How will medical education change?

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"... the reforming of education ... one of the greatest and noblest designs than can be thought on"—Milton, *Of Education*

What will medical education be like in 2021? There is an old joke that prediction is difficult, especially when it comes to the future. It may be folly to speculate publicly about changes three decades hence—three decades ago, in 1961, who would have predicted lap-top computers, fibre-optics, genetic engineering, or AIDS? Yet *Homo sapiens* is the only animal with a sense of past and future; and human vanity remains unchanged from 30 or 60 years ago, making the challenge irresistible.

Medicine in three decades' time will have changed so as to be almost unrecognisable, and education will follow it. Of course there will be new drugs, some new diseases, and ingenious new technologies for displaying the nooks and crannies of the viscera. But the major qualitative change, as others have recognised,[1,2] will be in information technology. Computing power grows exponentially, with ever more megabytes and megaflops per buck. High-speed networking grows apace. The advent of "neural computation",[3] based on parallel-distributed processing, will allow self-learning software of awe-inspiring sophistication. Already the inexorable progress of computing means that within half a decade the world chess champion will be defeated by a computer.[4] Researchers in artificial intelligence have already achieved success with programs that can diagnose disease and recommend therapy.[5] By 2021 the computer will surely dominate all aspects of medical practice, and medical education will have to cope with these changes.[6]

How will the information revolution affect practice?

In 2021 computers will collect histories (perhaps directly via speech recognition programs) together with the results of physical examination and special investigations. They will suggest diagnoses and therapy, taking into account previous experience and the existing state-of-the art. Networking will allow rapid recognition of epidemics, identification of new syndromes, audit of treatment, and assessment of side-effects. With the aid of massive molecular genetic databanks,[7] we shall be able to recognise thousands of new genetic syndromes—way beyond the memory capacity of the most obsessional examination candidate or examiner. Interactions of drugs, with each other or with genetic anomalies, will be detected by pattern recognition software.

How will the medical profession come to terms with such a doctor's dystopia? Politicians, patients, and patients' pressure groups will demand improved medical audit; increased litigation will result in ever more defensive medicine; and failure to use a computer will be prima facie evidence of malpractice. The output of the diagnostic programs, which will be used in every consultation, will be fed back to improve audit.

Will there be any need for doctors at all? Yes. Perhaps more than ever, despite the seemingly bleak picture painted above. Clinical skills will still be needed and doctors will still have the two roles that they have always had—specialist and generalist. Specialists (also skilled in computing) will oversee the computer programs, making policy decisions, initiating new research, and implementing consensus treatments that will perforce become truly consensual (rather than agreed and then generally ignored).[8] Other specialists will be skilled with diagnostic instruments. An ever diminishing number will use that primitive tool, the scalpel. In contrast, generalists will provide human contact between computerised high technology and patients themselves, whose troubles will of course be unchanged; interpretation, explanation, exploration, comfort, and reassurance will be needed more than ever in the face of powerful and impersonal computer systems. There may also remain a few skills beyond the reach of computers—a careful examination of the abdomen, the insertion of a cardiac pacemaker, or the diagnosis and treatment of an acutely psychotic patient. "To cure sometimes, to relieve often, to comfort always" will remain the motto of good medicine.

What is wrong with our current training of doctors?

Students are almost uniformly critical of conventional medical training. They compare themselves to Strasbourg geese, force-fed with facts merely to provide *pâté de foie gras* for fastidiously gourmet examiners, who are perceived as out of touch with the real needs of students, doctors, and patients. Ideas and intellectual analysis seem neglected, so that it is commonly joked that medical schools are rightly called *schools* rather than universities. The principal educational method is often humiliation, and teachers do not like to be challenged or questioned; indeed teaching tends to be a low priority for clinicians, who increasingly follow the pattern "Patients first, research second, teaching third".[9] The result can be a scarcity of committed staff. Curricula are typically not used to further educational priorities but as weapons in a political battle for resources, where teaching time equates to income and power. Integration and interdisciplinary approaches thereby founder on the rocks of interdepartmental feuds. Examinations are limited in scope, requiring little in the way of creative thought, and fostering a mindless regurgitation of predigested lectures. Human aspects, such as communication and caring, are not subject to examinations (and therefore receive only lip-service in curriculum planning). Patients are equally critical. Doctors are seen as lacking in empathy, communicating only in a technical argot and without an understanding of patients' real needs.

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How will the curriculum change?

By 2021 medical educationalists will have a coherent cognitive psychology of medical education, perhaps involving the theory of contextual learning.[10] Today the theory is best illustrated by problem-based learning,[11] in which students, with guidance from teachers, determine their own learning objectives, set themselves appropriate goals, and achieve them by working together in small groups; they are assessed continually as they acquire new skills, ability, and knowledge. The method works because, as Flexner put it in 1910, "There is no cement like interest, no stimulus like the hint of a practical consideration".[12] Fundamental in implementation of such change is the acceptance that 80% of today's factual knowledge is unnecessary and rapidly forgotten, and that far more important is the ability to find secure knowledge when it is needed—and the omnipresent computers with vast data banks will always be available for that. From current exam syllabuses will be distilled the "core curriculum"[13]—the crucial 20% of factual information that is genuinely essential for medical practice; and knowledge of it will satisfy statutory bodies for licensing purposes. The intellectual space thereby created in the curriculum will be rededicated to wide-ranging optional modules, drawn from the whole of biopsychosocial medicine, and chosen by students to fit their particular interests and career choices. Modules will emphasise not mere facts but ideas, logic, methods, and approaches, enabling graduates to understand change when it happens.

Even in the era of the biological clone it should be apparent that doctors do not all need the same training and fund of knowledge. In the pre-specialist nineteenth century it made sense for all qualified doctors to be totipotent; in the twenty-first century it will make no sense. The basic medical degree, though, will remain undifferentiated; society will accept that the primary medical degree does not imply competence at neurosurgery or paediatrics, any more than a PhD means that all who hold it can discuss Spinoza or Kant.

Will courses be integrated, rather than divided into preclinical and clinical?

Yes and no. Modular courses, if well designed, can be taken in almost any order, allowing students to study, say, a module in respiratory physiology *after* studying a clinical module on respiratory disease. The traditional curriculum of basic science followed by clinical work will be replaced by something resembling a sandwich or layer cake, with alternating basic science and clinical medicine, each reinforcing the other.

How will teaching be done?

The lecture is often derided by those who emphasise its inefficiency for transmitting factual material; the medieval habit of a hundred or more scribes each taking down the spoken word of a "reader" surely makes no sense in the age of the photocopier; in 2021 it will seem antediluvian. Once factual transmission is removed as its rationale, the real purpose of the lecture will be fully exploited: it should be a vehicle for the telling of tales of scientific adventure and clinical endeavour, providing pleasure and entertainment on each retelling. It should motivate both young and old to return to their books, computer terminals, laboratories, and patients with renewed energy, purpose, direction, and interest; and may also renew dreams and aspirations.

Computers will be involved in almost all teaching. Apart from acting as data bases for information, computers will guide students by devices such as hypertext,[14] and will also provide assessment at critical junctures, giving immediate feedback. Clinical skills such as anaesthesia, image interpretation, and cardiopulmonary resuscitation will be taught through realistic simulations on screen or via computer-controlled mannequins. The advent of "virtual reality",[15,16] in which a three-dimensional scene is viewed through stereo-goggles, and objects within the computer-generated scene are manipulated by movement sensors in the operator's gloves, will even allow surgical training by simulation. Obvious advantages will be safety, the ability to repeat tricky manoeuvres, and simulation of complications. No expensive operating-theatre staff will be needed, and "patients" will be available at the touch of a button. There will be rich potential for examinations, both undergraduate and postgraduate, and for selection of candidates for particular jobs; interviewees for a surgical post will each be observed removing the same "virtual appendix".

Not all simulation will be by computers. Communication skills may be better taught by use of actors to simulate patients. Simulated patients will be freely available for students, who will borrow them from a "skills lab".[17] Maybe they will want to practise talking with the terminally ill, or the parent of a handicapped child. The actors will be teachers in their own right.

Who will do the teaching?

The past century has seen an ever-accelerating proliferation of medical subspecialties. Perhaps the sole exception is medical education, which assumes that if one can sequence DNA, perform a coronary-artery bypass graft, or run a diabetic outpatient clinic then one must also be able to teach about it. Logic and students' experiences suggest otherwise. In 2021 a teaching hospital doctor will no more teach without training in medical education than a psychiatrist today would carry out a gastrectomy. Medical education will be a seamless robe of integrated, inter-digitated parts, reflecting a coherent educational philosophy, woven jointly by doctors experienced in teaching and by medical educators. Since a medical school's income from student fees will depend on teaching quality, teaching will be accorded high status and be well rewarded. Neither lecturers nor professors wil be appointed solely on research ability, and clinically qualified teachers will not be dissuaded by lower salaries from teaching basic science. Medical education will be professionalised. Quality control will be assured by the new College of Medical Education.

Is this all cloud-cuckoo-land?

Well, perhaps, yes. A cynic might say that my original task, of prophesying medical education in 2021, was too easy. Medical education in 1991 differs little from medical education in 1961, 1931, or 1901. Why therefore expect change in the *next* 30 years? That view is indeed overly cynical. One certainly should not underestimate the obstacles within the conservative world of medical education,[18,19] in which short-term interests prevent structural change. But change is both possible[20] and inevitable—and it will be driven principally from outside rather than from within. Either medical education pre-empts such pressures and reforms itself from within, or change will come from without.

As Wordsworth said, the child is father of the man; and medical education is the father of medical practice. Society expects much of medical schools, and even more of their graduates, who are required to show diverse skills and abilities. J. A. Ryle's 1931 description is valid today, and will continue to be so in 2021; and, in posterity's harsh judgment, doctors will continue to be found wanting on at least the last of Ryle's attributes: "There is probably no servant of the community of whom a greater degree of omniscience is demanded, or upon whom a graver responsibility in respect of personal and sometimes social guidance is . . . imposed. As a rule, differing but little in native endowments and early training from others who are given the advantages of a higher education, he is nevertheless expected to combine in his person the attributes of scientist, healer, priest and prophet".[21]

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CLINICAL PRACTICE

Classification and natural history of clinically identifiable subtypes of cerebral infarction

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We describe the incidence and natural history of four clinically identifiable subgroups of cerebral infarction in a community-based study of 675 patients with first-ever stroke. Of 543 patients with a cerebral infarct, 92 (17%) had large anterior circulation infarcts with both cortical and subcortical involvement (total anterior circulation infarcts, TACI); 185 (34%) had more restricted and predominantly cortical infarcts (partial anterior circulation infarcts, PACI); 129 (24%) had infarcts clearly associated with the vertebrobasilar arterial territory (posterior circulation infarcts, POCI); and 137 (25%) had infarcts confined to the territory of the deep perforating arteries (lacunar infarcts, LACI). There were striking differences in natural history between the groups. The TACI group had a negligible chance of good functional outcome and mortality was high. More than twice as many deaths were due to the complications of immobility than to direct neurological sequelae of the infarct. Patients in the PACI group were much more likely to have an early recurrent stroke than were patients in other groups. Those in the POCI group were at greater risk of a recurrent stroke later in the first year after the index event but had the best chance of a good functional outcome. Despite the small anatomical size of the infarcts in the LACI group, many patients remained substantially handicapped. The findings have important implications for the planning of stroke treatment trials and suggest that various therapies could be directed specifically at the subgroups.

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Introduction

Any classification of cerebral infarction (CI) should be based on a detailed understanding of the pathophysiological mechanisms operating in each patient so that new

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