The excitement of microbiology

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Several years ago, I volunteered to teach a course in introductory microbiology when my department was faced with the unexpected retirement of the person who had been teaching the course previously.

As a research scientist, I had been insulated from the realities of undergraduate education, so it was not surprising that I was shocked at what I learned about the prevailing approach to undergraduate teaching in the earliest microbiology courses.

I and others had noticed that many undergraduates were turning away from microbiology, and seem to view the discipline as old-fashioned and not relevant to modern day concerns.

A perusal of the texts then available provided an explanation for this phenomenon – these textbooks are boring and out of date in the sense that they do not reflect the exciting developments in modern microbiology. If professors are following these texts, as I assume many are, they are teaching courses that make students think that microbiology is at best an interesting historical footnote.

In an excess of what proved to be misguided zeal, Dixie Whitt and I decided to write an introductory textbook that would correct this problem. The result was *Microbiology: Diversity, Disease and the Environment*, published by Fitzgerald Science Press. This book has a very strong emphasis on infectious disease (viewed from an ecological perspective) and topics in environmental microbiology that have a high 'gee whiz' quotient.

I have used this book for the last few years and I have found that students love it. Unfortunately, the professors who teach introductory microbiology feel very differently. Reviews of this text have been largely negative; the reason for this negative response is interesting and, to me, troubling.

The main complaint seems to be that there is too much emphasis on medical microbiology. I was surprised about this response, given that medical microbiology has been one of our main areas of success, and so I started asking other microbiologists about the attitude of teachers of introductory microbiology courses in their institutions. This was hardly a rigorous survey, but the consensus was that there is a general aversion to medical microbiology among teachers of introductory microbiology. If you look at the most popular textbooks, you can see the result of this – medical microbiology is generally relegated to the back of the book and consists of the 'bug parade' treatment of the subject.

This may sound like a tirade that leads to an advertisement for the book Whitt and I wrote, but that is not the case. We are giving up the battle and our book will soon go out of print. Instead, this short article is a plea for teachers of microbiology to take a second look at the way they are presenting the discipline.

Teachers of microbiology face a problem most other areas of biology do not face – lack of a prior connection of students with the subject matter. If you are teaching a general biology course and you mention corn or pandas, students immediately feel connected because they have some sense of what these entities are. If, however, you mention bacteria or viruses, you get a blank stare. Certainly, students have heard the words 'virus' and 'bacteria', but they have no concept of what these entities are.

My suggestion is to start where the students are and lead them into the excitement of modern microbiology. Where the students are, is inside their own bodies, and they are very interested in anything that affects their bodies or the bodies of people they know.

For this reason, I advocate starting very early with the normal microflora and with infectious diseases. Yes, I know the mantra, which I chant routinely myself – microbes that cause disease are only a tiny minority of all microbes. But, in my experience, once students are 'hooked' on the infectious disease topic, they become a lot more curious about symbioses and even about microbial energy metabolism.

Also, topics in the news such as astrobiology, agricultural use of antibiotics, and (groan) bioterrorism, give students the sense that what they are learning is *au courant*. Incidentally, I am not above pressing home the point that microbiologists are the people with the cures. So, when I am teaching undergraduates, antimicrobials are brought into the picture at every opportunity. Let the neurobiologists top that!

I am not making a case for reducing the rigour of what we teach, but rather for rethinking how we package the hard science content. As a research scientist, I know that in my research and in that of others, the research starts with a biological question. Only after that real world question is identified and justified as interesting enough to pursue does the rigorous, scientific examination begin. Why don't we teach microbiology that way, by starting with the real world context and the rationale for looking into what would otherwise be dry subjects like energy metabolism or DNA sequence analysis?

I have yet to see a book (or course) on pandas that starts with glycolysis and the panda growth curve. I rest my case.

Note: The other ASM, the American Society for Microbiology, has initiated a programme of 90 second radio spots on microbiology. This is 'gee whiz' microbiology at its finest. The radio segments that have been aired are available on the American Society for Microbiology website.

Teaching and research: impossible or essential link?

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The belief that there is a positive link between research productivity and teaching effectiveness is widely held among academics in higher institutions, even though published studies do little to support its existence [1-4].

Although acknowledging the conflicting demands of teaching and research on time, energy, and commitment, most academics see many examples of the mutual benefits of combining the two activities, not least of which is to sustain the generation of new researchers.

Universities are now taking initiatives to make the teaching-research nexus more explicit by providing incentives for linking teaching and research [5]. Rather than these being seen as two opposing activities (Figures 1 & 2), the aim is to increase student opportunities to benefit from their teachers' research ('research-led teaching') [6, 7]. These issues are explored more fully below.

Teaching and research: mutually exclusive?

There can be no doubt about the tension that exists between the conduct of teaching and research. Both activities require their own set of skills and significant time for scholarship [8, 9].

Teaching is often perceived as 'relentless', with timetable constraints and escalating student demands. Increased student numbers and new teaching methodologies such as the move from large, didactic classes to self-directed and small group project approaches and on-line interactions, are adding more and more to the teaching workload.

Research is seen as having more 'freedom', being more 'fun' and bringing greater returns – higher salary, peer recognition, travel to conferences. However, as outcomes in research, measured by publications, grants and patents, are crucial, there is always this pressure to remain competitive (the 'treadmill'/'paper-trail').

Figure 1. Engaging medicine IV students in clinical medical microbiology.

The differential reward system, which gives separate awards for teaching and research, further segregates teaching from research. Academics are, in effect, usually forced to trade off one activity against the other to progress their careers. For an individual, the 'juggling' may vary at different points in the career path.

Little wonder then that, on the whole, studies that have investigated the teaching-research nexus show no support for the complementary nature of teaching and research or, at best, find that they are very loosely coupled [1, 2, 10]. It has even been suggested that different personalities may be required to succeed at either activity [2].

Teaching and research: irreversibly linked?

Despite the above, at the department level at least, if not the individual level, most academics hold strongly to the belief that both teaching and research are essential ingredients for higher education [2, 4]. There are in fact many reciprocal benefits to be derived from linking teaching and research. Currently, these are often not sufficiently exploited.

Irrespective of their research endeavours, good teachers have enthusiasm and breadth of coverage and try to stimulate a critical inquiry approach to learning. However, a researcher who is also a good teacher and has 'travelled the journey' may bring extra depth and confidence to his/her teaching which students find inspiring [3]. The teaching becomes more 'alive'. By way of illustration, one needs only think of the 2002 Rubbo Oration [11].

There are also reports that good researchers are more efficient at lecture preparation and have better organisation and presentation competencies than non-researchers [1]. More significantly, with first hand research involvement, it is likely to be easier to understand, and hence

Figure 2. Sharing a research moment with BScHons student, Che O'May.

convey, the complexities of knowledge and the challenges offered by what is still unknown. At its best, the teaching approach of a 'researcher' can model (often unconsciously) research thought processes. This is more than just being able to present advanced material well or keeping lecture material up-to-date. It has been shown, for example, to translate into student assignments that are more likely to reinforce and convey research skills[4]. Hence, not only teaching but also ultimately research is benefited.

However, while it is taken as a given that staff responsible for research students have a definite obligation to engage in research, there are still conflicting thoughts about the benefits of those who are at the 'cutting edge' of research teaching in the early undergraduate years. They are perceived by some to have 'too narrow' a focus. Studies confirm that the closer research is to the frontiers of knowledge, the less likely it is to be directly quotable in teaching[2, 8].

Others argue that the benefits of exposure to 'research culture' are cumulative and that the earlier such exposure can be introduced the better[4]. Thus, universities are including in their mission statements and planning strategies the goal that researchers be involved in teaching from first year level.

Other initiatives are to increase the involvement of research higher degree students as tutors throughout courses, and to involve undergraduates in later years in ongoing research projects as part of the practical components of their courses. At the University of Tasmania in the smaller microbiology science classes, these initiatives can, and are, being implemented, but they present more of a challenge for the larger and more content-driven medicine and pharmacy microbiology courses.

To drive such innovations, the introduction of rewards for tangible demonstrations of the integration between teaching and research has been proposed[5]. The aims of these efforts to strengthen the teaching-research nexus are to excite and enrich the learning environment for all, as well as capture and maintain student interest, model the processes of investigation, and provide mentors and role models to encourage the next generation of researchers.

There are also benefits of involvement in teaching for the researcher, although these are often less appreciated. The broader base of teaching at the undergraduate level necessitates a greater understanding of the discipline area and its interactions with the other subject areas with which students are involved. This can only facilitate the development of ideas and multidisciplinary approaches to research.

Student questions demand an in-depth knowledge of the subject areas and directly or indirectly can even trigger new research directions. Being required to communicate and deliver complex material in a simpler way develops skills that can be directly applied in writing more readable grant applications. Moreover, as research can often be alienating, the interactions that teaching brings with students and peers can create greater satisfaction with the work environment.

The way ahead?

In view of all of the above, it is not surprising that the discussion as to how to further encourage the links between teaching and research is gaining momentum. However, to achieve and foster this desired nexus, a broad base of basic research is needed. To achieve this academics need time and resources if they are to keep up in their fields of study.

Finding a balance between teaching and research activities is essential. The present danger with competitive research funding is that individual researchers in teaching-research institutions are increasingly being cut out of the research-funding loop. It is the contention of many that this is a real cause for concern that threatens not only the generation of future researchers but also the quality (depth and breadth) of undergraduate teaching overall. Research funding will need to be maintained/enhanced if the advantages of the teaching-research nexus are to be fully exploited.

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Serving two masters: the student work dilemma

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About 12 months ago I read with interest a letter from a university student published in the education section of *The Age* [1], which commented on a statement by the Australian Vice Chancellors that tertiary students were committing significantly more time to part-time work. This was, they believed, the product of financial exigency and they were consequently asking for more financial aid for students.

In his response, the student rejected the reason given for the increase in students' paid working hours and stated that the real reason for the increase in the level of student employment was to provide them with real-world experience and skills which universities fail to develop. He further stated that 'real' learning took place only when students started their careers and that students only tried to obtain degrees because employers saw them as evidence of "intellectual and emotional intelligence and qualities such as perseverance".

My first reaction to this letter was disbelief that anyone could dismiss the value of a university degree so cursorily. However, on reflection and considering my growing dismay over the last few years at the lack of commitment and involvement I had observed in an increasing number of students, I began to wonder if this student was representing the views of a significant proportion of students, i.e. the cohort that was always late for lectures, or attended only intermittently, or whose answers to exam questions had me wondering if they had attended at all; the cohort that submitted carelessly written practical reports or sat impassively in the laboratory doing only what was necessary, motivated mainly by a need to finish the class and get to work.

Around three quarters of full-time undergraduate students in Australian universities participate in some paid work. On average this amounts to 15 hours per week, almost as many contact hours during semester as required by their university studies. Many are unlikely to spend any additional hours on campus, catching up on or discussing topics covered in lectures. Often their subjects are even chosen to accommodate this work.

While it is difficult to know exactly what proportion of the student population really needs to work to survive, it is evident that there are students who do not receive support from their families, or who actually provide support to their families, either directly by paid employment or indirectly by unpaid employment in family businesses. Every year I come across two to three students (of 400) in this category. Many of these students juggle work at nights with day time lectures and practical classes. They are faced with an unenviable task which cannot help but compromise their commitment to their studies.

However, these students are not the subject of my current concern. I admire their determination and perseverance and try to assist them where possible.

My concern is for the far larger group of students who work, but not to survive in the real sense of the word. These students usually live at home and it is their parents who put the food on the table and provide the roof over their head. The money these students earn is theirs to spend, or even save, as they wish. More often than not this work is not related to their course of study and provides a very limited exposure to real world experience and skills.

Students often put a high priority on this work, and the things this the money allows them to buy and do. However, I believe that this increased commitment to work goes a long way to explaining the desultory attitude they develop towards to their studies and the growing disengagement I see in students on a daily basis. I believe this work prevents them from becoming immersed in both their studies and all that university has to offer. Preoccupation with paid work often means that they can fail to see and explore beyond the immediate and the obvious.

Don't get me wrong. I am a firm believer in the importance of students participating in the workplace. Part-time work can serve many important functions and enable students to acquire skills which universities often cannot teach. Punctuality is one. I can only express displeasure at late arrivals, employers can wield a far heavier sword.

Furthermore, exposure to a dreary workplace, or better still, one which provokes their interest, can often provide the incentive, motivation and direction lacking in students with no clear idea of where they might be going. Of course, voluntary community service can also provide many of these lessons but it is not an option taken up by many students. An appreciation of the effort involved in obtaining a salary, the importance of

considering other people and of taking instruction and responsibility are lessons well learnt.

But full participation in university life can offer so much more. It can provide a student with the opportunity to begin to develop skills that will last and enrich a lifetime. To mention only a few – the ability to critically examine and evaluate information, to separate fact from fiction, to relate different areas of study and investigation, to clearly present an argument and to listen carefully to an alternative point of view.

Lecture handouts or web downloads rarely convey all that a lecture covers or offers. Debates and discussions about what a lecturer actually meant, or questions raised by topics presented, are a most effective way to really come to grips with a subject. Often such debates are most effective when conducted informally – student-driven rather than teacher-organised, scheduled sessions in tutorial rooms. Time spent regularly with a group of colleagues on campus thrashing out a problem over a coffee is often much more productive and worthwhile than hurrying off alone to a workplace and subsequently shooting off extensive e-mails to an overloaded lecturer.

But students today rarely make time for this. They do only what is essential to pass, and they do not engage in such dialogue. By doing this, I believe they miss so much that is an essential part of their education. University years are precious times, with opportunities for exploration and discovery rarely repeated when full-time work eventuates. University can and should be, so much more than 'drop-in' centres issuing students with potential work permits. Yet it seems that for many students, university has become just that.

I am often consulted by employers who ask me about the suitability of students for positions in the workplace and the questions they ask usually require very thoughtful appraisals of a student's skills. Good marks on an academic record may indicate an ability to learn, a commitment to hard work, and the possession of a specific knowledge base. But some skills are difficult to measure.

No one would doubt the value of travel as a way of enriching a person's life, but how would we measure the value of that experience? The number of countries or churches visited, rolls of film exposed? Or the memories, the sense of wonder, the ongoing sense of connection to and concern for a particular race of people, tract of land or ocean?

The journey through university is not so different. It can be 12 subjects in three years and a degree scroll. Alternatively, it can be the beginning of a lifetime of joy and exploration, the fostering of a passion for learning capable of enriching both the individual and the wider community. I believe this to be an essential aim for all students and teachers.

In the years ahead most people will have several changes in occupation, involving significant retraining and re-skilling over their working lives. This will be as much a matter of survival as a matter of choice and successful career maturation. Of course not all the learning will be formal and necessarily result in the issue of a certificate, but some of it will, and this is where the true value and purpose of time spent completing a university course will come to the fore. An individual whose mind is open to learning will welcome such a challenge, accept and gain from it. He or she will be able to move onwards and upwards, not be left by the side with irrelevant skills and outdated information.

Education is a continuous process not a piece of paper or a retail product, despite what some would have us believe. At its best, it is not an experience that can simply be bought.

My late father, a primary school teacher, gave me both a love and a respect for teaching and learning. His admission to teachers' college came only after he had served a 12 month apprenticeship working as teacher's aide in a series of country schools.

His favourite phrase was "When you stop learning you might as well be dead". To appropriate his saying, I feel that when we no longer see any intrinsic value in education, when we no longer see universities as instigators of true learning, we will no longer have a real future.

In conclusion, I return to the student writer whose interpretation of the Vice Chancellors' motivation for asking for financial aid was that they were trying to increase the number of students, even further, to "turn the whole population into perpetual learners".

Financial aid does not seem to be the pivotal question here. What we must address is a question of attitudes. To engage our students and carry universities successfully into the future we must embrace the 'experience' of learning as not just a lecture but a way of life.

Money can buy many things but it cannot buy an enquiring mind nor a lust for, and love of, knowledge.

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Medical microbiology education: what's missing?

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In the medical curriculum in Australia the practical application of microbiology is often lacking. Proper collection of specimens, optimal use of the clinical laboratory and interpretation of microbiology reports are not adequately covered or emphasised in medical and nursing education in Australia, leading to sub-standard management of infections. Some possible solutions are proposed.

In the 1970s, there was a general feeling that infectious disease/clinical microbiology was a 'dying' profession. The euphoria was due to the 'conquest' of smallpox and very good control of TB and malaria in the developed world. Then along came HIV in the early 1980s and most recently the human SARS virus. These have changed the way we looked at infections.

Infectious diseases are one of our major health problems

Infectious diseases are the leading killer (almost half the mortality) of young people in developing countries (Table 1). Approximately half the infectious disease mortality can be attributed to just three diseases, HIV, TB and malaria, which cause over 300 million illnesses and more than 5 million deaths each year [2]. With the increasing political and social disturbances in the developing world, migration from these countries to Australia will certainly increase, and infections will become an increasing problem.

The following facts support the increasing importance of infectious diseases worldwide.

- In our institute the numbers of blood cultures received in the laboratory have been going up (by 12% in the last year). The numbers of clinical infectious diseases consultations have gone up substantially, from 490 in 2000 to 650 in 2002.
- The top Australian medical journal, *Medical Journal of Australia*, has ranked infectious diseases in the top two specialities of accepted manuscripts for many years [3-5].
- Infectious diseases represent a major part of the two leading medical journals in the world:
  - *The Lancet* has recently introduced a new journal dedicated to infectious diseases – *The Lancet Infectious Diseases* [6].
  - The highest single speciality articles in the *New England Journal of Medicine* collection of articles since 1996 are infectious diseases [7].
- Of the 118 WHO publications on health topics, the largest single speciality (37 publications) is infectious diseases (31%) and at least 10 others in which infectious diseases are a part of the publication [8].

Even though infections are a leading health problem, they are quite often not managed appropriately. Why is this so? Are we, in the developed world, complacent about infectious diseases? Are there subgroups of doctors (e.g. surgeons) who do not deal with infections properly? Or are we not teaching enough of it? Or perhaps we are not teaching it in the right way.

I think it is a combination of all of these, but the last one is probably the most important. Our teaching lacks emphasis on important practical aspects leading to sub-standard management of infectious diseases. The knowledge and skills required to manage an infectious disease efficiently are outlined in Figure 1.

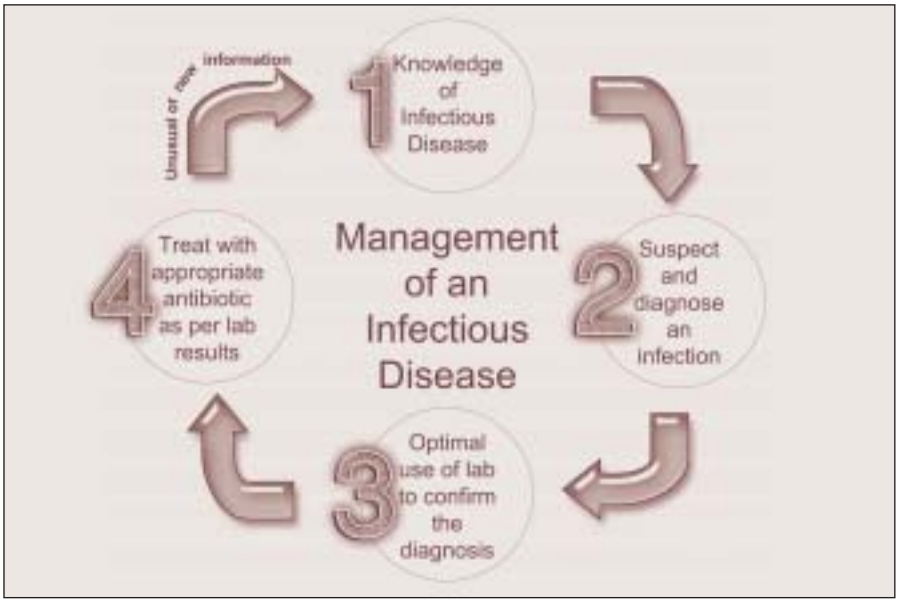
How can we measure what is lacking?

We observed how MPs (medical practitioners, including doctors in teaching hospitals, general practitioners who refer patients to our pathology services and nursing staff in some instances) use their skills in each of the above parameters (Figure 1). We assessed the quality of specimens received in the laboratory, how results are interpreted, the antibiotic prescribing habits and analysed the phone consultations we are involved in. Our

Table 1. Percentage of deaths from disease (reproduced with permission [1]).

Disease	% deaths from disease that occur among the poorest 20% of the total global population
Malaria	57.9%
Childhood diseases	55.0%
Diarrhoeal diseases	53.2%
Perinatal conditions	45.0%
Tuberculosis	44.4%
Maternal conditions	43.2%
Respiratory infections	42.6%
HIV/AIDS	41.8%
Weighted average	48.6%

Figure 1. The four steps for efficient management of an infectious disease.



observations are documented in the discussion that follows.

Theoretical knowledge of the infectious disease

This aspect is adequately covered in Australian medical curricula.

Suspect and diagnose an infection

Diagnosis of an infectious condition clinically starts with a good detailed history, followed by appropriate specimen collection and proper interpretation of results. Common deficiencies observed are:

A good clinical history

Epidemiological and travel history is extremely important in infectious diseases, but is not always taken. In multicultural Australia, due to migration from and travel to tropics and the developing world, this aspect of the history is extremely important. To illustrate this, two cases (Case 1 & 2) where diagnosis was delayed with serious consequences are presented.

Misinterpretation of laboratory results

The clinical information/impression should always come first and should *always* be used for proper interpretation of laboratory results. For specimens with normal flora (sputum, urine, wounds etc) the importance of the microscopy/Gram's stain report and correlation to the culture findings is quite often missed. Apart from being a rapid method, the microscopy report also identifies the specimen as being adequately or appropriately collected.

The culture and sensitivity result should be taken into consideration only if the first two criteria mentioned (namely clinical impression and adequacy of specimen) are fulfiled. *After all, the aim is to treat the patient, not the bug!* If an organism name and sensitivities appear on a laboratory result, it is often interpreted as being the cause of the clinical problem.

Using the laboratory appropriately

Optimal use of the clinical microbiology laboratory is crucial for management of an infectious disease. In order to achieve this, MPs need to understand that the microbiology laboratory is very different to other sections of a pathology service. The turn around time of a microbiological report varies greatly (as compared to biochemistry or haematology) and can be unpredictable. *Bugs take their own time!*

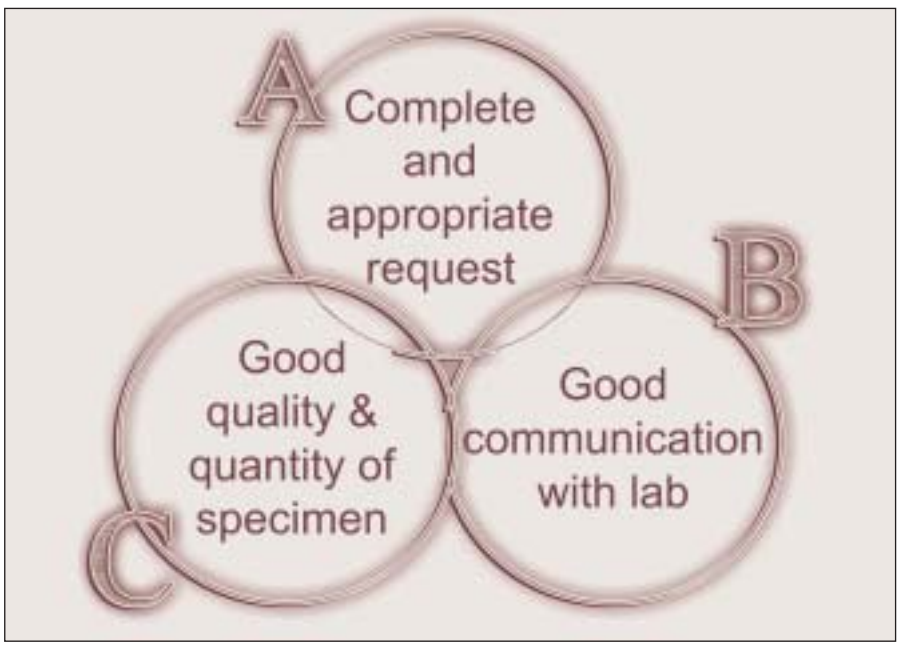
There are three key aspects for optimal use of the microbiology laboratory (Figure 2), which are often overlooked.

Complete and appropriate request

Often the MP referring the patient is not aware of what tests are available or what should be asked for. Acronyms are made and used for convenience but are quite often used in the wrong context.

The acronym MC&S which stands for microscopy, culture and sensitivities, pertains to bacterial examination. However, it is loosely used to request any microbiological examination including viruses (which are commonly diagnosed by serology or Polymerase Chain Reaction – PCR), parasites (which are commonly diagnosed by microscopy alone) and fungi (for which sensitivity testing is not well standardised and not routinely done).

Figure 2. Key features for optimal use of the clinical laboratory



The term MSU (mid stream urine) is often used synonymously with any urine specimen. On many occasions a specimen labelled 'MSU' is found to be a urine specimen collected through a catheter or occasionally a stent or by aspiration. The criteria for 'significant bacteriuria' are standardised on a MSU specimen and cannot be applied to other types of urine specimen.

Another common request is 'viral studies', without specifying which virus is clinically suspected. Since the introduction of PCR in diagnostic laboratories, it is being requested for a variety of organisms. The message that seems to have gone out is that PCR is Harry Potter's magic wand! The confusion seems to stem from the fact that medical journals publish research studies that are automatically interpreted as being available in the diagnostic laboratory.

Good communication with the clinical laboratory

Communication is critical to get the best out of a laboratory service. Appropriate clinical notes are not commonly received with the request, which disallows laboratory personnel to suggest or initiate a suitable test. Case 3 illustrates that good communication can help diagnose unusual infections [9]. 'Urgent' tests may be delayed with possible detrimental effects due to poor communication. Updates on new procedures or new knowledge can also be more efficiently passed on if regular communication is in place.

Good quality and quantity of specimen

Some critical considerations while collecting a specimen for microbiological testing (as compared to histology, biochemistry or haematology) are often not followed. These are:

- Asepsis: the impact of normal flora of the body on microbiological results is unfortunately not always understood. The normal flora can easily overgrow and 'mask' the true pathogens. At other times these organisms can become 'opportunistic' pathogens in certain circumstances. Avoiding or minimising the normal flora while collecting a specimen with aseptic technique is absolutely essential in microbiology.
- Some specimens (e.g. sputum, urines, faeces) are collected by patients themselves. Explaining the importance and proper technique of collection (e.g. what is meant by MSU, difference between sputum and 'spit' etc.) to the patient is of utmost importance.

Case 1

A female student from Bangladesh presented to a GP with enlarged lymph nodes in the neck. Suspecting lymphoma, she was referred to a haematologist, who organised an open biopsy of one gland. This was promptly transported to the pathology laboratory in formalin. A few days later the result was 'granulomas suggestive of tuberculosis'. Since the tissue was sent in formalin, it was not suitable for culture. The young lady was told to undertake another incision on her neck (and another scar!) for a repeat biopsy.

When we were involved, we suggested an aspirate rather than a second biopsy, and *Mycobacterium tuberculosis* was isolated which was found to be fully sensitive to first line drugs. She promptly responded to appropriate treatment.

This is not an uncommon scenario where there is over diagnosis of cancers in young people from the developing world presenting with 'lumps'. Tuberculosis is a very common infection in the developing world and should always be first in the differential diagnosis of such cases. The associated mental agony can be easily avoided.

Case 2

A young Australian lady visiting a infertility clinic fell pregnant in the IVF programme.

A few months later, she had to be rushed to hospital with ruptured tubal pregnancy. The tubes were removed and sent for histopathological examination.

The specimen was found to have extensive granulomas and structures suggestive of *Schistosoma haematobium* eggs, with subsequent positive Schistosoma serology.

When she was seen in the ID clinic, the history revealed she had travelled extensively in Africa about 8 years ago and swam in lakes and rivers there.

A few months after her return, she had haematuria and consulted a GP who, suspecting urinary tract infection, prescribed antibiotics.

Had a proper history been taken earlier, schistosomiasis could have been diagnosed and treated earlier and would most likely have avoided the ectopic schistosomiasis with the consequent complications.

Case 3

A teenage female was admitted to the hospital with a diagnosis of possible bacterial sepsis. *Bacillus* species was repeatedly isolated from blood cultures even after appropriate antibiotics were administered. There were no localising signs and the patient was not immuno-suppressed and denied use of intra-venous drugs.

The clinicians were alerted to the unusual nature of the isolate and a detailed history and a search of her room revealed that the patient had a psychiatric disorder and was 'self injecting' an unknown substance (Münchausen's syndrome). A literature search revealed that the species of *Bacillus* isolated were a part of a drain cleaner. A psychiatrist was involved in her long time care.

The case illustrates the importance of good communication with the laboratory and a detailed history that led to a proper diagnosis and management without much delay. *Bacillus* species are common in the environment and could easily be discarded as contaminants. Repeated isolation of the same organism made us suspicious and the clinicians were alerted early.

- Collecting specimen *before* antibiotics are started.

Rightly or wrongly, the 'culture' of specimen collection is changing. The 'chore' of collecting specimens has shifted from doctors to ward nurses to a new generation of 'pathology nurses' in many instances. Whilst this may not be a problem when collecting specimen for biochemistry or haematology (mostly venous blood), these staff members have not been adequately trained in microbiology specimen collection and in the concepts mentioned above.

A couple of examples of inappropriate or inferior specimens that are commonly received in the laboratory come to mind. Swabs are favourites with collectors, probably because these are easy to collect! But the collector (and the doctor who requests it) fails to appreciate that this may be sub-optimal. Even if there is a volume of pus to aspirate or infected material to collect, a swab is sent to the laboratory with a long list of tests to be carried out on. We have even received 'swabs' of sputum and faeces!

Another inappropriate specimen (not uncommonly) received are whole organs removed at surgery (e.g. appendix, amputated toes etc.), put in a sterile container, with a failure to realise that the affected part is 'bathed in' the normal flora that will overgrow the suspected pathogen.

Treat the infection appropriately

The 'inappropriate use' of antimicrobials has been mentioned time and again. Australia is one of the leading users (and abusers!) of antibiotics in the developed world [10]. We have observed a number of times that antibiotics have been prescribed just because they appear on the microbiology report.

When clinical notes are not provided, we report a 'potentially pathogenic' organism with an antibiotic sensitivity profile and a comment that the result may be significant only in the right clinical context. However, the result of the microscopic examination and the comment is quite often ignored.

Such results should be interpreted cautiously, taking the clinical picture in context. An approach we have taken to curb the over use of antibiotics in our practice is to withhold antibiotic results (and make it available only on request) where clinical information is lacking or there is sufficient doubt about the significance of the isolate cultured.

Understanding the concept of MICs (minimum inhibitory concentration) and interpreting antibiotic sensitivities is also not always clear. The knowledge that the *in vitro* testing does not always correlate to the *in vivo* effect of the antibiotic is sometimes forgotten.

Another fact that is not commonly appreciated is that, due to various technical reasons, every organism cannot be tested against antimicrobials in the laboratory. Knowledge of antimicrobial resistance (inherent or acquired) also quite often goes astray. This is important while starting antibiotics empirically, before laboratory results are available.

Overall, our observation is that there is inadequacy in three key areas of infectious diseases management (points 2, 3 & 4 in Figure 1) and these are the practical aspects of clinical microbiology. We should not 'blame' MPs for not having the appropriate clinical microbiology knowledge and skills, because we would be assuming that this knowledge has been given to them and is not being properly used. These aspects are *not* being adequately covered or emphasised in medical and nursing education in Australia.

The new medical curriculum at the University of Melbourne (and many other Australian universities) has addressed a few of these issues with problem based learning (see the article by Sandra Uren elsewhere in this issue) and it will be interesting to observe how this will impact on infectious disease knowledge in the future, once this 'new breed' of doctors pass out. The new curriculum is based on 'integrated learning', so measuring the amount of clinical microbiology/infectious diseases taught will be difficult. The pre-clinical years cover the basic principles adequately. However, the clinical years will need 'fine tuning' with emphasis on the three key practical aspects as discussed above.

What implication does all this have on the health care service?

From a patient's point of view, due to inappropriate or missed diagnosis, there can be increased morbidity (and occasionally mortality). Inappropriate antibiotics, unnecessary testing and longer hospital stays also add to the overall cost of the health services.

What are the possible solutions ?

Modify teaching of clinical microbiology. More emphasis should be placed on the practical aspects discussed above, especially in later clinical years or during internship. Sessions in the diagnostic laboratory would be ideal. This will give the MPs an insight into the working of the laboratory, will emphasise the importance of good specimen collection and improve their interpretation skills.

Encourage communication with the laboratory to maximise the use of the microbiology services in management of infectious diseases.

Establish on going education programmes in order to keep knowledge of emerging microorganisms, new laboratory techniques, antibiotics and emerging resistance up to date.

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