TOPIC 1

Why biochemistry?

Aims of biochemistry

‘Why do we need to learn this stuff?’ is a question that every biochemistry lecturer is likely to have met over and over again in teaching healthcare students. It is somehow easier and more obvious to see why you need to know what the heart and kidneys do, where the veins and nerves are, etc., than how and why we metabolise glucose. So do you as healthcare professionals really need to bother about biochemistry?

It is now possible to provide a reasonably good broad description of what is going on at a functional level in most of the processes of the body, e.g. fertilisation, growth and differentiation, inheritance, immunity, hormone action, nerve conduction, muscle contraction and so on without biochemistry, but all these accounts end up prompting a degree of disbelief and the vigorous question ‘How on earth can that possibly work?’ Each of these stories invokes shadowy objects and influences that seem to have amazing powers – substances that recognise an invading bacterium or virus and target it for destruction, substances that switch on a program to turn a girl into a woman or substances that allow something happening inside my head to move my fingers across my keyboard! Biochemistry recognises that none of the marvels of biology can be properly understood without getting right down to the chemical level. Over the past hundred years or so this discipline has emerged by developing and refining chemical and physical tools to study very complex molecules and systems and has achieved an in-depth understanding of many of life’s processes that, even 30–40 years ago, were entirely mysterious.
Health care and biochemistry

Even so, do you need to understand at that level? Leaving aside the thought that you might be genuinely interested and curious to find out, there are many other pressures on your crowded learning time. We should therefore recognise that the people you will look after will usually be under your care because something has gone wrong! Even healthy people coming in for a check-up need clinical staff who can recognise the early signs of a problem. These days the check-up is likely to involve a battery of ‘tests’, which typically involve sending blood and urine to ‘the lab’. Some of these tests may involve microscopic examination, e.g. to recognise abnormal distributions of blood cells, but very many of the tests are biochemical, and ‘the lab’ is the hospital’s biochemistry department (possibly under the label of chemical pathology). If indeed there is a problem, patients ideally want you and your medical colleagues to offer something more than sympathy. Accurate diagnosis and effective treatment are what they are after – in much the same way that, if there was something wrong with their car, they would also hope for accurate diagnosis and treatment!

All the same, could you not leave all that detailed biochemical knowledge to the physicians and surgeons? Here we need to think about where the analogy with getting a car fixed falls down: when a car is fixed the owner collects it at the end of the day and drives it home; when he or she takes his or her body to be fixed, the chances are that he or she will have an aftercare period in the hands of nurses, physiotherapists, etc. It will be the nurses who deliver the drugs, set up the drips, take the blood samples, change the dressing and supervise the feeding. The patient is going to have far more contact with the nursing staff than with the surgeon and therefore will hope that the nursing staff understand what they are doing!

In considering how far biochemistry is essential to that understanding, let us briefly touch on four disease conditions, two of them longstanding killers and the other two more recent, but all four in their separate ways a source of fear for the public, and see where biochemistry fits in. The first two are the main killers in Western society: cancer and heart disease.

Cancer

In 1972, US presidential candidate Richard Nixon announced that, if elected, he would devote $100 million to curing cancer. The clear implication was that, in its pursuit of frivolous curiosities, the irresponsible, self-absorbed scientific community had overlooked this major source of public concern. It did not occur to Mr Nixon that the real problem was that we could not launch a full frontal attack on cancer until we understood what it was. Of course, at one level we knew that cancer involves our own cells growing out of control, and, knowing that, it was already
possible to attack cancers by surgery, chemotherapy and radiotherapy. What we did not know, however, was what led a particular cell or set of cells to become cancerous, and scientists were hotly contesting various rival theories—cancer was caused by viruses, cancer was inherited in our genes or cancer was provoked by dangerous chemicals, carcinogens. These were all advanced as mutually exclusive alternatives. Today, we understand that all these factors play a part and that a cell has to take several steps, not just one, to become committed to cancerous development.

What had to happen to reach our current understanding was a whole series of discoveries from various unexpected directions, many of them helping us to better describe normality, before we could explain abnormality. The point is that the new understanding is entirely biochemical. No amount of staring down the microscope at stained histological sections of diseased tissues would have brought us to the destination. What was needed was a proper understanding of the various molecular switches involved in cell division, and also an understanding of what controls the development of new blood supply—because once a tumour acquires its own blood supply it becomes more dangerous, seeding new tumours round the body by a process called metastasis. Today, with a much fuller understanding of what is going on and of the differences between different tumours, it is possible both to refine diagnosis and to devise better targeted and more effective treatments, so that at least some cancers that were fatal 30 years ago, such as testicular cancer, are successfully treatable today.

Heart disease

What about heart disease? Again it has been known for a long time, at a plumbing level, that the pipes get furred up. A build-up of plaque on the walls of the coronary arteries eventually leads to serious constriction and angina, and, if a blood clot builds up, possibly also to a fatal heart attack. As with cancer, this level of knowledge has provided a basis for surgical intervention of various kinds for a long time, but what about prevention, what about prompt and secure diagnosis, what about long-term medication? And once again, if there are genetic factors, how does this work? Are we all equally at risk? And does it matter what we eat? A proper biochemical understanding is really rather helpful. Today, one of the most widely prescribed classes of drugs is the statins, given prophylactically (i.e. for prevention rather than cure) to middle-aged patients, especially men. These are designer drugs specially targeting the production of cholesterol by our own body chemistry (see Topic 21), excessive levels of cholesterol now being well understood as a risk factor. Recognising the role of cholesterol and then targeting the drugs to decrease cholesterol levels is based on detailed biochemical research.
AIDS

The other two examples relate to more recent scares. In the 1980s, there was near-panic among various communities over the emergence of a new and deadly sexually transmitted disease, AIDS (acquired immune deficiency syndrome). The first step towards effective action was a recognition that AIDS is caused by the human immunodeficiency virus, HIV. The panic, however, reflected the fact that the condition was so poorly understood that there was no basis for effective therapy. What followed over a very few years was a truly remarkable response by the international biochemical community, which established exactly what HIV was, how it worked and where its weak points might be, allowing us to attack it instead of letting it attack us. This work led on to several strategies for drug design and to the current combined therapies, which allow HIV-positive individuals many years of healthy life rather than a very high chance of debilitating and terminal illness. AIDS, of course, is still devastating many parts of the developing world, but this is now an economic and political problem. The scientific and clinical problem is largely solved.

BSE

Finally, even more recently, in the 1990s, we have had another panic in Europe, this time over bovine spongiform encephalopathy (BSE – ‘mad cow disease’) and beefburgers. In this case, the successful containment of the problem, which seems to be steadily abating now, has been down to successful public health and agricultural measures rather than clinical intervention. Nevertheless, those measures in themselves have depended on gaining an understanding of an exceptionally baffling disease. It was baffling because it was an infectious disease that challenged all our previous notions of infection – no bacteria, no viruses, just the prion protein. In this situation, epidemiology (the study of the pattern of the spread of disease) clearly took us some distance in identifying a link with cattle, sheep, etc. even before we knew exactly what it was in the meat that was so dangerous. This left political dilemmas over the correct way to proceed, as possible methods of prevention struck at people’s livelihoods. Deep study at the molecular level since then has helped our understanding not only of BSE but also of various so-called amyloid diseases, such as Alzheimer’s. The original puzzle is solved when one understands that prions (and similar proteins) are molecular troublemakers! They not only misbehave themselves but they also lead their fellow molecules astray. It is inconceivable that BSE could have been properly explained by anything other than biochemical research.
Aims of this book

Biochemistry, then, is very clearly the engine driving major advances in clinical understanding, in diagnosis and in intelligent therapy. It is also a fascinating subject, but it is undeniably complex. Life is complex, and we cannot escape some complexity if we want to understand it. If you want to read *War and Peace* in the original, you have to make an investment in learning the Russian alphabet and language. The effort, one assumes, is finally rewarding. Similarly, biochemistry has its own alphabet and language, which can seem intimidating. My contract with the reader is to try to explain things as simply as possible, to explain the language of biochemistry clearly, and not to introduce complexity for its own sake. I would like to produce a few converts, students with a real sense of intellectual satisfaction in understanding the scientific basis of procedures in everyday clinical medicine and nursing. However, even if I do not succeed to that extent, I hope I will persuade you that biochemistry is not an unnecessary imposition but an essential tool, and that, with a little effort, the main principles can be understood.

This book

Finally, a word then about the organisation of the book. The numbered chapters listed in the Contents are essentially of three kinds and are colour coded as such by title. The majority (blue titles), of course, are mainstream biochemistry, and the individual biochemical topics are presented in short chapters, each making one main point and of a size to be taken in at a sitting. Interspersed, however, especially in the first half of the book, are chapters (red titles) providing some basic chemistry. This is gently presented on the assumption that you may have done very little chemistry, may have found it hard or perhaps did it so long ago that you have forgotten it. On the other hand, if you have a confident foundation of school chemistry, you can probably skip these red chapters. Finally, a third category of chapter, especially in the later stages of the book, presents clinical topics from a biochemical perspective (green titles).

Throughout the book there will also be reference to a series of appendices. Biochemistry is a vast subject, and for most healthcare purposes you probably need only the broad outlines plus certain relevant details. On the other hand, here and there puzzling facts may seem to emerge like rabbits out of a hat. If you are happy to take these facts on trust, you can safely ignore the book’s appendices without your patients suffering in years to come. If, on the other hand, curiosity or frustration draws you in further, the appendices are there to help out.

Like all subjects, biochemistry has its own secret language that is very useful once you know it, but a bit offputting till then. Therefore, there is also a glossary at the back for quick reference, to remind you of the meaning of individual terms.
Lastly, students always worry – Have I really understood it? Will I pass the examination? To help check on that there are about 150 MCQs, a few on nearly every topic and immediately following that section, with answers given at the end of the book. The best way to use these is probably not to look at them until a few days after reading the topic. The topics are so short that, if you look at the questions immediately, you are almost bound to get most of them right. If you revisit a few days later, the questions will be more effective in helping you decide what has or has not sunk in.

The book as a whole is intended to help and fill a need. In that spirit, feedback, no matter how critical, will be very much appreciated (to paul.engel@ucd.ie). Comments and suggestions from nursing or other healthcare students would be especially welcome.