

## Articles

# The Relevance of Student Seminars on Clinically Related Subjects in a Biochemistry Course for Medical and Nutrition Students\*

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Marcelo Hermes-Lima<sup>‡§</sup>, Karinne C. Muniz<sup>‡¶</sup>, and Iracema S. Coutinho<sup>‡||</sup>

From the <sup>‡</sup>Oxyradical Research Group, Departamento de Biologia Celular and the <sup>¶</sup>Faculdade de Medicina, Universidade de Brasília, Brasília DF 70910-900, Brazil

The aim of this study was to determine the value of a system of seminars on clinically related biochemistry topics for undergraduate students in medicine and nutrition at the University of Brasília, Brasília, Brazil. During the second semester of 1998 (1998–2), the teaching staff decided to establish new and stricter rules for the seminar method and to adopt a system of peer tutoring, whereby former good to excellent students of the class Bioquímica e Biofísica helped in the planning and preparation of the oral presentations. The average performance grades for the seminars in the first semester of 1998 (1998–1) ( $7.19 \pm 1.42$ ) were significantly lower than those for the following semesters (ranging from 8.10 to 8.91), indicating some degree of success with the new system. We also conducted, by means of questionnaires, an evaluation (scores ranging from 0 to 4) of each student seminar (14 topics) in relation to the overall biochemistry learning experience connected to the clinical expectations of the students. All seminars but one averaged above 3.0. Moreover, when asked whether (i) the seminars were relevant to a more clinical approach to biochemistry and whether (ii) the oral presentations could be viewed as valid tools for the understanding of biochemistry, 96% ( $n = 188$ ) and 80.6% ( $n = 150$ ) of the students, respectively, answered, “yes.” The students also scored the work of the peer tutors high (ranging from 3.38 to 3.90, out of 4). A seminar system for a clinically related biochemistry course may also open the minds of students about the relevance of biochemistry to their future medical or nutritional practices.

**Keywords:** Oral presentations, clinical biochemistry, applied biochemistry, peer tutoring, Brazil.

The teaching of introductory biochemistry to undergraduate medical students, together with undergraduate nutrition students, at the University of Brasília has been carried out since the early 1980s. Biochemistry is currently divided into a theoretical 90-h course (Bioquímica e Biofísica, BioBio)<sup>1</sup> and an experimental 60-h course.

BioBio is taught to 65–80 students by three staff members, each covering separate modules, with separate exams (one written exam per module). The first three modules of BioBio focuses on the properties of water and biomolecules, bioenergetics, and general metabolism and interorgan integration of metabolism, covering 73–80% of the total grade for BioBio (introductory molecular biology is taught as a part of the cell biology course). The fourth module consists of the biochemistry of several clinically related topics (applied biochemistry module), based on oral presentations (given by the students) and short mono-

graphs, 20–40 pages long. There is also an exam for the fourth module (introduced in 1999–1, referring to the 1st teaching semester of 1999) covering the subjects of the oral presentations.

### *Modification of the Seminars toward an Organized Activity*

From 1995–2 to 1998–1, several specific topics of clinical biochemistry were taught through seminars by groups of three to six students of BioBio. The organization of the seminars was based on an oral presentation by each member of the group, plus a monograph. Even though it was a good idea to try to make biochemistry more interesting to medical and nutrition students by means of seminars on clinically related topics, most students were not satisfied by the quality of the oral presentations and by various subjects chosen by the staff. The major complaint (both from staff and students) was the overall lack of organization of the seminars. In many cases, the seminars were too long, including as many as 2 h of tedious discourse.

In 1998–1 BioBio was moved to the 1st semester. That created a major concern that the quality of seminars was going to be even more jeopardized, because they would be presented by freshman students. These students come directly from secondary education, with no prior college-

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§ To whom correspondence should be addressed. Tel.: 55-61-307-2192; Fax: 55-61-273-4608; E-mail: hermes@unb.br.

¶ Present address: Departamento de Ecologia, Universidade de Brasília, Brasília DF 70910-900, Brazil.

<sup>1</sup> The abbreviations used are: BioBio, Bioquímica e Biofísica; ADV, adequacy value.

like education (even though selection for medicine and nutrition involves a rigorous process that rejects over 95–98% of the applicants). Thus, before the start of 1998–2, the instructors of BioBio decided that relevant changes had to be made if the student seminar system was going to be continued. Strict rules were adopted to improve the organization of the seminars.

First, the groups had to be composed of either four or five students (groups of two, three, or six were no longer allowed). For the presentations of the seminars, each member of a group was given an average of 10–15 min to present, 1 h being the maximum time for the whole presentation (questions could be posed during the presentation by the students attending the seminar or by the instructors). Moreover, each student would have to speak at least 50% of their time about the biochemistry involved in the subtopic they were presenting.

Second, the % value of the seminars in relation to the overall grade of BioBio was substantially increased from 5% (oral presentation + monograph = 10%) in 1998–1 to 8–10% in the following semesters (see Table I). There is an individual-based evaluation of the seminars (adopted in 1998–1) based on the weight of three elements totaling 10 points, quality of the contents of the presentation (5 points), lecturing quality (3 to 3.5 points), and didactic quality of the slides (1.5 to 2 points).

Moreover, the final grade of the student for the oral presentation was not dependent only on his/her own performance. The overall performance of the presentation of the group also greatly influenced the score of each student. For example, if a student received 9.0 points (90% of what was expected for his presentation) and the seminar received an overall grade of 8.0, then the final grade of the student was 7.2 ( $8.0 \times 90\% = 7.2$ ). This kind of evaluation was implemented in 1999–1 to improve the teamwork ability of the groups.

Third, by 1999–1 the number of seminars was reduced from 14 to 10. Because not all students (from classes of 65–80) were fit for oral presentations (or were not willing to participate), only 40–50 students were granted participation in the seminars. The students excluded from the seminars still had to prepare a monograph (individually or in groups of two to five) about other clinical/biochemical topics chosen by the staff. To participate in the oral groups, the students had to volunteer.

Fourth, by 1999–1, the selection of the students for seminars was carried out by means of an exam-like questionnaire inquiring about (i) skills for oral presentations and capacity for teamwork, (ii) the ability to use the Internet for English-written literature searches, and (iii) the ability to prepare a one-page item-by-item prospectus of what was to be presented orally. It is interesting how much the students really argued for participation in seminars and the presentation of a specific subject, diabetes and obesity being among the more popular subjects.

Fifth, by 1998–2, a system of peer tutoring was remodeled to give specific support to the seminars. Peer tutoring is a process used in many schools of medicine and biosciences and has been shown to be effective in improving learning [1, 2]. The tutors of the course were usually good/excellent former students of BioBio and (since 1999–1)

also had to have attended a 60-h course of advanced biochemistry (*Tópicos em Bioquímica 1*) taught by Dr. Hermes-Lima. Approximately 20% of the time of the advanced course was dedicated to general discussions about the seminars of BioBio and new strategies/contents for the presentations. The instructor stimulated the peer tutors to accommodate themselves within an appropriate profile, very similar to the profile presented by Rangachari and Crankshaw [3].

The number of tutors per semester increased from seven in 1998–2 (one tutor supervising two seminars) to 14 in 2000–1 (one or two tutors supervising each seminar). Because of the popularity of the advanced course of biochemistry and the peer tutor system of BioBio, 22 students worked in 2000–2. In that specific semester we noticed that some of the tutors did not have an appropriate profile for the job. Thus, from then on we decided to set a maximum of 15 tutors per semester and interview the candidates for tutoring (over 20 candidates applied in 2001–1).

The tutors also aided the staff with the correction of the monographs and helped in the evaluation of each oral presentation. The peer tutors, since 1999–1, were also responsible for the preparation and grading (with the supervision of the staff) of the written exam for the fourth module. This exam consisted of 50 straight questions about key items presented in the seminars. The tutors also had a specific E-mail address so that simple questions from the students could be answered within 24 to 48 h, and literature lists could be interchanged among students and tutors.

Before 1998–2, peer tutoring was used for BioBio, but the tutors were responsible for helping the students with overall questions/problems, not only related to the seminars. Their involvement with the seminars was negligible.

#### *Clinical Biochemistry Subjects Covered in Oral Presentations*

Table I shows which seminars were offered to the students of BioBio since 1998–1, as well as the grades for each seminar. When the 10-subject seminar practice was adopted in 1999–1, we decided to retain only the seminars with clear clinical connections. The contents required for each main seminar are depicted in Table II. All seminars contained specific subjects of biochemistry with clinical correlation. This is important not only for the medical students but also for the nutrition students who are going to specialize in either clinical nutrition or dietetics. In the case of diabetes, this subject is not only offered to the students as a seminar but is also covered during the 2nd and 3rd modules [4].

Table I shows that the average grade performances from 1998–2 to 2000–2 (ranging from 8.10 to 8.91) were significantly higher (as a group of results) from those of 1998–1 ( $7.19 \pm 1.42$ ;  $n = 13$ ; the grade for the seminar on free radicals was not considered) ( $p < 0.05$ , post-analysis of variance Scheffé's multiple contrasts test). In addition, five to six performance grades equal to or greater than 9.0 were awarded in semesters 1998–2, 1999–1, and 2000–1, and only two scores above 9.0 were awarded in 1998–1. Moreover, five performance grades below 7.0 (the seminar

TABLE I  
List of seminars (1998–2000), their grades, and their average adequacy values (average-ADV)

\*, significantly different from the average of grades from 1998–2 to 2000–2 (as a group of results),  $p < 0.05$  (post-ANOVA Scheffé's multiple contrasts test).

Semesters (% value of the oral presentations) <sup>a</sup>	98–1 (5.0)	98–2 (8.3)	99–1 (10)	99–2 (9.0)	00–1 (8.0)	00–2 (8.0)		
Main seminars	Grades for the seminars <sup>b</sup>						Mean	Average-ADV <sup>c</sup>
Diabetes	9.6	9.6	8.6	9.5	8.1	7.3	8.78	3.81 ± 0.44 (188)
PKU and galactosemia	6.3	9.1	10	6.9	9.4	7.8	8.25	3.19 ± 0.78 (188)
Cholesterol metabolism	8.5	7.3	9.9	8.3	9.0	8.3	8.55	3.72 ± 0.52 (188)
Corticoids	6.6	9.5	9.7	8.2	8.5	8.5	8.50	3.43 ± 0.57 (187)
Obesity	7.6	9.2	8.4	8.6	8.7	8.4	8.48	3.75 ± 0.54 (188)
Free radicals	0.0 <sup>d</sup>	7.4	9.8	7.1	5.6	8.1	7.60	3.50 ± 0.73 (187)
Iron metabolism	9.5	7.1	7.4	8.3	9.7 <sup>e</sup>	8.5 <sup>e</sup>	8.42	3.28 ± 0.93 (188) <sup>e</sup>
Heme metabolism	7.2	9.0	8.5	8.8			8.38	2.86 ± 0.86 (119)
Ethanol metabolism	5.7	8.2	7.8	6.6	6.2		6.90	3.30 ± 0.71 (151)
Biochemistry of vision				8.7	9.2	9.4	9.10	3.06 ± 0.94 (95)
Blood coagulation	7.3	8.5	9.0				8.27	3.24 ± 0.72 (93)
Neurotransmitters						8.5	8.50	3.60 ± 0.60 (36)
Muscle contraction		8.5			9.3		8.90	3.32 ± 0.81 (34) <sup>f</sup>
Micronutrients	7.2					6.7	6.95	3.04 ± 0.95 (36) <sup>g</sup>
Other seminars <sup>h</sup>								
Purines and pyrimidines	6.5							
Malnutrition	7.0							
Phospholipids	4.5							
Pyruvate dehydrogenase		8.1						
Synthesis of ATP		7.8						
Signal transduction		9.7						
Average of the grades (and S.D. values)	7.19* 1.42	8.50 0.88	8.91 0.92	8.10 0.93	8.37 1.37	8.15 0.74		

<sup>a</sup> The monographs have the same % value as the seminars.

<sup>b</sup> The performance grades shown are the average of the scores of each member of a group. For example, the 7.3 grade for the diabetes seminar in 2000–2 was the average of five scores (from five students) ranging from 7.1 to 8.5.

<sup>c</sup> Average ADV was shown as mean ± S.D.;  $n$  values per each semester ranged 25–36.

<sup>d</sup> This score was because of severe problems within the group and thus was not considered for statistical calculations.

<sup>e</sup> By 2000–1 the seminar on iron metabolism (FE) was merged with heme metabolism (HE), being renamed "Iron and heme metabolism." Moreover, the average-ADV of the seminar FE before the merger with HE was  $3.23 \pm 0.76$  ( $n = 118$ ).

<sup>f</sup> ADV of 2000–1 (1998–2 ADV,  $3.15 \pm 0.88$ ;  $n = 34$ ).

<sup>g</sup> ADV of 2000–2 (1998–1 ADV,  $3.15 \pm 0.97$ ;  $n = 26$ ).

<sup>h</sup> From 1999–1 to 2000–2, several of the seminars (listed above, plus sickle anemia) were presented only as written monographs.

on free radicals was not considered for 1998–1) were conferred in 1998–1. In the following semesters, zero to two grades below 7.0 were conferred (Table I).

Overall, it is clear that the seminars improved in the semesters following 1998–1. When observing the quality of the graphics and general organization of the presentations (not considering just content quality), the semester of 2000–2 was the best of all; that was the general feeling of the students, tutors, and staff. The seminar system of 2001–1 was also highly organized, with good/excellent performance grades for nine of 10 seminars, averaging  $8.66 \pm 1.28$  (range 5.9 to 9.9; data not shown).

#### The Evaluation of the Seminar System by the Students

*The Assessment of the Adequacy of the Subjects for Oral Presentation*—We were also interested to know the opinion of the students about the usefulness of the oral presentations, the adequacy of each seminar subject, and the role of the peer tutors in the whole process. On the last day of class, questionnaires were distributed among the students inquiring about the subjects. Each questionnaire was answered by two students, *i.e.* one questionnaire per two students makes  $n = 1$ .

First, we asked the students to give an adequacy value

(ADV; from 0 to 4) for each seminar in relation to their overall biochemistry learning connected to clinically related expectations. The students were asked to mark the adequacy value independently of the quality of each oral presentation they attended. Table I shows the average of the adequacy values (average ADV) when grouping together all the semesters of observation. All seminars, except heme metabolism, averaged above 3.0 (75% of the maximal ADV). Moreover, four seminars had superior evaluations, with average values equal to or greater than 90% of the maximal ADV.

A relevant fact is that the mean of the performance grades per seminar ( $n = 14$ ) did not correlate whatsoever with the average ADV of the main seminars ( $r = 0.227$ , not significant). For example, biochemistry of vision scored modestly in average ADV (3.06) and excellently in mean performance grade (9.10). This analysis clearly indicates that the students were not marking ADV values based on the quality of the presentations.

*The Usefulness of the Seminars, Oral Presentations, and Peer Tutoring*—Two other questions were posed to the students (covering from 1998–1 to 2000–2). We first asked if the seminars (oral presentations + monographs) were relevant to a more clinical approach to biochemistry. Most students responded, "yes" to this question (181 of 188).

TABLE II  
Objectives that should be met by each main seminar

This list includes current and past seminars.

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Diabetes: the basic biochemistry of diabetes type I and II with an integrated view of metabolism; insulin metabolism and insulin resistance; diagnostics; basic pharmacology of diabetes treatment;<sup>a</sup> diabetes versus diets;<sup>b</sup> [Refs. A to E].

PKU and galactosemia: the basic biochemistry behind each form of PKU and galactosemia; prevention and diagnostics (including the well known “foot test”); [Refs. C to E].

Cholesterol metabolism: the metabolism of cholesterol and lipoproteins; LDL receptors; molecular basis of atherosclerosis (including LDL oxidation);<sup>a</sup> cholesterol versus diets; [Refs. B to G].

Corticoids: the physiological and biochemical basis of corticoids; the action of corticoids at the DNA level and metabolic consequences; examples of diseases related to endogenous corticoid imbalance; use of corticoids in clinical therapies; comparison with the mode of action of thyroid hormones; [Refs. C to E].

Obesity: the pathophysiology and biochemistry of obesity (with a link between fat and sugar metabolism); bioenergetics versus obesity; the role of leptin and UCPs; treatment and prevention of obesity;<sup>a</sup> diabetes and obesity;<sup>a</sup> genetics of obesity; [Refs. A to C and H].

Free radicals: what they are and how they are formed; cellular targets of free radical attack; endogenous, dietary, and artificial antioxidants; human disorders related to oxidative stress;<sup>a</sup> aging and oxidative stress; [Refs. B, F, and I].

Heme metabolism: heme biosynthesis and regulation; heme catabolism and bile; acute intermittent porphyria and porphyria cutanea tarda (with etiology and treatment);<sup>a</sup> free radicals and porphyria; [Refs. C to E and J].

Iron metabolism: iron as a nutrient; iron absorption; ferritin, transferrin, and transferrin receptor; regulation of iron metabolism; diseases of iron metabolism; free radicals and iron; [Refs. C to F, I, and K].

Ethanol metabolism: ethanol metabolism in humans and yeast; role of P450 in ethanol detoxification; pathophysiology of ethanol-induced liver damage;<sup>a</sup> alcoholism; [Refs. C to E and L].

Biochemistry of vision: introductory anatomical physiology of the eye; basic biochemical/physiological mechanism of vision; rhodopsin and retinal; G proteins and signal transduction; vitamin A and/or  $\beta$ -carotene deficiency;<sup>a</sup> color vision; [Refs. C and E].

Blood coagulation: blood coagulation factors and their protein-protein interactions; intrinsic and extrinsic pathways; vitamin K; disorders of blood coagulation (and<sup>a</sup> treatments); [Refs. D and E].

Neurotransmitters (NT): types of NT; synthesis, release, re-uptake and degradation of NT; drugs that alter the metabolism of NT; the structural similarity between NT and psychoactive drugs; [Refs. D and M].

Muscle contraction: the organization of actin-myosin filaments; biochemistry of skeletal muscle contraction; muscle relaxation versus calcium transport; heart and smooth muscles; human muscle disorders; [Refs. D, E, and N].

Micronutrients: vitamins D and the “complex B;” phosphorus and calcium; their biochemistry and relation to the integrated metabolism and human nutrition; [Refs. C, E, and K].

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<sup>a</sup> Non-obligatory subtopics.

<sup>b</sup> Suggested references: A, American Diabetes Association; www.diabetes.org. B, American Heart Association; americanheart.org. C, New York Online Access to Health; www.noah-health.org. D, Dr. Michael King’s site; web.indstate.edu/thcme/mwking. E, T.M. Devlin, Ed. (1997) Textbook of Biochemistry with Clinical Correlations, 4th Ed., Wiley-Liss. F, B. Halliwell, J. M. C. Gutteridge, (1999) Free Radicals in Biology and Medicine, 3rd Ed., Oxford University Press. G, P. O. Kwiterovich, Jr. (2000) The Metabolic Pathways of High Density Lipoprotein, Low Density Lipoprotein, and Triglycerides: a Current Review (2000) *Am. J. Cardiol.* **86**, 5L-10L. H, E. Jéquier, L. Tappy (1999) Regulation of body weight in humans, *Physiol. Rev.* **79**, 451–480; Obesity (special issue with five reviews) (2000) *Nature* **404**, 631–677. I, P. T. Lieu, *et al.* (2001) The roles of iron in health and disease (2001) *Mol. Aspects Med.* **22**, 1–87. J, P. Ponka (1999) Cell biology of heme, *Am. J. Med. Sci.* **318**, 241–256. K, M. E. Shiels, *et al.* Eds. (1999) Modern Nutrition in Health and Disease, 9th Ed., Lippincott, Williams, and Wilkins. L, C. S. Lieber (2000) Alcohol: its metabolism and interaction with nutrients, *Annu. Rev. Nutr.* **20**, 395–430. M, J. G. Hardman, L. E. Limbird, Eds. (1996) Goodman & Gilman’s The Pharmacological Basis of Therapeutics, 9th Ed., McGraw-Hill; R. J. Reimer, *et al.* (2001) The essence of excitation, *Curr. Opin. Cell Biol.* **13**, 417–421. N, Mercier, *et al.* (1999) Muscle plasticity and metabolism: effects of exercise and chronic diseases, *Mol. Aspects Med.* **20**, 319–373; A. M. Gordon, *et al.* (2000) Regulation of contraction in striated muscle, *Physiol. Rev.* **80**, 853–924.

Among the students who provided written comments ( $n = 53$ ), 42% thought that the seminars, “interconnect basic biochemistry with clinical applications,” and 13% believed that the seminars, “give a more clinical view of the theory.” Among the suggestions for new subjects ( $n = 71$ ), biochemistry of cancer was the choice of 17%, followed by mechanisms of drug action (choice of 10%).

Based on a second question, we observed that 80.6% of the students (150 out 186) found the oral presentations a valid tool for the learning process of biochemistry. Among the students who approved of the oral presentations and provided written comments ( $n = 122$ ), 25.4, 23.8, and 16.4% pointed out, respectively, that the seminars, “are a training for future presentations in public,” “stimulate learning and/or research,” and “make learning more dynamic.” Indeed, the seminars may contribute to the improvement of communication skills of the students, which is so important for most clinical careers [5].

Among the students who disapproved of the oral presentations and provided written comments ( $n = 41$ ), 61% pointed out, “the lack of didactics (by the students) and/or the lack preparation by freshman students.” In addition, 24.4% wrote that, “the students attending the seminar do

not understand what was presented orally and/or that a specialist should be the one presenting the seminars.” The idea of bringing in specialists to give 60-min talks (about their own scientific work) has been applied a few times, once a semester (to either students of BioBio or to the tutors attending advanced biochemistry), with reasonably positive response from the students.

One problem that was discussed among the tutors and teachers is the necessity to make the oral presentations essentially different from the regular lectures. Moreover, there was a need to improve the participation of students attending the presentations, making their attitude less passive. As pointed out by Feldberg [6], as in the case of staff lectures, only a small number of students actively participate by posing questions to their classmates presenting the seminar.

Finally, by 1999–1 the students were asked to evaluate the quality/relevance of the work carried out by the peer tutors (in this case, each student evaluated the tutor(s) supervising their own seminar). From 1999–1 to 2000–2 the average score (0 to 4 scores) of the tutors ranged between 3.38 and 3.90 ( $n = 34$ –49).

### Concluding Remarks

The choice of the main lectures/seminars of BioBio, as well as the depth in which they are covered, is based on the notion supported by the General Medical Council (United Kingdom) that the teaching of biochemistry is much more formative than merely informative [5, 7, 8]. The major purpose of BioBio is to be part of the training of future physicians and nutritionists and not professional biochemists. With so much to cover and a limited availability of time [9], the instructor has to be creative in selecting key basic subjects for both lectures and seminars. Moreover, the staff tries to make the students understand the relevance of biochemistry to their future medical or nutrition practice. Thus, the seminars on clinically relevant subjects have the objective of being not just alternative learning tools of biochemistry.

The results presented in this paper indicate that the presentation of seminars of clinically related biochemical subjects (applied biochemistry) is a methodology accepted by the students of BioBio. They validated the usefulness of oral presentations and their clinical/applied relevance. The students also found most of the subjects appropriate for their basic learning of biochemistry, with a feel for clinical uses (see Table I). Heme metabolism was a topic poorly accepted by the students ( $ADV < 3.0$ ) and was thus removed as an independent subject for seminars. Possibly, the modifications initiated in 1998–2 (greater organization and the use of peer tutoring) yielded results that were significantly different from the previous semester (1998–1).

Moreover, the students found the work of the peer tutors to be relevant, scoring them with high marks. The idea of at least one tutor per group (started in 1999–1) and the preparatory discussions with the tutors during the ad-

vanced biochemistry classes might have been important for the general improvement of the seminar system.

It is also important to point out that during each semester (since 1998–2) one of the peer tutors, the chief tutor, was responsible for running the administration of the seminar system. Usually, the chief tutor was a student performing tutoring work for the second time. Without the work of the chief tutor, the staff (and the regular tutors) would be spending too much time/energy dealing with the day-to-day problems of the seminar system.

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### REFERENCES

- [1] M. Carroll (1996) Peer tutoring: can medical students teach biochemistry? *Biochem. Educ.* **24**, 13–15.
- [2] D. A. Lake (1999) Peer tutoring improves students performance in an advanced physiology course, *Adv. Physiol. Educ.* **21**, S86–S92.
- [3] P. K. Rangachari, D. J. Crankshaw (1996) Beyond facilitation: the active tutor in a problem-based course, *Biochem. Educ.* **24**, 192–195.
- [4] P. N. Campbell (1995) Some thoughts on problem-based learning, *Biochem. Educ.* **23**, 202–204.
- [5] R. G. Dennick, K. Exley (1997) Tomorrow's doctors today: innovations in medical teaching and learning – responding to the challenge of tomorrow's doctors, *Biochem. Educ.* **25**, 6–11.
- [6] R. S. Feldberg (1999) Increasing student involvement in lectures: (very) low tech innovations in a biochemistry lecture class, *Biochem. Educ.* **27**, 71–73.
- [7] R. D. Cohen (1996) How much biochemistry should a medical student be taught? The viewpoint of the General Medical Council, *Biochem. Educ.* **24**, 80–82.
- [8] J. E. Wood (1996) How much biochemistry should a good doctor know? A biochemist's viewpoint, *Biochem. Educ.* **24**, 82–85.
- [9] R. Boyer (2000) The new biochemistry: blending the traditional with the other, *Biochem. Mol. Biol. Educ.* **28**, 292–296.