over centuries but the potentials of knowledge and science output grew exponentially, modern medicine had to divide and share tasks and activities.

Neurootology nowadays is not merely a discipline of very special and sophisticated diagnostics. It is a medical specialty with a great body of knowledge about a differentiated spectrum of therapies for a broad variety of disorders afflicting human sensory performance in everyday life.

The modern methods for measuring disorders in hearing are termed *audiometry,* and those for measuring equilibrium together with the symptoms of vertigo, nausea, giddiness, and instability are called *equilibriometry*. For diagnosing taste disorders, we apply modern methods of *gustometry*. For those of smell disorders, we apply *olfactometry*. A huge and permanently increasing number of facts have to be incorporated into the medical work of superspecialized "neurootologists," who already represent a medical subspecialty. A large network analysis called *tinnitology* now deals particularly with tinnitus. Not only the doctors but the patients perceive remarkable changes according to such determining factors as their demographics, for instance.

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KNOWLEDGE

For us humans, knowledge is the representation of environmental facts and subjective experiences established in the memory. Individuals can understand the world and then have an effect on their surroundings specifically with the help of their knowledge. Knowledge is the result of studying on the one hand; on the other hand, it forms the basis for studying, for thinking, and for solving problems. This certainly applies to special medical knowledge.

Knowledge basically deals with asking the structure of this knowing in humans and their use of what they know when solving tasks in daily life, similar to specialized areas of the life of experts. Present-day persons develop models as the knowledge is represented in spirit. They then transfer these models to computer programs. Programs that store knowledge about special areas of life are called *expert systems*.

We distinguish different kinds of knowledge: *Factual knowledge* is knowledge on the world around facts and events. *Procedural knowledge* contains the control forms for using various skills (e.g., cycling). *Rule knowledge* contains primarily strategies for the mastering of problem situations. *Metacognitive knowledge* involves reflections about the other knowledge forms and possible actions connected to that about the contents of what is known.

Knowledge psychology can examine knowledge based only on a verbal encoding and tie this into models that are analyzed by computers. However, there is not yet a place for concrete, intuitive knowledge that plays a particularly large role in the creativity and classical work of medical doctors.

The kind and order of knowledge and its distinction were less at the center of interest during antiquity, at the beginning of modern times. In particular, the practice of life also is rather decisive for education and development of the individual character of modern subjects.

The intellectual principle of deduction was already described by Aristotle as a central feature of scientific intellect so that something else can be derived from a

preceding little knowledge. A broader knowledge of science refers questions to "through what" and "why" is this phenomenon existing?

MEDICINE

A doctor's tasks include diagnosing illnesses to be cured or soothed and to protect lives, even that of the unborn. A doctor must serve the health maintenance of individual patients and of the total population. This service includes health advice, illness precautions, early diagnosis, and reintegration (rehabilitation) of sick and handicapped persons into society.

The job picture of doctors has changed much in recent decades, becoming more and more specialized and detailed and involving increasing mechanization in modern medicine. Legislation and administrators continually intrude more severely on medical behavior.

With postgraduate education after certification, the doctor acquires thorough knowledge and experiences in special areas, branches, and minor specialties of medicine. Modern methods of diagnosis related to treatment of illnesses, body damage, and suffering include the correlations between humans and environment and the assessment and necessary measures of rehabilitation and quality reassurance. By postgraduate education, doctors deepen their knowledge and abilities, maintaining a par with the modern level of medical science. Also, medical conduct has to be distinguished by formal postgraduate education. Doctors are obliged to practice their profession conscientiously and with dignity, according to the Hippocratic oath (Bezeichnung so laut; *Encyclopedia Britannica* 2004).

SCIENCE

Modern science regularly poses such questions as "through what" and "why?" to obtain a functional and causal explanation of various phenomena. Knowledge in modern science—how it has developed since Galileo and Newton—is less aimed at describing than at practically using knowledge for mastering natural processes and artificial entities. The philosophical treatises of Hobbes, Locke, and Hume in England and Descartes in Holland provided scientific approaches based on facts to understand the physical and biological phenomena of our environment (i.e., a scientific approach based on the development of a systematic method of understanding one's experiences based on facts and logic).

A corresponding scientific orientation regularly is found in our world in the lifestyle, health precautions, political planning, professional orientation, and psychological self-image up to the scientific findings of sexuality, dreams, and scientifically inexplicable phenomena (parapsychology). This permanent influence is regarded as the central and common level of science and the technologies derived therefrom. The application of such deductive, systematic, scientific thinking—which in the past has resulted in an understanding and finding of solutions to the problems of society, politics, and the economy of nations—will, I predict, expand into the future and open the door into a new era for all humanity.

Science nowadays puts all knowledge referring to an object area into certain rules or institutional organization. A tendency toward systematization, toward institutionalization, and toward distinction of abstract (theoretical) and weekday-related (practical) knowledge indicates that these societies and their history express themselves in the distinction characteristic for Western modern societies. For modern functionally and subtly differentiated societies, science represents a subsystem of its own in the view of certain questions of manageable knowledge (truth).

Conversely, modern academic life is determined by a high specialization and sharing among numerous (approximately 4,000) individual disciplines and sub-disciplines. Furthermore, we observe the incorporation of scientific activities into institutions (universities, industrial, state-promoted research institutes) as well as into projects of public, industrial, and military research.

Besides governmental science support, the economy increasingly wins as a financier and as the client, customer, and place for scientific research tasks. From an economic point of view, public support of science has grown stronger within the last few years.

MEDICINE

The specialization of clinical medicine into many individual disciplines became established during the nineteenth century. It is an expression of the upswing of modern medicine by a consistent application of scientific results of thinking and methods. For a doctor's education, university training was compulsory.

In the field of modern therapy, decisive progress reaches the rational use of substances defined chemically and synthesized partly (e.g., in the field of pharmacology in the twentieth century). Important further developments took place by vaccinations where certain viral illnesses, such as poliomyelitis and smallpox, declined sharply or were eliminated.

Medical diagnostics were refined by imaging methods —by ultrasound, computer and nuclear tomography, endoscopy, and immunological and molecular biological methods. During recent decades, artificial prosthetic medicine has flourished (e.g., hearing aids, cardiac valves, joint substitutes), largely in response to increased life expectancy and general technological progress.

Despite critical public discussions about genetic engineering and stem cell research, the introduction of molecular genetic treatment principles will considerably change scientifically oriented medicine of the twentieth century. Moreover, new areas were disclosed with respect to psychosocial sickness by the help of medical psychology, psychosomatics, medical sociology, and environmental medicine. These new areas are, meanwhile, folded into medicine and represent a counterbalance to a purely scientific philosophy of humans. According to the change of the present spectrum of illnesses in industrial countries, infectious diseases are replaced by chronic "illnesses caused by civilization." Also, a change is occurring in the area of responsibility of medicine: advice, prevention, investigation of risk factors, and rehabilitation gain increasingly in meaning.

Though the twentieth century has brought about great progress in diagnostic and therapeutic medicine, new challenges have arisen in the treatment of hereditary diseases, chronically degenerative illnesses (e.g., Parkinson's disease, dementias, multiple sclerosis), and especially cancer and the acquired immunodeficiency syndrome (AIDS).

Increasing mechanization and automatization of sophisticated diagnostics and intensive therapy has led to criticism of so-called high-tech medicine. Therefore, the question was raised whether everything that is medically feasible is, *ipso facto*, ethically allowed (medical ethics).

During the last 100 years, the diagnostic and therapeutic possibilities of medicine and the conditions of life have improved considerably. By the help of intensive medical care, it has become possible to bridge the failure of organs. Finally, transplant medicine allows replacing failing organs durably.

This progress has been the reason that most infectious diseases have become controllable. Mortality from such diseases has dropped practically to zero. The diagnosis of cancer nowadays no longer means an unavoidable death sentence. Patients with diabetes and high blood pressure can enjoy a better quality of life. Medical progress, therefore, is not yet at an end.

We have begun to identify the molecular control elements of known disease processes and the genes involved in them. This knowledge allows us to predict that current nonspecific therapies frequently connected with untoward side effects will someday be replaced by further advances in medicine.

In its success story, modern medicine is based on experience. It has developed into a discipline oriented scientifically and supported by theoretical knowledge. Knowledge about various diseases and therapies is collected systematically and subjected to an objective analysis today. Preclinical experiments and models are developed that permit better understanding of illnesses without our having to be engaged in direct research on affected patients. Analyzing biological processes and characterizing their single components has been successful. In this way of evolution, hormones and messenger substances were discovered and methods of signal assignment could be decoded. Genes that steer cell growth and maturation have been identified within cells.

In the last few years, tremendous progress has been obtained by use of modern technical aids in the surgical arena. For instance, a laser beam has replaced a scalpel in many operations (e.g., in the eye or within the brain). Emphasis nowadays is on minimally invasive surgery. Flexible endoscopes and catheters carrying tiny optics and instruments at their head can be directed to the region of interest through a small surgical cut or through a natural body orifice. Laser beams and miniaturized instruments permit interventions that can be much more exact, faster, and gentler than those previously carried out for the same therapeutic purpose.

The role of the computer and telecommunications cannot be underestimated in modern medicine. Computers often make the use of medical equipment, especially imaging systems, possible. Data-processing telecommunications form the basis for the exchange of data between among clinical complexes so that resources can be best used.

The primary goal of modern medicine is the human health condition. This is also the basis on which ethics must be defined in medicine. Only by keeping this goal in the forefront will medicine manage, by self-reflection and further development of its aims, to meet human needs—social requirements—and to cope with its own progressive dynamics as a scientific discipline.

LOSS OF HOLISTIC MEDICINE DUE TO TOO MUCH INFORMATION

With medical progress, a wealth of new information has flooded in, expanding the knowledge we have about humans. Basic medical knowledge is progressively replacing itself at present approximately every 5 to 7 years. This means that what students of medicine are learning at the beginning of their studies might already have been revised or replaced by the time their formal education is ending. Active doctors, from whom knowledge about the new possibilities for diagnostics and therapy are demanded, are increasingly confronted with this educational lapse.

Every day we are challenged by the progress and developments of modern medicine, in their complexity and entirety, to understand and to convert this for researchers and clinicians. Actively practicing researchers and clinicians also must concentrate on their individual areas of expertise, to remain at the front line of medical

development in their chosen specialties. Many years ago, this medical knowledge evolution began to separate basic researchers and clinicians from one another and, even within these two groups, the concentration and, with that, the division continually brought greater progress into special and further subdivided subjects. For example, in clinical medicine, hand surgery, trauma surgery, heart surgery, psychosurgery, and abdominal surgery are sub-disciplines of the main field of surgery. In the field of internal medicine, there are specialists for lungs, heart, kidneys, intestines, blood, cancer illnesses, and the like.

Such specialization is necessary and inevitable. However, it holds the danger of a restricted philosophy in which individual doctors lose the perspective of seeing a problem in its entirety and complexity. Specialization can have the effect of shrinking focus, with the consequence that medical measures are reduced to one single aspect only.

However, it is not only the development of medicine that encourages specialization. Modern-day patients, having access to voluminous medical information via the Internet and other resources, are more knowledgeable than ever and are demanding that an existing illness be treated and cleared by a well-known expert in the appropriate field—that is, one who is as competent and specialized as possible. This drags the patient into a situation comparable to that of a car in the repair shop: Medicine and the doctor's role are reduced to a service job in an alarming way, with the primary goal of clearing defects.

NEW ASPECTS OF MEDICINE IN TWENTY-FIRST CENTURY SOCIETY

In considering and discussing medicine of the twenty-first century, we must not look at the medical profession in isolation. The medical community is part of society and therefore is decisively influenced by the entire social situation. We humans have had to endure traumatic experiences in our nations in the twentieth century—two world wars, numerous economic crises, unemployment, and an obvious increase in the elderly population—but much also has improved during that century: People in the developed world have never been better off than in the most recent decades. Despite some steps backward, most people in developed nations live in circumstances that must be described as economic prosperity, even in the worldwide scope. Thanks to modern technology, working hours could be shortened, the workload diminished, and leisure time increased, including regular holidays.

The record of success that technology and medicine could produce is impressive. Our awareness of life still is marked by the ideal of healthy young persons who care for the integrity of their bodies and who are forced only in exceptional cases to make use of modern medicine. This help they then believe they are able to call in. These people believe that by paying their health insurance premium they have purchased the claim to cure and health. We underestimate illness and death, because the great successes of modern medicine make us feel assured, thereby skewing the relationship between modern medicine and society. Natural limits are not taken seriously any more. Unreasonable expectations are offered up by various media reports related to the advances of medicine. Many people also withdraw from modern medicine because of its increasing mechanization and specialization in conjunction with complicated information that is difficult to understand. Such people, not unreasonably, escape into alternative or natural forms of treatment. To bring the disturbed relationship between society and medicine into plumb again, we must orient ourselves anew and try to devise a jointly accepted basic agreement. For this, we must promote the belief that modern medicine is part of society. Apart from this, we must regularly publicize that illness is a natural component of life. To any human being can befall an unforeseeable defect or state of health emergency and, for any of us, death is unavoidable. Only by sharing such a view will it be possible to find reasonable answers to the difficult questions of modern medicine in the twenty-first century. Fundamentally, it is important that our medicine not demote itself to a technological health repair institution, simultaneously full of ignorance and boasting of its successes and self-satisfaction.

Doctors also must revive the ability for self-reflection and self-criticism and find their way back to an integral philosophy by, for instance, seeing the entire person in his or her personal environment. Quite recently, the picture of the doctor more and more frequently has begun to appear as supplier or seller rather than being regarded by the patient as customer or consumer. This picture reduces the relationship between doctor and patient to a purely business or technical level and disregards the human partnership and basic sympathy. Exactly this interpersonal relationship distinguishes the classical doctor from the modern doctor, because it differentiates between technical and more medical ethical considerations and action.

Modern medicine is not only the teachings of bodily illnesses but includes pure natural scientific knowledge, such as biochemistry and molecular biology, in its therapies. Humans are more than a collection of molecules. The doctor's expertise is imperative for successful treatment. The doctor's readiness and ability to deal personally with a patient are, however, just as important to the ethical aspect of the medical relationship, for risk-use

analysis, and in terms of social responsibility. The doctors and others working in patient support must be competent in serving as the patient's rights activist and must be sensitive to a patient's existential fears. Only then is a patient's confidence in the doctor justified. Both doctor and patient must share this confidence in order to work as a team in fighting an illness or soothing its symptoms.

MEDICINE IN AN INDUSTRIALIZED SOCIETY

A technically and economically highly developed society that is characterized largely by industrialization in its structure and dynamics needs medicine that fits with its expectations. The operational, industrial production method employed by the factory system and the dominance of the (secondary) economic sector are at the center of an industrialized society—opposite the primary and tertiary sectors. The mass production possible through this economic structure characterizes social living in modern cultures. The results of such industrialization are urbanization by concentration of the workers in big production centers, a subtly differentiated structure of occupation, a system of values oriented to performance ideas and a sociological model of meritocracy, functional losses of the nuclear family, and an increase in the standard of living and consumption dynamics (consumer society), while simultaneous ecological damages cause economically faster social change and taking out of function-specific social subsystems or sections (economy, politics, education, etc.).

Since the beginning of the 1990s, industrialized Western societies have been changing to postindustrial societies that can be described as combination models of a service economy, an information society, knowledge polls, and a leisure society for humans, stemming from biological roots, which now become technically exploited.

The possible applications of modern, science-based biotechnology covers a wide spectrum from material sciences and environmental protection of medicine and pharmacy, to food technology, chemistry, and farming, to information technology. According to the application fields, one frequently distinguishes between a red, green, white, or gray and blue biotechnology, as they are labeled in Europe now.

Under the concept of red biotechnology, one combines all areas of today's biotechnology that aim at medical applications. Thanks to genetic engineering, new active agents developed can both be cheaply produced and carry progress further. Biopharmaceuticals are therapeutically effective substances produced genetically by the help of microorganisms or cell cultures. On the one hand, it is proteins that one uses to isolate the so-called human factory. On the other, by biotechnological production, many risks can be excluded.

The human genome project laid out worldwide has strongly accelerated the development of biocomputer science (i.e., the computer-assisted generation and evaluation of molecular biological data). The search for more efficient and faster medically active agents is on, to more comprehensive and faster data processing in genome deciphering and to more recent development of gene technology. Genetic diagnostics also make use of a number of modern techniques and are applied in many areas. A relatively new research direction is the pharmacogenomic, in which genetic drugs and therapies for a specific patient shall be adapted individually. In addition, cells can be cultivated that will be used as transplants in tissue engineering. The use of stem cells will open up broader possibilities by which cloned stem cells can prevent rejection reactions from the body of a patient receiving such therapy. Adult stem cells are already used successfully in stem-cell treatment.

Biogenetic techniques will provide an enormous push to medicine in the twenty-first century; they will become the indispensable tools of doctors. However, a controversial question—should researchers use clone technology to develop new therapies?—will continue to plague people in the twenty-first and twenty-second century. Medical progress forces us to consider such concepts as human dignity, humanity, and personality—perhaps more thoroughly than ever before.

Most bioscientists are convinced that an exact understanding of the function of every single gene will fundamentally change medical practice. To date, both the diagnosis of and therapy for illnesses has been aimed at "general" symptoms, such as headache, tinnitus, or nausea, but this is not likely to persist in the future. Rather, bioscientific research is steering diagnosis and therapy toward molecular interactions that are involved causally in the illness process.

BIOENGINEERING IN MEDICINE

Largely unnoticed by the public, bioengineers stand on the brink of accomplishing real medical miracles. They work in interdisciplinary teams to make blind people see again and to cause lame people to walk again. Approximately 50,000 deaf people worldwide have regained their hearing thanks to a cochlear implant.

As opposed to comparatively simple external hearing aids, these electronic artificial organs stimulate the auditory nerve directly with a number of inserted electrodes. Experts regard the cochlear implant to be the most successful technical solution to date for a severe sensory problem. We also expect comparable microimplants for the blind and paraplegic in the near future.

A suppressive computer for treating epileptic seizures already has been successfully tested. The information technology program used by this computer recognizes an immediately forthcoming cramp attack by using characteristic brain current curves. With the help of modern data processing, this tool can prevent attacks. Doctors may one day be able to apply this technology to treat parkinsonism, muscle trembling, and bladder weakness that causes irregular urination.

Paraplegic persons may hope to regain some of their walking capabilities. After some weeks of intensive training, the intact nerve cells of the spinal cord trigger striding reflexes independent of the brain. Researchers are designing tiny guide rails that will clear the way for nerve fibers to grow again. Thus, we will enable lame persons to walk. Additionally, neurobiology is creating the possibility for paralyzed people to steer a computer by means of brain current activity.

HEALTH AND POLITICS

According to a popular proverb, "Health is the greatest wealth." For example, the Germans spend 10.5% of their gross national product on their health. However, within the last few years, a trend toward cost reduction ordered by the state stands out in Western countries. Some doctors deny that it is possible, under such an economizing regime, to care for their patients optimally. They already point to creeping rationing, which could result in many intensive medical measures becoming available only to younger patients. With elderly people, the medical supply will concentrate on maintaining independence in the state of health in the best possible way.

In the opinion of experts, as middle-aged life expectancy rises further, a biological age limit of as much as 120 years can be foreseen in the future through the use of life-prolonging machines. Therefore, the public exerts much pressure on politicians to develop new ways of covering the increasing demand for medical aid with sufficient supply. New methods of medical management will substitute for the classical medical profession.

The traditional enemies of health—infectious diseases and malnutrition—are retreating in all parts of the world. Conversely, such inherent illnesses as circulation disorders and cancer as well as depression, accidents, and injuries will remain on the list of the most frequent causes of death. Through preventive measures, protection from widespread diseases such as heart attack, high blood pressure, and diabetes is, in principle, possible. Thus, the potential for a premature death can be converted into a later demise.

Illnesses that affect intellectual capacity and emotional state and cause intellectual fluctuations or drive unusual behaviors proportionally receive little attention, despite their widespread distribution in the population. However, if one measures the burden of these sufferings by epidemiological standards, this complex of disorders can be seen to cause many lost years of life due to illness. Even if cancer cases decrease, such neurological suffering as Alzheimer's disease will presumably appear more frequently. Using suitable medicine, scientists hope to be able to postpone by an average of 5 years the outbreak of this brain disease.

This raises the worrisome question: whether people will pay for their increasing life expectancy with additional years of neediness and infirmity. According to the analyses of demographic statisticians, we can conclude that men and women can look forward to spending more than 90% of their life expectancy in a state of health that does not limit them in their daily activities and between 80% and 85% in a state of health that they themselves assess as satisfactory or better.