TEACHING THINKING IN MEDICINE

Sean M. Lavelle, Department of Experimental Medicine,
University College Medical School, Galway, Eire.

Introduction

Teachers like to believe that they teach their students to think. However it is not clear that thinking-ability is often measured. There are various meanings for 'thinking'. Some people equate it with the application of logic, philosophy or mathematics. Formalisms or disciplines like these take three or more years to learn, and are concerned with ideal or absolute entities and relationships which are rare in the everyday world. Thinking, however, goes on continuously in our minds, whether or not we have learned formalisms. This thinking seems to be associative, a process of finding and relating two appropriate elements in memory and assessing the relationship for its truth, usefulness, or ability to facilitate perception of further relationships. These operations are carried out on notions in memory. It thus can be difficult to separate thinking from knowing. The emphasis in teaching however may favour one or the other. One can 'teach' by requiring rote memorisation. One can also address the other extreme, and emphasise the process of thinking, without stressing the assimilation of the stimulus material.

The operations of thinking would seem to be much the same no matter what the material to which they are applied. Scientific thinking may be that in which the elements, the relationship and the testing are quantitated. In this regard, it can be difficult for medical thinking to be scientific. Few clinical presentations of disease are objectively defined or quantitated (Burbank, 1969; Staniland et al, 1972; O Beirn et al 1987). Further, much of the output of technology generates images or traces for sensory perception, and which are not quantifiable. An antecedent for scientific medical thinking is quantitation of medical data. In the meantime, ordinary associative thinking must go on. It is this that guides the professional in the delivery of his knowledge. Perhaps, then, it deserves cultivation no less than does memorising data. There is however a difficulty, in that no two people share identical experience or its associations. There are thus certain conditions to be met if associative thinking is to be cultivated.

Requirements

1. To evoke thinking processes, the stimulus must be something the student has not already formally studied, otherwise one gets recall.
2. To make the thinking discernible, the stimulus must be simple and self-contained: that is, it must not require extensive external associations or subclasses to be evoked in order to deal with it.
3. To ensure that attention is paid to the process of thinking, rather than to the content, the content must be of little import to the student.
4. To provide feedback the exercise must have some quantifiable output and reference standard.

The above points are in contrast to those of memorisable content, which is usually discernible, quantifiable, important for examinations or real life, and constitutes its own reference standard. However, if thinking is an examination of experience to control the present or anticipate the future, then in this process there are skills - to select the appropriate exploratory behaviours, to carry them out with least effort and to do so completely. It is clear that there must be a best way, or ways, of doing so. To teach thinking, these ways are to be demonstrated, sought, and rewarded.

The need

There is a need to foster cognition in medical students.

1. They are asked to learn too much. The undergraduate course encompasses some 140,000 facts and principles (Anderson and Graham, 1980) or up to 24 new facts per hour of their course.
2. The problem can become more acute on graduation. The facts/principles of internal medicine are estimated to exceed a million (Pauker et al, 1976). Clinical experience helps sort and integrate the knowledge. But clinical experience can be highly personal, and the resulting judgement is guided by personal thinking (Grant and Marsden, 1987).
3. Furthermore, under present training methods, the cognitive performance of doctors is suboptimal. It has long been known that even senior specialist clinicians agree altogether on as little as a third of case findings (Fletcher, 1952).

Observer error can exceed 20% in all aspects of medicine (Koran, 1976). Much of it may arise from lapses in cognition or motivation, rather than in knowledge (McDonald, 1976).
On the whole, it seems advisable that medical students should receive guidance and training in thinking as well as in the factual matter, concepts and interpretation mechanisms specific to medical data. There is a growing literature on teaching thinking (deBono, 1971; Maxwell, 1983; Nickerson et al., 1985). As memory and calculation can be delegated more and more to computers, cognition, rather than information, becomes the limiting resource in human endeavour.

Curricular time

A suitable placing for such guidance may be during the first clinical year, integrated with the developing clinical knowledge. There the thinking that is generic can be taught uniformly in a scientific atmosphere in the same way that the disease processes that are common to all specialties are taught in the course on pathology. We have been exploring this approach in a course on objective methods that occupies 160 hours in the first clinical year (Lavelle, 1989). It shares the same university examination as Pathology. The teaching method is to give the students a task that exercises the particular skill, and to feed their performance back to them together with that of their peers. The class composite is used as a standard. The results are discussed. The procedure is repeated six or so times and the progress of the class is mapped. Students become aware of their own performance, of that of the best in the class, and of the class mean.

The module of thinking occupies some 8 hours, or some 0.15% of the undergraduate course time. It evolved from one on problem-solving. This was not problem-solving of the case-elucidation type, which is really no more than the process of diagnosis. It was problem-solving in the sense of finding a way out of a difficulty into which one had fallen. A development of that thinking can be regarded as the creation and exploitation of opportunities prospectively. The elements addressed are observation, interpretation of data, the inter-relating, generation and assessment of ideas, and relationships of cause, consequence and purpose. The patient is too complex a stimulus for these exercises, even it it were possible to get the whole class around one bed. The stimulus used must be simple if it is to promote concentration on the process.

Rationale

Why should we believe that we can improve students' skill in thinking, an unquantitated, multifactorial, stimulus-oriented, unobservable process? Firstly, any training that provides awareness, a vocabulary, experience and pursuit of performance allows people to improve skill. Secondly, observation is a process similar to thinking (which is, after all, internal observation) and observation seems to be improved by training (Fig. 1). Thirdly, there is some evidence that thinking improves if persisted with (Crowell, 1982; Edwards and Baldauf, 1982).

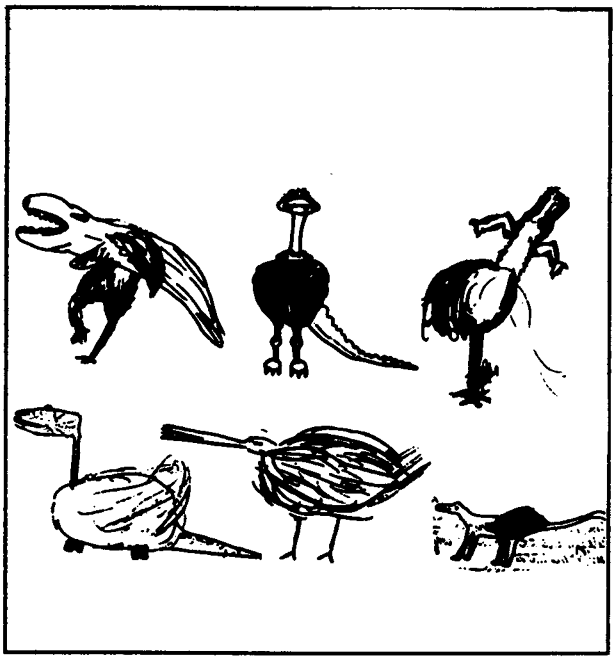

Fig. 1. Illustrative responses to the task 'draw a cross between an alligator and an ostrich'. Although some 14-20 items (teeth, tail, toes etc.) are involved, no two drawings are alike, illustrating the variability in the selection of associations from experiential memory.

Nonetheless it seems wiser to follow an experiential approach than a theoretical one. So we look to see what the mind does when faced with a task, then we classify and quantitate the responses, and finally attempt to focus on 'specific' operations. This is, of course, a bit artificial, since the processes are integrated and interdependent, but we could find no better way. With 65 students in a class, the performance of the group should be fairly representative. The exercises are tentative: better ones will emerge with time. The students are asked not to try to replace their own cognitive methods, but to look at and think about what happens and take up anything that improves their performance. However they are expected to be able to carry out the exercises.

Method

Observation and overload: Observation is dealt with in a separate module. Students observe simple objects. Sensory overload is demonstrated by dictating numerals (0-9), or letters, or monosyllables, at one second intervals in sequences of increasing length and getting the students to write them down immediately afterwards. They remember on average 7 figures, 6 letters and 5 monosyllables, with some variation. This limit of 6-7 appears repeatedly in the cognitive performance of untrained subjects.

Idea structure: Next the structure of ideas is addressed. A simple object is shown and they write down what comes into their heads. We use non-compound objects of everyday experience that have not been formally studied, such as a toy balloon. Aside from the observable characteristics and functions of the object, its 'idea' contains associations of space (where it is found; what things are found with it); likeness (things like it; subclasses); time (origins and causes; fate and consequences), relationship to observer (feelings aroused) and value (rules for use of). For a given object, some of these may be trite. But incorporation of these elements into an experiential memory tree may help to make it more systematic and thus searchable. It is interesting that in such a goal-less search of memory, the average number of the areas accessed by untrained subjects is always less than half. The students are given exercises in drawing products from each area of association. Some find it difficult, but it does provide a general map for a comprehensive sweep over the common sectors of memory.

Relations: All thinking, not least creativity, appears to be reducible to relating two ideas. Relationships between ideas may be explored by writing down what comes to mind when shown two objects together. The products exhibit much the same categories as do single objects. The names of objects appear to serve just as well as their physical presence. The process would seem to be fundamental in looking for a novel connection between two ideas. It may deserve expansion. Some students find if difficult. Perhaps the advantage to them is to have gone through it and set a behavioural precedent.

Interpretation: The steps in interpretation are shown by asking the class to make the best sense they can out of a scrambled sentence. The way the elements are put into segments that are familiar, and the way the segments are rearranged into a whole that corresponds to experience or to possible experience, are made manifest. Most students decipher the sentence correctly. Some make an incomplete synthesis and an element is left unaccommodated. Others produce a construction which requires them to add an extra word in order to make sense. Both mechanisms occur in the development of explanation in science. In the same way, when they are asked to observe a novel event (a fluid 'spontaneously' changing colour), many produce 'explanations' which demonstrate the stages in the emergence of 'hypothesis' or provisional interpretation of the component events (deBono, 1971).

Idea generation: The dependance of creativity on knowledge is illustrated by asking the students to draw a novelty, such as a cross between an alligator and an ostrich. Although no two drawings are the same (Fig. 2), they are assemblies of the same dozen-odd features taken from either animal: teeth, head, forelimbs and so on. They can be assessed by counting the number of elements included in the drawing. They represent the easiest case, as there is a one-to-one correspondence between the stimuli.

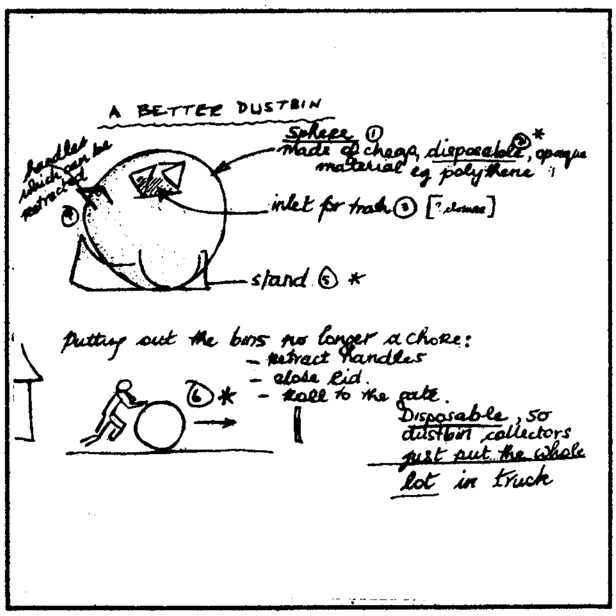

Fig 2. A response to the task 'draw a better dust-bin'.

The next task has less structure: it is to 'draw a better...' design of any commonplace functional object, labelling the elements. The drawing has the advantage that it 'permanentises' the thinking onto paper, allows update, and focusses attention on elements which have not been thought through (deBono, 1969). The exercise can be marked by counting the elements, with extra marks for implementable novelty. It is however in part dependent on the individual's experience of the stimulus, and successive exercises are not highly comparable. Some students prove highly creative and set track records to be emulated (Fig. 3). A few have difficulty in accessing any new element to include in their design. If the ability is a necessary one in medicine, (and general practice often calls for creative use of resources) then they badly need practice in it.

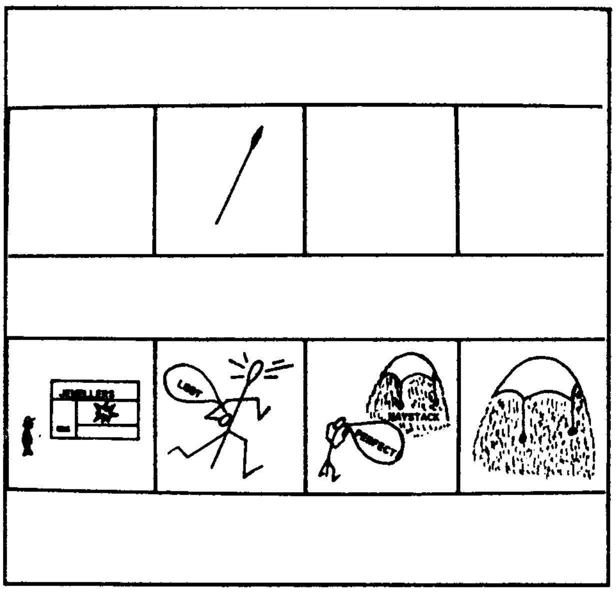

Fig. 3. A response (lower frame) to the task 'complete the cartoon', the stimulus being a needle drawn in the second panel (upper frame).

A dynamic aspect is provided by sequence-completion. A four-panel cartoon is given with a stimulus (flower, ladder) in one panel. The task is to complete the cartoon as a logical story. A stimulus in the first panel requires consequential thinking, one in the second or third panel event-reaction thinking (Fig. 4), one in the last panel causal thinking and one in the first and last, means-end thinking (Spivack et al, 1976). These can be marked from 1 for a prosaic completion to 4 for a highly imaginative one. When a sample of the cartoons are displayed for the students to assess, the mean mark they award correlates well with that awarded by the instructor.

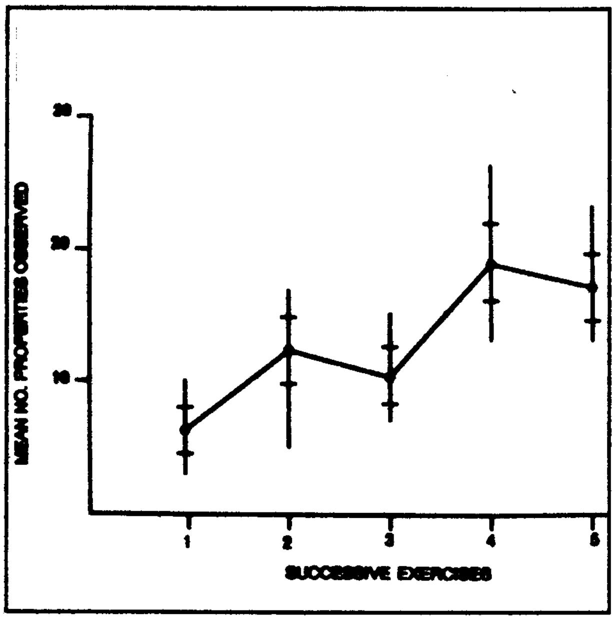

Fig. 4. Mean class scores in exercises observing successively a rubberised mat, aluminium bar, perforated metal sheet, bathroom sponge, pane of glass and toy balloon.

<u>Assessment:</u> One must, when memory or sensation fail, have recourse to thought. It is vicarious experience. If one had perfect information there would be little need to think. In many ways thought is a reaction to novelty, external or internal. A novel idea, or any idea for that matter, will benefit from assessment under eight headings:

A. What are its immediate advantages?
B. Can they be bettered by adding something to the novelty?
C. If it is not of advantage now, are there 'catchy' or memorable points that may be of use in the future?
D. What drawbacks has it?
E. Are there other objects or situations whith would benefit from extension of this novel element to them?
F. Are there further or alternative ways of achieving the same end with less drawbacks?
G. What other novelties in general come to mind as this one is explored?
Q. What questions does the novelty provoke?

The process of assessment leads inevitably into idea generation. B, E and F (above) invoke creativity directly, while C stores away raw material for future originality. A, D and Q are stimuli to innovative acts. Assessment is a springboard to creativity. The process can be exercised on simple novelties that do not distract attention from it, such as a shoe with the heel in front (useful for walking downhill) or with a side zipper instead of shoe-laces (Table 1).

Table 1. Some class responses to the task 'assess the novelty' of a zip fastener in the side of a shoe, to replace the lacing in front.

<u>ADVANTAGES</u> NO LACES TO BREAK * NO LACE TO TRIP ON * SAVES TIME IN LACING * NO TRAILING WET LACE * DONT NEED TO BE ABLE TO TIE KNOT * GOOD FOR CHILD AND OLD * SAVES BENDING * MORE WATERPROOF * EASIER TO POLISH * COVERS ODD SOCKS
<u>BUILD-ONS</u> ZIP ALL THE WAY ROUND AND REMOVE HEEL * PUT ZIP AT BACK * ZIP ALSO AT OTHER SIDE * CLIPS ALSO IN CASE ZIP BURSTS * SERIES OF ZIPS TO ALLOW WIDE OPENING * RING PULL ON ZIP * PAD UNDER ZIP * FLAP OVER ZIP * DOUBLE ZIP TO AERATE SHOE
<u>CATCHY</u> NO FRONT OPENING * ZIP INSIDE OR OUTSIDE ANKLE * SHOE LACES REDUNDANT * MAN'S RATHER THAN WOMAN'S * ZIP REPLACES LACES * ZIP UP AND KEEP DRY * ZIP IN A SHOE * SHOE WITH NO LACE
<u>DISADVANTAGES</u> MAY NOT FIT ALL FEET * NO RELIEF FOR SWOLLEN FEET * ZIP MAY CATCH IN SOCK * ZIP MAY BURST UNDER STRAIN * ZIP DIFFICULT TO REPLACE * ZIP MAY GET STUCK * ZIPS RUST * LESS VENTILATION * WATER LEAKS THROUGH ZIP * MUST REACH TO GROUND TO DO UP
<u>EXTENSION</u> ZIP SAIL TO MAST * ZIP CURTAINS TOGETHER * ZIP UNDERPANTS * ZIP SURGICAL GOWNS * ZIP HAT * DOORS OF PRESSES ZIP SHUT * ZIP DOORS FOR CARS * ABDOMINAL SURGERY - LATERAL INCISION AS NORM * BUS DOOR AT BACK * ZIPS INSTEAD OF BUTTONS FOR ARTHRITICS * BUILT ON GLOVES OR RAINCOATS
<u>ALTERNATIVE MEANS</u> GO BAREFOOT. - NO FASTENINGS * ZIP UP THE FRONT * VELCRO. PUT A DRAWSTRING AROUND THE TOP * USE PRESS-STUDS INSTEAD.
<u>QUESTIONS</u> WHAT KIND OF ZIP WOULD STAND THE STRAIN? A WATERPROOF ZIP? HOW WOULD THE SHOE STAY ON?

These are of course trivial stimuli. Usually they are inferior alternatives to the conventional. They are used because they are virtually knowledge-independent (everyone has prolonged experience of shoes) and they call attention to the thinking process applied and make it manifest. The basic operations of thinking (same as, greater than) are themselves trivial, like those of the computer. What gives them their power is doing them rigorously and completely in optimum succession. A doctor has the same cognitive ability to apply to trivial as to complex stimuli. It should surely cope better with simple than with complex tasks. The stimuli seem to be adequate, since the students cannot all perform to top level in the exercises. In any case there has to be a beginning, and beginnings are generally weak. Better objectives, better exercises and better assessment procedures will emerge with time. Some students at the outset tend to be critical, even dismissive or scornful. But even after several exercises many have difficulty with items C, E and F. It is hard to say whether it arises from the nature of the objects, or from the students' training to date. Perhaps a memorisation training may lead to a critical outlook instead of an appreciative one. At any rate, they do not find the operations trivial to perform.

Examination

The module is assessed by setting examples of the exercises in the examinatin paper and marking as before. It lends itself well to the OSCE format (Lavelle and Harden, 1987). Performance falls a little at the examination. The improvement on thinking exercises is less than that seen in other exercises such as observation or diagnosis. Habits of thinking may be more strongly ingrained, or the exercises less efficacious. This aspect deserves research.

Discussion

It is very important in such training to use a persuasive, non-coercive approach, and a light-hearted style to avoid the exercises becoming a drudgery. The students enjoy and appreciate the module. They consistently rate it the best-liked in their end-of-year assessment of the course. Many find it a heartening change, and claim that they have attained a valuable aid to their thinking. However, a number of obvious questions arise.

1. Can one really develop thinking by teaching?
Some evidence suggests that one can (Crowell 1982; Edwards and Baldauf, 1982). Other aspects of clinical skills improve with study (Gill et al, 1973). Students produce what is demonstrated, sought and rewarded. A teacher may not seek or reward thinking but he cannot avoid demonstrating it - good or bad. Similarly, texts provide a reasoning model even when presenting knowledge. Formal tuition only serves to broaden and strengthen these. Evaluation of the validity of the thinking output may need to be added (McPeck, 1982), but this seems to be automatic in our students.

2. How much do teachers try to develop thinking?
Demonstration, seeking and reward of thinking should perhaps appear frequently in a teacher's interaction with the class. Other things can be addressed instead, such as recall, exercise-of technique, discipline, or even dysfunctional behaviour, as sarcasm or condemnation. Their relative frequencies indicate the degree to which the teacher promotes each. I was able to obtain a few tape-recordings of secondary school teachers conducting classes. Formal demonstration, seeking and rewarding of thinking were rare behaviours. The same may be true of much medical school teaching. The effect of teachers' body-language and expectation were not assessed.

3. How effective are these exercises in promoting thinking?
Thinking about performance can improve it (Jansson, 1982). The exercises are an adjunct to, not a substitute for, traditional medical thought. They are probably no more effective than are the exercises in other courses. How much pharmacology, pathology, haematology is retained six months after the course is completed? But we do not question the efficacy of subjecting the students to them. Some material is retained. Some will crop up continuously in clinical experience. The remainder is familiar to the students and they know where and how to find what they want. The need to think arises fairly often. The students probably continue to employ any technique they find to be of use. Students returning to a 'memorisation-oriented' environment may retain little.

4. Does a general course in thinking improve medical thinking?
This is the significant question. At present we do not know. Nor is it easy to design and organise a proving ground. What is meant by medical thinking? Professionals will reduce as much as possible their stock-in-trade of knowledge to 'rules of thumb' (formulae), which they apply in routine cases. Such 'medical thinking' the student gets in the wards and texts. Doctors feel confident about typical cases (O Beirn et al, 1987). However, roughly one third of cases are atypical (Sterne et al., 1973). Rules of thumb may not suffice for these. The doctors then have to find and put together disparate data from their stored knowledge, to 'think'. They may be more effective in doing so if they have studied the process experientially and are aware of their personal tendencies to deficiency, as in the case of golfers seeking to improve their swing.

5. Should a course in thinking be introduced to the curriculum?
The traditional orientation is to get on with presenting the facts and their immediate import, test them at the examination, and leave the use of them to the cognition of the individual. Should that continue? In the information age, with an observer error rate in medicine exceeding 20%, the public may be less than satisfied Moreover, when there is a problem, and the consequences are deleterious to patients (Adams et al, 1986), there is perhaps a

Hippocratic obligation upon us to institute remedial action. Students seem to appreciate it. It may be that they are entitled to a formal development of their ability to think. Perhaps funding should be released to explore how that may be best done.

Thought-worthy clinical data

Current textbook descriptions of diseases, treatments, and outcomes are often imprecise and unquantitive, using descriptors such as 'common, ususal, rarely', whose interpretation by the individual shows a profound variation (Bryant and Norman, 1980; Toogood, 1980). Scientists use the same associative thinking as other people: but on precise and quantitative data and procedures. For the development of scientific thinking in medicine, it is necessary to provide defined, numericised data to work with. In this regard, there is an interesting initiative of the European Community to realise a test-set of such data.

European initiative on scientific clinical data

The beginning of good thinking lies in accurate and relevant observations. Clinical data is biologically determined. It is likely to be the same from one country to another. It does not change with changing technology. It thus is likely to be a standard to which all subsequent health data can be referred. The EC has set up an initiative to gather accurate and significant biological observations for the diagnosis of two disease presentations (Lavelle, Beneken and Dawids, 1990). One is on jaundice, a mixed medical-surgical, acute-chronic and technologyêconsuming-illness. The other is on acute abdominal pain, an acute surgical condition with low use of technology. An internationally-agreed diagnostic data set is being gathered on a large number of cases of both conditions in some 100 hospitals throughout the EC during the 2 years up to early 1991. The resulting database will be analysed with a variety of statistical and reasoning techniques. It should provide an accurate, quantitated, clinical description of each disease involved.

In the second phase of the trial, in 1991, a diagnostic-aid computer program founded on the database will be tested in many other hospitals. Information can be obtained from the project leaders*. The database will be made available to the centres which participate. If the effort is successful, similar documentation of other presenting symptoms may well follow rapidly. There will be adequate quantitated and significant material for true scientific medical thinking. It may be our task to ensure we have thinking-trained young doctors coming through to utilise it.

* Project-leaders: jaundice: Dr. P. Keeling, Euricterus, University College, Galway, Eire; acute abdominal pain: Dr. FT de Dombal, Clinical information Science Unit, University of Leeds, United Kingdom.

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