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European Medicinal Chemistry Education: The Transformational Accomplishments and Challenges

Gloria Cristalli,^[e] Péter Mátyus,^[b] Peter Mohr,^[c] Giuseppe Ronsisvalle,^[d] Noel J. de Souza,^{*,[a]} and Anna Tsantili-Kakoulidou^[f]

Medicinal chemistry education and training was the subject of a half-day round table discussion, initiated by D. Kikelj and P. Mátyus, and organised by the latter, which took place on the occasion of the 5th Austrian–German–Hungarian–Italian–Polish–Slovenian Joint Meeting on Medicinal Chemistry, organised by the Slovenian pharmaceutical society under the auspices of the European Federation for Medicinal Chemistry (EFMC), at Portorož, Slovenia (June 17–21, 2007). The participants were Péter Mátyus^[1] (Chairman and Semmelweis University, Budapest, Hungary), Anna Tsantili-Kakoulidou^[2] (University of Athens, Greece), Gloria Cristalli^[3] (University of Camerino, Italy), Giuseppe Ronsisvalle^[4] (University of Catania, Italy), Noel de Souza^[5] (University Institute of Chemical Technology, Mumbai, India) and Peter Mohr^[6] (F. Hoffmann–La Roche, Basel, Switzerland), as

well as those participants in the audience who made a significant contribution to complete the round table discussion. This discussion has followed in quick succession its two similar predecessors, the first at a satellite meeting of the 15th Camerino–Noordwijkerhout conference in Noordwijkerhout, The Netherlands on May 20, 2005, and the second at a session on the occasion of the EFMC-sponsored XIXth international symposium on medicinal chemistry (August 30, 2006) at Istanbul, Turkey. Moreover, it is the first round table discussion organised by the Education and Training Committee (ETC) of EFMC since its formal establishment.

These multisequential thrusts to grapple with the fundamentals of medicinal chemistry education and training in Europe come at a time when the Bologna process, addressing European higher education and research in response to challenges in a globalised world, is gathering momentum to vault itself as it approaches the 10th anniversary of completing its first set of harmonised European supremacy-centred objectives in 2010.^[7,8]

Fuelled by several national discussions on the future of medicinal chemistry teaching and training in Europe,^[9] by the EUA creativity project 2006–2007,^[10] by doctoral programme discussions in Europe,^[11] and by deliberations on challenges facing EU research and universities at the Hampton Court summit 2005,^[12] this 2006-installed EFMC ETC-sponsored round table in Slovenia focused on going beyond increased diametrical teaching and training to expanding circumferential career development, through presentations on:

- the educational infrastructure under reconstruction

- the evolving transdisciplinary nature of medicinal chemistry
- the role of summer schools^[3,6,13–15] and industry-sponsored symposia^[6]
- university–industry relationships and globalisation networks^[5,6] &
- the need for a new definition of medicinal chemistry.^[9]

All of these themes have essentially been eruditely addressed in the seminal policy overview published following the Noordwijkerhout meeting in 2005 and entitled “Medicinal Chemistry Education: What Is Needed and Where Is It Going?”^[16] In the abstract of this publication, it is summarised that “organic chemistry remains at the heart of the discipline, but structure–property relationships are now an increasingly important component”, that “the linkage between chemistry and biology is more important with the rise of chemical biology”, that “relationships between industry and the university have become more important in recent years”, and that the “strong dominance of the Western world in science for the past two centuries is likely to be diminished in the next several decades.”

At this Slovenia meeting, there has been reaffirmation of virtually all of the fundamental concepts that were spelled out at Noordwijkerhout and at Istanbul. It has also become clear that, at many levels, European medicinal chemistry education has undergone good overall progress in the intervening two years since the publication. In conveying below the progress, this report aims to avoid repetition of the previously published fundamentals, to take the previous publication as required prior reading, and rather to serve as complementary to the previous publication.^[16]

[a] Prof. N. J. de Souza
Department of Pharmaceutical Sciences & Technology
University of Chemical Technology
Matunga, Mumbai 400 019 (India)
Fax: (+91)22-2648-0104
E-mail: noel.desouza@vsnl.com

[b] Prof. P. Mátyus
Chairman, Committee for Education & Training, EFMC
Director, Department of Organic Chemistry
Semmelweis University, Budapest (Hungary)

[c] Dr. P. Mohr
Discovery Chemistry
F. Hoffmann–La Roche, Basel (Switzerland)

[d] Prof. G. Ronsisvalle
Department of Pharmaceutical Chemistry
University of Catania (Italy)

[e] Prof. G. Cristalli
Director, European School of Medicinal Chemistry
Department of Medicinal Chemistry
University of Camerino (Italy)

[f] Prof. A. Tsantili-Kakoulidou
Department of Pharmaceutical Chemistry
School of Pharmacy
University of Athens (Greece)

Current EFMC initiatives include:

- generation of a compendium on existing undergraduate and postgraduate level training courses within Europe to enable analysis of structure and profile of education and teaching
- creating a network of Ph.D. schools in medicinal chemistry in Europe to facilitate database formation, mobility of faculty/students, joint teaching courses, and answering the question of a European diploma
- conducting sessions on a regular basis in selected EFMC-sponsored symposia
- making connections to other organisations for example, EUFEPS, IUPAC (Chairman Mátyus, Hungary)^[1]

At the university and higher education institution (HEI) levels, progress is made on:

- introduction of an uniform three-cycle degree (Bachelor, Master, Doctorate) system at several national and institutional levels, for example, the ETH M.Sc. in medicinal chemistry programme
- increasing the number of structured doctoral programmes including labour market-oriented and study-oriented multidisciplinary curricula in syllabi for employability enhancement and career development inside and outside academia (the professional doctorate vis-à-vis the industrial doctorate)
- a focus on creativity as an essential factor to respond to demands of the current knowledge society, and to be a major force in shaping social and economic development
- understanding their role as the “intellectual commons” to strike a balance in fulfilling “their fundamental mission of a gift economy”, while encompassing a “commodity economy” (cf. David Triggler^[17])
- interuniversity international agreements including the award of a joint doctorate
- industry–university collaboration. For instance, for the “Roche symposium

for leading scientists of the next decade^[6] twenty outstanding young talents, most of them in the last year of their Ph.D. thesis work are invited to attend the Symposium.

Today's students, whether graduate or doctorate, opting to become medicinal chemists:

- can originate from the different undergraduate streams of pharmacy, pharmaceutical sciences, or chemistry
- are apprised of the unique role they play in the multidisciplinary process of drug discovery and development, requiring R&D project management to create newer chemistry-oriented and biotech-oriented intellectual property
- are taught to develop equal fluency in the fundamental skills and language of both medicinal chemistry and biology required of drug discoverers cum developers
- have the opportunity to move away from teacher-driven provision towards student-centred higher education and to shape it through more active engagement in the Bologna process activities^[18]
- are offered participation at different summer schools and interdisciplinary courses,^[6,13–15] constructed around lectures and practical workshops, with invitations to present posters and oral communications illustrating their research studies.

The need for a new definition of medicinal chemistry^[9]

This theme was raised by different speakers and was the subject of keen discussion by the audience at the round table. Is a new definition of medicinal chemistry needed or is it that the name “medicinal chemistry” has to be changed and newly defined. Is there really a need for a name change? A rose by any other name smells as sweet, it is said. Different recent publications^[19,20] and forums, for instance at the above-mentioned meetings at Noordwijkerhout and Istanbul,

have already been engaged with “working” definitions, whether official or proposed. The publication “Medicinal Chemistry Education: What Is Needed and Where Is It Going?”^[16] commences with the International Union of Pure and Applied Chemistry's 1998 definition, goes on to astutely analyse the complex multidisciplinary issues involved, and concludes that “...medicinal chemistry is all about drug discovery..., and...facilitates establishment of educational structures that provide the opportunity for a medicinal chemist to move increasingly in the direction of becoming a successful drug discoverer or of making substantive contributions to the process.” At the Istanbul and Slovenia forums, proposed definitions ranged from being artistically concise such as that of Timmers: “the architecture and construction of drug properties in molecules”^[21] to those more consolidated ones on the “new face” of a modern medicinal chemist as a drug designer/discoverer by Cristalli,^[3] Tsantili-Kakoulidou,^[2] and de Souza.^[5] In relation to this point, Ronsisvalle^[4] expressed the view of “the time being mature for a degree in drug discovery: One main course with several different specialisations and a multidisciplinary training...”.

Newer disciplinary developments are germane to the discussion and add grist to the mill of the debate. Increasing successes are being totted up by the new science of synthetic biology, which enables synthetic biologists to take differently sourced enzymes and turn out “things like drugs and precursor molecules for plastics more efficiently than traditional chemists can”.^[22] In the newsletter EFMC MedChemWatch, 2007,^[23,24] the readers' attention is drawn to two items which signify new trends in how medicinal chemistry is viewed. For example, in pain management in clinical settings, the link to medicinal chemistry is stated to be attenuated through invoking the beneficial consequence of the up-stream modulatory role of the cognitive factors of perception and emotion over the ligand–receptor interaction at the end of the chain.^[23] As another example, in the strategic research agenda for the Innovative Medicines Initiative of the coordinated European Commission

and European Federation of Pharmaceutical Industries and Associations, which includes education and training in its "roadmap" to address key "bottlenecks" in the biomedical R&D process, what is emphasised is not medicinal chemistry, but predictive safety and efficacy, and knowledge management.^[24]

Conclusions

Overall, the most important effect of this roundtable discussion of European medicinal chemistry education is that it provides newer perspectives from speakers and a participating audience mainly from European countries not previously present at the earlier forums. This report highlights the accomplishments and the progress that is being made at different levels, whether in the accent placed on shaping education policies, or in the manner universities and HEIs are reorganising syllabi, or in the flexibility with which the student of medicinal chemistry may orient his training for a future in academia/industry, or in the industry interactions with the teaching/student community. Such a forum permits the expression of newer concepts or practices being put into effect and enables a choice to be made of best practices. Future forums of this nature need to consider that the panel of speakers also includes graduate student and junior industry scientist representatives, and that the session is fitted into, not as is usually done, at the fag end of a day shortly before the symposium banquet, but at a time when a larger audience is more likely to be attracted.

Whether or not an overarching new discipline such as drug discovery will arise to embrace the well-established subdiscipline of medicinal chemistry (which includes computational chemistry/drug design, synthetic/combinatorial chemistry, other chemistries, intellectual property, project management) and the yet-to-be-coined or -defined subdiscipline of "medicinal biology" (which can be postulated to include cellular therapeutics,^[25–27] genomics, all the new relevant "omics", synthetic biology, pharmacology, ADMET-related disciplines) will

depend on scholarly rather than polemical handling of the debate. The theme is clearly one of the transformational challenges that will form part of EFMC's bid to keep European education and training exquisitely attractive to students and faculty, as well as to be competitively supreme among the developed nations and the emerging intellectual property-oriented globalised countries.^[5] No matter how this debate unfolds under the influence of forces that may be Newtonian, Lamarckian, or Darwinian, European medicinal chemistry education is headed towards an exciting period.

In his concluding remarks, chairman Péter Mátyus emphasised the importance of such regular periodic forums, to continuous adjustment of curricula to the new challenges, and most importantly that the principal goal of medicinal chemistry (and medicinal chemists) should always be to get better drugs, to cure diseases, and/or (at least) to improve the quality of life of patients. Somehow the last-mentioned and very important ethical aspect often—if not always—disappears from all definitions of medicinal chemistry.

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