Science and medicine: implications for the future.

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The relationship between science and medicine has been an uneasy one and, to some extent, it still is. To identify and understand some of the difficulties that created these tensions it is necessary to examine the origins of this relationship. A better understanding will help to find new ways of organising medical education and training, of encouraging research and incorporating it into medical practice with benefit to the patients’ health and their medical practitioners’ morale.

Youth in discovery

It is often said that mathematicians have made their greatest contribution by the time they are thirty, and by inference that biologists are slower to develop. Most people are ready to accept that a talent for mathematics or music is genetically determined and may emerge at a remarkably young age, but surely it is a mistake to believe that the same is not true of other talents. The talent to be prized above all others is the power of original thought, and there is evidence that in biology too it occurs at an early age. While discovery is not necessarily tied to any particular age group, there are so few really original minds that it is our duty as a society to nurture and encourage them, leaving the rest of us with what Trotter [1] described as our ‘herd instinct’ to go on repeating the same experimental approaches with whatever new technique emerges.

I now want to list a selection of innovators and achievers whose outstanding characteristic was to believe in their own observations, often despite the weight of authority ranged against them (Table 1). The names on this roll of honour were chosen with little effort from the 16th to the 19th century and they are all those of young men who changed the direction of medicine and science in a completely revolutionary way. They usually worked on their own, at least initially, and it is natural to associate their youth with the intense desire and thrill of discovering something new for themselves. This certainly leads to a self-centred, sometimes selfish approach and may be criticised as scientific elitism, but of that we need all we can get.

Table 1. Innovators in medicine and science.

| Name      | Birth date | Age | Achievement                                           |
|-----------|------------|-----|------------------------------------------------------|
| Vesalius  | 1514       | 29  | De humani corporis fabrica libri septem              |
| Bellini   | 1643       | 19  | Exercitatio anatomica et usu renum                    |
| Hales     | 1677       | 29  | Mathematical biology                                  |
| Morgagni  | 1682       | 33  | Father of clinical pathology                          |
| Cheselden| 1688       | 25  | Anatomy of the human body                             |
| Baillie   | 1761       | 32  | Textbook of morbid anatomy                            |
| Young     | 1773       | 28  | Rosetta stone interpreted; colour vision              |
| Laennec   | 1781       | 36  | Stethoscope invented                                 |
| Magendie  | 1783       | 26  | Basis of pharmacology                                 |
| Bright    | 1789       | 31  | Renal clinical pathology                              |
| Hodgkin   | 1798       | 34  | Described his disease                                 |
| Bowman    | 1816       | 26  | Glomerular capsule and structure                       |
| Virchow   | 1821       | 28  | Father of microscopic cellular pathology             |
| Pasteur   | 1822       | 30  | Father of microbiology                                |
| Ehrlich   | 1854       | 23  | Harnessed organic chemistry in medicine              |
| Murray    | 1865       | 26  | Treatment of myxoedema                                |
| Elliott   | 1877       | 27  | Chemical theory of nerve transmission                 |

It seems to me that today the barriers to youth in science and medicine are becoming increasingly great. In past centuries the knowledge of a shorter life span may have played some part in the urge to make an impact at an early age, but it is well to emphasise that even today it is possible to achieve great things in the early twenties. Too much in science and medicine is now geared to putting off the time and opportunity for the really talented, and it is now an occasion for comment if anyone manages to achieve much in clinical research before the age of 35. I wish to contrast the individualistic approach of the original discoverers

SIR STANLEY PEART, MD, FRS, FRCP
Master, The Hunterian Institute, London
with the military approach of the Grande Armée in the shape of the Medical Research Council’s interdisciplinary research centres, where, to paraphrase Oscar Wilde, the majority is in full pursuit of the unachievable. Neglect of human nature is the feature of some of these grandiose visions of research structure; they are building idols in their own image! While there is no doubt that the organisation of medical and scientific research needs larger groupings of disciplines, their success depends on the way in which they are created. The best grow out of a demand by the people concerned who respect and like each other. The real need, however, is to create the scientific atmosphere in which these aims seem achievable. To this end, government must publicly acknowledge that it will put its trust in this driving force of new ideas that challenge present and past beliefs. Youth has the unfettered mind and energy to make this challenge, and morale among scientists will only rise again when there is a declaration of faith in the importance of discovery.

In medicine the imagined necessity for a long professional apprenticeship before giving the young doctor the chance to develop independent views on the needs of patients is another of the restraining forces of our establishments. Our professional institutions seem over-keen to preserve the influence of experience and age, supposedly for the protection of the patient. So the years between the ages of 25 and 35 are devoted to dissipating youthful energy in order to gain an accreditation label which is long past the sell-by date. In my experience good people learn very quickly indeed. The argument that science and medicine are now much more complex than they used to be does not impress me. In the past, bright people contributed in many fields despite their medical career, ranging over chemistry, mathematics, geology and palaeontology to cartography, zoology, botany and art, and they took part in expeditions of exploration. They spread their interests wide to fill their minds and use their energy.

Scientific discovery and medicine

For centuries scientific discovery and the practice of medicine had been going along side-by-side without the science rubbing off on to medical practice. It is fair to say that it is only in the past fifty years that the impact of science has really had much influence on medical practice.

When Steven Hales made his observations on the blood pressure of the horse in 1733 it was not because of any feeling for medicine, but part of his urge to measure as many biological phenomena as possible. His work on Vegetable Statics (1731) [2] was even more extensive and impressive than that on Haemostatics (1733) [3] and his most original and important contribution was to introduce mathematics into biological subjects. It was a hundred and fifty years before consideration of cardiac output and raised blood pressure had any place in human medicine [4,5].

In the 19th century, the century of enlightenment in physiology, chemistry, bacteriology and immunology, medicine trailed behind science. The most striking example of this lack of relationship is seen in the composition and activities of the Royal Society in the early 18th and 19th centuries. Who today would have expected the Philosophical Transactions of the Royal Society during the presidency of Sir Isaac Newton in 1720 to have had a mix of surgical cases, medical treatment, natural science subjects and mathematics [6]? In 1830 one hundred of the Royal Society’s 662 Fellows were physicians or surgeons, and many of them were more interested in the physical sciences than in physic [7]. For example, Roget, elected in 1815, inventor of the slide rule, was a practising physician, and many medical practitioners were attracted to geology. The British Geological Society grew out of Guy’s Hospital, with such names as James Parkinson, Wollaston and Astley Cooper, joined by Allen who lectured on pharmacy and later founded Allen and Hanbury’s pharmaceutical firm [8].

British science itself was at that time under considerable criticism, in constructive and refreshing fashion by the Home Secretary, Robert Peel, himself an FRS in 1822, who believed British zoology was inferior to French and considered ways in which the government could improve the country’s science. Less refreshing were the views of Thomas Wakley, editor of the Lancet, who spent the middle years of the 19th century attacking the leaders of science and medicine. He believed all these establishments were self-serving. In June 1829 he stated that jobbing at the Royal Society was making it a snug nest for the medical profession; worse was to follow, with the statement: ‘It is the topmost bough of quackery that we have attacked’ [9]. This came after a pessimistic view from Herschel, the Astronomer Royal, in 1828:

‘It is idle to attempt competition with continental neighbours, whether French or German, in matters of science generally. Our day is fast going by, and as we are both proud and poor and negligent we are rapidly dropping behind in the race.’

There are familiar echoes here today! The contrasting view was expressed in an address to the council of the Royal Society by Thomas Young, MD, FRS, of the Rosetta Stone, colour vision, and much else:

‘The way in which science ought to be encouraged in this country, not by tormenting the government to do this, that and the other for us, but in doing what is wanted for ourselves, which is the truly dignified character of an independent English gentleman.’ [10]

The relation of science to medicine is, however, best expressed in a letter to the Lancet of 3 April 1830, signed only ‘FRS’ and possibly from Babbage of calculating machine fame:
‘The glory of our Society is fast fading away. Rescue the noblest institution of our country from the degrading condition to which it is now reduced, that of a medical advertising office. A very puff shop for the chaff of medical scruples.’

It is nevertheless striking that the Fellowship of the Royal Society represented principally the wealthy dilettantes, often however of high originality expressed at an early age. Joseph Banks was elected president at the age of 34; Spottiswoode of the famous publishing firm started to run the business at the age of 21 while making important geological discoveries.

It was only later in the 19th century that the profession of scientist was recognised as being suitable for a gentleman. The British class system, therefore, had its influence on the development of science. The development of physiology, which greatly influenced the introduction of scientific principles into medical practice, attracted the greatest opposition from the so-called upper classes by its reliance on vivisection. A paradox indeed!

The 19th century saw the development of other scientific disciplines which were to make a great impact on medicine. Magendie (1783–1855) and Pelletier (1788–1842) in France discovered and developed the alkaloids (emetine and strychnine), and in so doing laid the bases of modern pharmacology and therapeutics. Liebig (1803–1873) and Wöhler (1800–1882) in Germany established organic chemistry and set the scene for its introduction into biology, medicine and therapeutics.

The remarkable and early founding of scientifically based pharmacy, almost completely independent of medicine, was due to the efforts of Jacob Bell [11]. In 1842, five years into Victoria’s reign, the School of Pharmacy opened, followed in 1845 by the Birkbeck Laboratory at University College.

Ancell, in 1839, said in the Lancet:

‘There is far more chemistry and far more science in medicine than physicians are inclined to believe.’

He was right and wrong, since it was to be a long time before chemistry or science were incorporated into medical practice. Concurrently in France, battles over ‘medicine secrète’ (that is the power of the committee to regulate drug composition) were raging, reminiscent of current battles over the regulation of intellectual property rights in discovery [12], except that in the former case there was very little intellectual content, and much avarice in the prescribed elixirs which are common to both (as in patenting human genes).

Despite all this activity, in which apothecaries and drug dispensing chemists fought with medical practitioners, perusal of Osler’s textbook [13] or Lauder Brunton’s Therapeutics of the circulation [14] reveals how little of real value was available in medical practice at the end of the 19th century. Medicine first had to catch up with some of the scientific principles that had been evolved in the 19th century before it could begin to incorporate them during the 20th century. It was no mere flourish for Claude Bernard to start his first lecture in the mid 19th century with the phrase:

‘I have to tell you, gentlemen, that the scientific medicine I have to teach you, does not exist.’

[13]

Medicine in conceptual development

While it is clear that medicine had to await the development of a scientific base for human anatomy, physiology and biochemistry before their principles could be absorbed into medical practice, it was a reluctant passage well into the present century.

The growth of observational medicine in the early 19th century, giving increasing importance to the physical examination of the patient, was aided by technical developments such as Laennec’s stethoscope (1819), culminating at the end of the century in Roentgen’s discovery of X-rays (1895). This approach marks the biggest change in medical practice since Galen, linking clinical symptoms and signs with post-mortem findings or those seen at surgical operation. The physician/pathologist was exemplified in Britain by such men as Bright, Addison and Hodgkin. They built on the forgotten brilliant descriptive methods used by Thomas Sydenham (1624–89) [16] whose gripping account of his own gouty sufferings caught the artistic imagination of Gillray a century later in 1799. Virchow (1821–1902) in Germany, with his extensive use of microscopic anatomy, and the introduction of cellular pathology to complement gross pathology, revolutionised the scientific approach to clinical practice.

Nothing, however, reveals more clearly the continuing influence of the ancient concepts of disease on medical practice at that time than the treatments that continued to be employed. The ancient Greeks would have been happy with these concepts, since all were based on the existence of an ill humour within the body fluids or cavities which concentrated in different organs to produce the disease process, and often in more than one, creating the concept of metastatic or sympathetic processes. These ill humours could be drawn out through the natural orifices, or finally by bleeding. Therefore, seemingly paradoxical and horrific therapy appeared to have a rational basis, and purging could justifiably be prescribed to help the patient expel the ill humour causing the diarrhoea, and the pale anaemic girl had to be bled to remove the pallid blood-borne humour visible in the buffy coat of the blood. The ‘constitution’, the physical equivalent of the soul, could be strengthened or weakened by various means, but was particularly affected by miasmas and noxious fumes in the environment,
hence the *mal aria* of Francesco Torti of Modena (1709), a concept which still holds today.

When spontaneous generation was still a subject of dispute even after Pasteur had demonstrated the relation of bacteria to fermentation and disease, it is not surprising that it took longer still for the principles of infection to permeate medical and surgical practice. By comparison with medicine, surgery was much more straightforward and, despite sepsis, surgeons dealt with various pathological conditions, often with amazing success in some hands, particularly those that were clean. Ovariectomy for ovarian tumour was first carried out in 1809 [17], and opening the abdomen or other body cavities gradually became a less dangerous occupation. However, I well remember my mother’s fear, shared by her generation, of hospitals and infirmaries, since hospital fever and subsequent death was too often the outcome even in the 1930s. Lister had to fight not only infection with phenol, but also his antagonistic colleagues, and in that he was more successful than Semmelweiss who was hounded by his colleagues for suggesting that they themselves might be the cause of high maternal mortality by infection. It is salutary to reflect that in 1842 Oliver Wendell Holmes [18] had suggested that puerperal fever was a contagious disease brought from the pathology department. It all had to wait for Koch in 1878 to demonstrate the basis of wound infection [19], but how slow to follow were antisepsis and asepsis. Ehrlich [20] then built upon the synthetic capability of the dye industry, to produce biological stains and a chemically based theory of immunology. This only emphasises how slow the progress had been since Jenner (1798) [21] introduced vaccination, and the time it takes for science to cast out the empirical approach to treatment. Salvarsan (1910) (Ehrlich’s ‘magic bullet’) marked the enormous therapeutic change that took place at the end of the 19th century [22]. Before this the only supposed cure for syphilis had been mercury, given until the flow of saliva reached up to three or four pints daily, the teeth fell out and untold damage was done to the kidneys.

Medical practice is slow to accept and slow to relinquish procedures or beliefs: what could be more illustrative than George Orwell describing how bleeding was still a remedy in the hospital in Paris where he languished in 1929 [23].

**Health**

Until recently the practice of medicine has been mainly concerned with the diagnosis and treatment of disease and paid little attention to health. It is worth reminding ourselves in Britain of the great contributions to public health that were made by the enlightened entrepreneurs of industry [24]. Men like Sir Titus Salt, Samuel Morley, Jeremiah Coleman, Lever, Beecham, Crossley and Wills were characterised by Quakerism, nonconformist religion of other sorts, teetotalism and voting Liberal. They looked after their workers’ health in an often paternalistic fashion, including education and housing, and probably did more for their health than any other medical, political or social movement. As a boy I lived close to Saltaire in Yorkshire, but without realising the social revolution that accompanied the name. The cynical may claim that productivity was their aim, but I find that difficult to believe.

Also, since control of reproduction has always been a most important part of public health, and is increasingly so, it is necessary in this context to mention Annie Besant and Charles Bradlaugh, prosecuted in 1877 for their pamphlet on birth control, and Marie Stopes in this century.

**Present trends**

How far, then, have we moved on from Claude Bernard’s remark in 1847: ‘the scientific medicine which it is my duty to teach you does not exist’?

There are scientists who have had a greater impact on the practice of medicine and the way that disease processes are thought about than any practising physician. Cell fusion, and DNA and RNA resolution have done more for medical concepts than most clinically inspired processes, but one must remember that one hundred years ago the relation of individual organ function to disease was only just becoming established and that cell physiology and pathology were still in their infancy. The cytokines of today are only additions to the hormones of ninety years ago, so while the rate of change and accumulation of new discoveries is increasing, their assimilation into medical practice and into social awareness is hard pressed to keep pace. New ideas are treated with caution and antagonism and their acceptance is often extremely slow, even when it is obvious to the impatient scientist.

Gene therapy, prenatal genetic diagnosis by sampling the chorionic villi, the introduction of human genes into bacteria, yeast cells or mice, are not all received with wild acclaim by society. The reasons for such reluctance are sound. The penalties for being wrong in such major revolutions are great, and scientists and doctors regrettably do make mistakes and puff up claims and counter-claims. It is, after all, only recently that clinical trials showed that in breast cancer total mastectomy did not produce better results than local removal, and people do remember the conviction with which surgeons applied one procedure rather than another without real evidence to support their view.

Society instinctively recognises that there is no absolute truth, only a set of probabilities paraded for their astonishment, disbelief, and occasional acceptance. The capacious critics in art and literature will always be the best at expressing these feelings, and scientists and doctors must learn how to respond and accept with good grace that it is not enough to say that smoking
kills, or that research on the embryo up to fourteen days of age is essential, without continual discussion and explanation. Many have now responded to this challenge [25]. Readiness to listen and discuss is the key, allied to scientific education of a wide audience from an early age, and the understanding that many social vices give great pleasure. It is also well to remember that major biological changes in populations have a price, and one cannot always forecast what that will be. Eradication of smallpox was one of the most dramatic and important achievements of man, but antibiotics breed resistance, myxoma viruses breed resistant rabbits, and preventing coronary deaths and stroke may lead to a more miserable death from cancer or an increasing proportion of demented citizens. This is the best argument for present and future research that I know.

What of the future?

Support for youth in scientific and medical pursuits remains my central theme. If we fail to support their mental and physical energy, we will fail as a nation. I am impressed by the calibre of the young we now have in medicine who deserve the encouragement of much better defined opportunities. Although their calibre is high, their morale is low because the government’s funding agencies are sending signals that indicate that the difficulties for research in science and medicine are not really understood or, if understood, ignored, and by inference therefore that they matter little. The frequent reorganisations, or disorganisations, of the National Health Service may make support for research even more difficult.

The incorporation of scientific advances into medical practice will have important organisational consequences. Medical and surgical practice and investigation is now on a converging course. The traditional role differences, based in part on temperament and manual dexterity, are disappearing, and it is likely that in the near future hybrid doctors will take over the major needs, leaving only a few areas of highly specialised medicine and surgery.

But where will research fit into medical practice, which despite that convergence becomes ever more specialised? Competition in research is so great that to be successful one needs to concentrate on a restricted area and give it undivided time. For the doctor who also looks after patients this means restricting clinical practice to a specialised field, devoting all mental energies to it and collaborating with scientists in many disciplines. To achieve this within the current structure of medical schools and National Health Service hospitals needs fresh approaches to the problems of careers and the critical mass of research workers. The statutory limitations on the numbers of young doctors who can undertake research training and compete with others for more senior posts is a real barrier, particularly when arbitrary quotas are imposed by those for whom research is of little concern. The Oxford Institute for Molecular Medicine remains the shining example, where basic scientists and clinicians complement one another in the same institute.

But where will this concentration of specialised effort leave the patient whose needs have not changed as quickly as the scientific advances around him? As he sits there saying ‘tell me doctor, am I here for you or are you here for me?’, doctors who can listen and make an assessment against a broad and knowledgeable background of medicine become increasingly needed. The family doctor becomes ever more important if what ails the patient is to be correctly assessed and the patient is to be given the right reference for special help. Who will train these doctors whose knowledge and standards must be at the highest level? Teaching hospitals will have to reinstitute the professor of clinical medicine and equivalent staff with a broad interest in diagnosis and treatment, who keep abreast of advances in all fields, and while utilising their colleagues’ specialised knowledge, are sufficiently informed to be able to debate the issues with them and therefore to protect the best interests of their patients.

The present reorganisation of the National Health Service, with the potential for specialised clustering of known conditions in hospitals, begs the question of how they come to be known. Now is the time for major decisions. We do not need a national institute for medical research as much as we need a national policy for medical research, and this cannot be separated from a national policy for the real needs of patients.

I would like to finish with this thought from Macbeth, of the most important part of a physician’s role and which is not incompatible with the application of science and medicine:

‘Cans’t thou not minister to a mind diseased: Pluck from the memory a rooted sorrow
Raze out the written troubles of the brain,
And with some sweet oblivious antidote
Cleanse the stuffed bosom of that perilous stuff
Which weighs upon the heart?’.

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**The title** of the article should be as succinct as possible and the text should be interspersed with subheadings, as appropriate.

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References should conform to the **Vancouver style**. They should give names of all authors, followed by initials (unless there are more than six authors in which case the first six only should be given, followed by *et al*). The title of the article should be followed by the title of the journal (**abbreviated to the style of Index Medicus**), the year of publication, volume number, and first and last pages. References to books should give the names of authors, (and/or editors), title, place of publication and publisher, followed by the year of publication.

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Each **Figure** (illustration) must be submitted on a separate sheet and given a number which accords with the order in which it appears in the text. **Tables** also should be presented in this way. **Captions** to Figures should be as brief as possible and listed separately. Each Figure should be identified with the name of the author as well as a number. The type area is 17.5 cm × 22.5 cm deep (single column width 8.4 cm). Figures will be reduced, where necessary, to fit this format.

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