for observation.

- 3) The system or some of its properties are not observable by experimental techniques:

In solution, structural investigations by X-ray or neutron diffraction methods are very restricted by the size of the solute, and by the stability of the structures involved against the influence of the experimental conditions itself. Therefore, most of the biochemically interesting systems are known only in their crystallized structure, which is not necessarily identical to the one in solution under biological conditions. The evaluation of the water and ion distribution around DNA strands by means of Monte Carlo simulation represents an outstanding example, how computational chemistry can expand our knowledge in this field. Even simple *ab initio* computations can be very helpful in such cases. X-Ray diffraction, for example, could

not reveal any associated structures for dimethylformamide, although the liquid state of this substance at room temperature strongly suggests such intermolecular interactions to exist. *Ab initio* calculations have shown that there exists a CHO-hydrogen bonded structure, whose energetic stabilization, however, is apparently too low to withstand the impact of X-rays used in the experiment.

Although there exist not yet so many examples to prove the general applicability of computational chemistry to all fields being investigated experimentally, the present data seem to allow the prediction that computational chemistry will be a tool of chemical research equivalent to the experiment, in the not too distant future, which even might be superior in several cases in its informative and illustrative power.

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Education of Analytical Chemistry in Europe at University Level

A Statistical Evaluation of a Survey Done by the Working Party on Analytical Chemistry (WPAC) of the Federation of European Chemical Societies (FECS) in the period 1983/84

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The FECS is a voluntary association of non profit European chemical societies with the objective to promote cooperation between them in important areas of research, development, standardization and education. In 1984 it had 30 member societies from 25 countries. Several aspects of chemistry are treated in special "Working Parties". One of them, the WPAC being in charge of Analytical Chemistry consists now of 28 societies from 23 countries and has its special activities to establish contacts and to promote research through organization of the broad spectrum conferences "Euroanalysis" (1987, Sept. 7-11, Paris, France, 1990, Vienna, Austria); organization of special conferences; standardization and regulation; activities in the field of education in Analytical Chemistry.

Activities of the WPAC in the field of education

At the Euroanalysis II-conference in 1975 in Budapest the discussion on the education topic has been started in a special session. In 1978 a second-extended-special session on "Education in Analytical Chemistry" was organized within the Euroanalysis III conference in Dublin. The plenary and discussion papers as well as many of the posters exhibited were published in a special issue of *Fresenius' Zeitschrift*.¹ At this occasion and also at the

following special FECEM-conference on Education in Analytical Chemistry in a Changing World (1980, Vienna, Austria) detailed information about the organization and the content of curricula at many European universities has been exchanged and documented. It turned out, however, that the situation in Europe is very

Table 1 List of countries (23 from 25 FECS member countries, 23 WPAC member countries*) (Dec. 31, 1984)

No. of inst.		No. of inst.	
*Austria (A)	4	*Netherlands (Nd)	6
*Belgium (B)	7	*Norway (N)	1
*Bulgaria (BG)	8	*Poland (PL)	9
*Czechoslovakia (CS)	2	*Portugal (P)	1
Cyprus (Y)	—	*Spain (E)	8
*Denmark (DK)	7	*Soviet Union (SU)	2
*Finland (SF)	9	*Sweden (S)	5
*France (F)	6	*Switzerland (CH)	6
*Federal Republic of Germany (D)	42	*Turkey (TR)	2
*Greece (GR)	3	*United Kingdom (UK)	45
*Hungary (H)	7	*Yugoslavia	20
*Ireland (IRE)	6	Total number of answers	229
*Italy (I)	23		

Table 2 Education of analytical chemistry in Europe-1983/84

heterogeneous and the authors felt that an attempt should be made to receive a comparable result by distribution and evaluation of a special questionnaire. This was done in the years 1983/84 and due to the excellent cooperation of the WPAC-members both in the design and the distribution as well as in the final checking of the questionnaires an evaluation of the basis of 229 answers can be presented here. Furthermore a positive contribution to the question of the position of Analytical Chemistry and an ideal model curriculum was published recently.²

Final evaluation of the questionnaire "Education of Analytical Chemistry in Europe" (Dec. 31st, 1984)

Questionnaires have been received from universities or equal institutions of all 23 member countries of the WPAC (Table 1). 229 questionnaires could be evaluated for institutions with a separate chair (or department) of

Analytical Chemistry (Table 2a), without a separate chair (Table 2b) and for all institutions together (Table 2c).

In the left side of the tables the absolute number of evaluated institutions and of those claiming to educate analysts, to provide for postdoctoral education in Analytical Chemistry and to offer a "complete curriculum" in Analytical Chemistry as well as the percentage are given. "Complete AC" refers to the right side of the tables indicating the total teaching hours per branch of AC. Only those universities offering courses in all 6 branches are considered to present a "complete AC curriculum". The figures are much higher for institutions with a separate chair (compare Table 2a and b).

The trend is significant and the following first conclusions can be derived from the data presented in Tables 2a,b and c.

a A comparison of Tables 2a and b shows that the 119 universities with separate chairs of Analytical Chemistry have a much higher average of total (obligatory) teaching hours (632) as compared to the 110 universities without an own AC-chair (367). The relative distribution of the total teaching hours to the six branches (chemical qualitative, chemical quantitative, physical, biochemical analysis, chemometrics and analytical strategies, environmental analysis, life and material-sciences) shows in addition the higher flexibility of universities with own AC chairs towards modern needs. Especially new fields are underrepresented at universities without own AC chairs while classical subjects of chemical analysis are extremely cut back without being replaced.

b Therefore, Analytical Chemistry being a complex "in-between-science" should not be an appendix to other subjects like inorganic, organic or physical chemistry any longer.

c A great diversification has been found even in the curricula of the 119 institutions with separate AC-chairs. This is a healthy sign of a dynamic developing science providing information for many other disciplines.

d Nevertheless the average distribution of the approx. 600 teaching hours for obligatory courses in AC (without diploma thesis) according to Table 2 can be considered as exemplary for today and the near future.

e The subject discussed in the chemical analysis courses at universities with an own chair of AC has already changed to modern fields of AC like extraction chromatography, ion selective electrodes, flow analysis, etc. The total teaching hours will be stable however.

f The importance of physical, biochemical and environmental analysis as well as chemometrics will further increase.

g More detailed results of this investigation will be published in a WPAC booklet (contact the Secretary, R. K.).

References

1. *Fresenius' Z. Anal. Chem.*, **297**, 241-340 (1979).
2. R. Kellner and H. Malissa, *Fresenius' Z. Anal. Chem.*, **319**, 1 (1984).

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