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Careers in toxicology in Europe – options and requirements

Report of a workshop organized on behalf of the Individual Members of EUROTOX during the EUROTOX Congress 2000 in London (September 17–20, 2000)

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Abstract In view of the lack of information regarding careers for toxicologists in Europe, the Individual Members of EUROTOX organised a workshop on careers in toxicology during the EUROTOX Congress 2000

in London. Toxicologists are mainly employed in academia, regulatory agencies, contract research organisations (CROs) and the chemical and pharmaceutical industries. There are also a few governmental institutes involved with toxicological work other than teaching or regulation. Toxicologists can also work as independent consultants, especially for commercial organisations. The requirements for starting a career in any of the above organisations, the need and the advantages and disadvantages of specialisation, and further career prospects are summarised and briefly discussed. The organisations, and also working as an independent toxicology consultant, offer interesting professional work of relevance to modern-day society. There is currently a shortage of toxicologists not only in the traditional field of risk assessment but also especially in new areas, e.g. toxicogenomics. This shortage may be at least in part due to insufficient training opportunities. Further consideration of career opportunities is planned and will be published in due course.

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Introduction

The last review of the European manpower situation for toxicologists dates back to 1978 (World Health Organisation 1979). Since then the definition of toxicology and the training of toxicologists has changed significantly (Aldridge and Schlatter 1975; Hesse-Callaway and Greim 1996; Ettlín and Hodel 2000). In recent years, some national reviews were published for Germany (Bock et al. 1992; Greim et al. 2000), the Netherlands (Nieuwenhuijs 2000), Switzerland (Rüegg et al. 2000) and Italy (Società di Tossicologia Italiana 2000). In addition, the (American) Society of Toxicology published a survey made in 1996 of the toxicology job market in the USA (Society of Toxicology 1997a) and of

the supply and expertise of toxicologists in the USA (Society of Toxicology 1997b) on its homepage.

With the opening of the European labour market (freedom of exchange of people), the change of research and development procedures (Silverman et al. 1998; Alden et al. 1999) and the rapid growth of new techniques (Andersen 1995; Menzel 1995; Corton et al. 1999; Nuwaysir et al. 1999; Rodi et al. 1999), job opportunities are growing substantially for toxicologists.

However, a number of factors have contributed to some uncertainty as to the number and type of specialists needed in future. Such factors are for example:

- The ongoing wave of mergers and acquisitions in the pharmaceutical and chemical industries and contract businesses
- The shortage of public and private funds affecting in particular academic research, resulting in the closure of institutes in some countries (Greim et al. 2000; Rüegg et al. 2000)

In view of the above situation, the Individual Members of EUROTOX decided at their 1999 business meeting to organise a workshop on career opportunities for toxicologists in Europe. The target population of the workshop was toxicologists in training or in the early stages of their career as well as experienced toxicologists interested in new job opportunities.

The workshop took place during the 38th Congress of the European Societies of Toxicology – EUROTOX 2000 – in London, on September 18, 2000. The panel consisted of the toxicologists who co-author this paper. They represented academia (ED, EN), the consultancy business (CMH, DV), the contract research business (RF), the chemical (WK) and pharmaceutical (RAE, ESH, CE) industries, as well as regulatory agencies (IP, HS).

The objectives of the workshop were to discuss typical modern career paths in academia, government and private business, in particular:

- How to start a career (the choices to be made)
- Career opportunities, future prospects, requirements for the job, “advantages and disadvantages” (including salaries), on-the-job training, etc.
- How to improve the CV as toxicologists (including specialisation)
- The transition from one type of career to another, e.g. from academia to industry, or from industry to government etc.

Methods

To prepare for the workshop the panel members were asked to collect information and data from their sector (academia, consultancy business, contract research business, chemical and pharmaceutical industries, regulatory agencies) in particular relating to the following issues:

- Current job market and future needs for toxicologists in European countries

- Typical training requirements and desired achievement records for a toxicologist for starting a career and for improving the career prospects later on
- Perceived advantages and disadvantages in the particular area, e.g. with regard to freedom of research and publishing, possible interactions with other organisations, job security, salaries, available budget for investment, flexibility of the organisation, etc.
- Typical career prospects

The information presented at the workshop was based on the personal experience of the panel members, which had been supplemented by interviewing colleagues in other countries by telephone or e-mail. As far as time allowed, the information was discussed at the workshop and the participants were asked for additional input. All information was reviewed before publication.

Results and discussion

Current situation (Table 1)

Toxicologists often make use of developments in other scientific areas including epidemiology, human and veterinary medicine, molecular biology, genetics, microbiology, chemistry and biochemistry (Tryphonas et al. 1994; MacGregor et al. 1995; Hesse-Callaway 1996; Hesse-Callaway and Greim 1996; Corton et al. 1999; Bass and Vamvakas 2000; Ettlin and Hodel 2000; Rüegg et al. 2000). The controversy regarding the definition of a toxicologist (Farlee 1979; Hesse-Callaway 1996) makes it difficult to estimate their number. For the purpose of the workshop a toxicologist was defined as an academically trained scientist performing studies – with any of the above tools – and/or evaluating data on adverse effects of chemical or physical agents on biological organisms (Table 1).

In Europe some 7,500 scientists are thought to work at least partly on toxicological issues. Some more detailed figures were recently published for Germany by Greim et al. (2000), for the Netherlands by Nieuwenhuijs (2000), and for Switzerland by Rüegg et al. (2000). These publications, as well as our experience, show that only a fraction (one-quarter?) of the above mentioned 7,500 scientists are really toxicologists in the strict sense, i.e. have an adequate training, are mainly involved in toxicological work, attend mostly toxicological congresses or workshops and publish mainly in toxicological journals. The majority of them are in the *private sector*, especially in the chemical or pharmaceutical industries. There are around 50 major chemical and pharmaceutical companies with toxicology laboratories and about 13 major contract research organisations (CROs) in Europe. The toxicology consultancy business has expanded during the past decade, partly because, for example, companies ask senior toxicologists to retire early or because senior toxicologists are more likely to undergo outplacement and therefore often end up setting up their own business. However, the number of renowned self-employed toxicology consultants is still relatively low (below 100).

There are also no reliable figures for the number of toxicologists working in the *public sector*. In Germany

Table 1 Current number and specialisation of toxicologists in academia, the consultancy business, contract research, industry and regulatory agencies (for details see also text) (CH Switzerland, IRL Ireland, NL the Netherlands, UK United Kingdom)

Current situation	Academia	Consultancy business	Contract research business	Chemical and pharmaceutical industry	Regulatory agencies
How big is the job market now?	Generally small number per department A few (e.g. CH, IRL) to around 100 toxicologists per country (e.g. NL, UK)	Generally one person to very few people per business A few businesses to some dozens per country "Joint ventures" networks	Generally > 10 toxicologists per facility Currently about 13 European facilities Europe-wide estimated total of over 150 toxicologists	In medium-sized companies around 20–40 graduate scientists (> 50% with doctoral degree) Some 50 major chemical/pharmaceutical companies with R&D activities in Europe	A few (e.g. IRL, CH) to some 40 toxicologists (e.g. UK) per regulatory body Generally several agencies per country (for drugs, for chemicals, etc.)
What kind of specialisation do toxicologists have?	Very diverse; often high specialisation, but broad expertise much needed to support regulatory agencies, etc.	Broad experience generally very important. For issues requiring high specialisation, people from academia are often consulted	Mainly classical toxicology expertise: acute to long-term animal studies, pathology, genotoxicity, reproductive toxicity	In vivo study directors, project team members with broad expertise, laboratory scientists (general, investigative, genetic, reproductive and environmental toxicology), pathologists	Many different backgrounds The smaller the unit, the broader the necessary experience of the regulator

alone there are some 23 federal or state offices with an unknown, but most likely very small, number of toxicologists with some interest in toxicology (Greim et al. 2000). Overall, it is estimated that a few hundred full-time toxicologists work in major European national and international regulatory bodies.

Several hundred toxicologists are working in academic institutions, many of them in temporary positions, partly in training, funded for example by research grants. The number of dedicated toxicology institutes is decreasing in some countries such as Germany (Greim et al. 2000) and Switzerland (Rüegg et al. 2000) but there are numerous groups working on toxicological issues in other institutes, e.g. institutes of pharmacology or pharmacy and in academic hospitals, etc.

There are a few governmental institutions with activities in toxicology that do not have teaching responsibilities or where a successful career does not necessarily lead to a teaching position. They may provide advice to regulatory agencies and have service functions (consultancy, monitoring, testing etc.), but not all of them have direct responsibilities for regulation of chemicals and/or drugs.

Future needs (Table 2)

Overall, the demand for toxicologists is expected to grow in all sectors (academia, the private sector and regulatory agencies), although there are some differences among countries. The decreasing training opportunities in some countries (e.g. Germany, Switzerland) will aggravate the shortage of toxicologists. Traditional toxicologists (general in vivo toxicology, pathology, genetic toxicology, reproductive toxicology, clinical toxicology), particularly those with a broad understanding for risk assessment (see for example Jorkasky 1998), will still be very much in demand. There is also an increasing shortage of specialists in the new fields including molecular toxicology and bioinformatics (Table 2).

Requirements for career initiation and progression (Tables 3, 4)

There are considerable differences among countries regarding the background and training of toxicologists: e.g. until recently in Switzerland a relatively large number of toxicologists qualified as MD. Study directors in France are predominantly pharmacists and veterinarians; in Italy they are pharmacologists; in the United Kingdom they are derived from a variety of academic disciplines, and in Switzerland they are mostly veterinarians.

As shown in Table 3, the training requirements and the necessary relevant experience differ significantly among the different sectors (Ettlin and Hodel 2000; Pratt 2000). It is therefore important for young toxicologists

Table 2 Future needs for toxicologists in academia, the consultancy business, contract research, industry and regulatory agencies (for details see also text). (CH Switzerland, GER Germany, NL the Netherlands, SP Spain, GMO genetically modified organisms)

Future situation	Academia	Consultancy business	Contract research business	Chemical and pharmaceutical industry	Regulatory agencies
Future trends: how many toxicologists will be needed?	Growing need in some countries (e.g. SP, NL) Stagnation or decrease in others (CH, GER)	Business seems to be growing	Business is growing At the moment traditional toxicology seems not replaceable by new approaches	Expected to stay at current level or to decrease slightly due to mergers and acquisitions, trend to outsource routine studies	Expected to increase in some agencies because of increasing complexity of regulations
Significant challenges that toxicologists are thought to face over the next 5–10 years?	Increasing dependence on private funds, e.g. those obtained by conducting problem solving studies for the industry	More contacts with regulators with more emphasis on mechanisms and less on phenomena Food and environmental testing become more important Continuing/increasing public concern regarding new approaches (recent examples: GMO, xenotransplantation) and partly hostile attitude towards animal studies Registration/accreditation as toxicologist will become more important New technologies (proteomics, genomics) have to be rapidly introduced Shift from regulatory testing in the industry (to be contracted) to early screening of new chemical/drug candidates and other support for drug discovery			Globalisation of registration process will continue Dealing with public concerns More emphasis on risk assessment
Any anticipated shortage in the future	In countries where training is cut back (CH, GER etc.) a shortage of all types of toxicologists is to be expected as other countries will train hardly enough for their own use				
Shortage of which specialty?	Toxicologists with a broad knowledge in basic toxicological sciences Molecular toxicologists Clinical toxicologists	Toxicologists with a broad toxicology expertise and risk assessment capabilities Scientists with expertise in emerging technologies, including molecular biology and bioinformatics (particularly in industry) Pathologists Toxicologists with in vivo expertise and certification in laboratory animal work Environmental toxicologists; fish, bird etc. toxicology			Particularly toxicologists with broad knowledge Specialists for carcinogenicity, genetic and reproductive toxicity

Table 3 Typical training requirements and achievement record for starting a career as a toxicologist in academia, the consultancy business, contract research, industry and regulatory agencies (for details see text). (*ABT* American Board of Toxicology, *UK* United Kingdom)

Requirement	Academia	Consultancy business	Contract research business	Chemical and pharmaceutical industry	Regulatory agencies
Basic training	MSc, PhD, DVM, MD, DSc, DPharm	Helpful: PhD, DVM, MD (less important in the UK for example)	Strong biological background; national differences (see text)	Strong biological background; PhD, DVM or MD helpful for rapid career progression	Science degree, preferably in a biological subject
Postgraduate training in toxicology	Needed for new academic staff	Increasingly expected (also needed for accreditation or registration as toxicologist)			
Accreditation as toxicologist (<i>ABT</i> , <i>EUROTOX</i> etc.)	Not necessary	Not necessary, but helpful	Some accreditation useful	Might become necessary in a not too distant future	Not necessary
Publications, presentations etc.	Crucial	Helpful to be known and accepted	Helpful, but not required	Not a high priority	
Experience (type, years)	To climb the career ladder, generally many years of experience and proven expertise in at least one specialty needed	Many years of proven and broad experience needed Good network to colleagues, academics etc. is helpful	Some experience of regulatory toxicology an advantage In-depth experience needed for interaction with clients	Some experience, including knowledge of regulatory requirements and drug/chemical development process of advantage For investigative toxicologists, research experience needed	Some experience is an advantage, particularly in industry or in contract research
Other requirements (see also text)	Outstanding abilities to teach and supervise student research Expertise in grant writing and obtaining extramural funds	Enthusiasm Determination Flexibility	Capable of working in teams Management experience of advantage Flexibility		Flexibility

Table 4 Once on the job, what is typically needed for improving market value and career prospects in academia, the consultancy business, contract research, industry and regulatory agencies (for details see text)

Career stage	Academia	Consultancy business	Contract research business	Chemical and pharmaceutical industry	Regulatory agencies
Young toxicologist (after completion of initial specialisation in toxicology, approximately 25–30 years old)	Become a internationally recognised specialist, preferably in an area of high scientific interest	Work with a renown consultant Continuous training to acquire broad overview over toxicology is essential	In addition to becoming a specialist in one area, acquire broad overview over toxicology Understand registration process for chemicals/drugs Create value for the company Show leadership Some marketing and sales training	Understand mechanistic toxicology Become a member of interdisciplinary project teams	Broaden experience with other activities of the organisation
Established toxicologist (after 10 years of experience on the job, approximately 35–40 years old, depends also on position)	Collaboration with national and international working groups/committees etc. Being active in scientific societies	Acquire excellent knowledge of registration process Work in national/ international groups and/or scientific societies	General management training Build personal network Work in national/ international groups and/or scientific societies	Become a member of national/ international committees, e.g. as National Expert to the EC	

collegists to consider their preferences and abilities. However, as shown later, the opportunities to move from one sector to another are considerable.

An education in natural sciences, preferably in biological sciences, is a good basis for starting a career as a toxicologist. Formal postgraduate training in a toxicology-related field is becoming increasingly important (Hesse-Callaway and Greim 1996; Neal 1996; Claude and Guittin 1999; Bass and Vamvakas 2000; Ettlin and Hodel 2000; Pratt 2000). Training on the job (e.g. Froberg 1972), though valuable, is alone generally no longer sufficient. Formal postgraduate training is also a prerequisite for obtaining accreditation in toxicology (Fowler et al. 1994; Chang 1998; Oehme 1998; Savolainen 1998; Tsuda 1998).

Interesting career guides for toxicologists are published by some professional societies: see for example the website homepages of the (American) Society of Toxicology (2001) and of the British Toxicology Society (2001).

Previous experience and a good professional record are prerequisites to becoming an independent consultant. The private sector will also generally prefer experienced toxicologists, unless a company is specifically seeking junior toxicologists as part of succession planning. Because the demand for toxicologists is expected to increase, the job prospects are good. Good knowledge of English (spoken and written) is now essential. A good publication record is *conditio sine qua non* for entry to an academic career, but can also be helpful in the other sectors.

Not surprisingly the requirements for advancement as a toxicologist in the different sectors become more specific and diverse as the career progresses (Table 4). In academia, a toxicologist must be recognised as a leading scientist in at least one area, while a consultant toxicologist must be well known primarily in the private sector. A CRO toxicologist must be particularly good at satisfying his external customers with reliable and timely work and balanced interpretation of results. A high degree of impartiality is essential in all sectors, but is particularly important for regulatory toxicologists. The latter must be particularly able to critically evaluate and interpret complex data and produce a balanced risk assessment.

Job attractiveness (Tables 5, 6)

Depending on the interests and stage of the career of the toxicologist, all five sectors can be of high interest, each with perceived advantages and disadvantages.

Pressure for good performance has increased everywhere, but is particularly severe for private consultants, CROs and in industry. In CROs and in industry evaluation of so-called key performance indicators (e.g. time between request for a study and delivery of the final GLP-audited report) has become a credo, with significant impact on salary rises and bonuses (see also Tables 5, 6).

Table 5 Attractiveness of a job in academia, the consultancy business, contract research, industry and regulatory agencies for a toxicologist (for details see text) (EMEA European Agency for the Evaluation of Medicinal Products)

Job feature	Academia	Consultancy business	Contract research business	Chemical and pharmaceutical industry	Regulatory agencies
Freedom of research, being at the cutting edge of sciences, access to information	Good Limitations of funds, often pay for continuous education at congresses out of own pocket	Everything at own expenses Generally own research not possible Great insight into different issues and how companies handle them	All activities generally very service-oriented	If activity is in the interest of the company: great opportunities including own research Great infrastructure	Generally no own research possible Great insight into different issues and how companies handle them
Freedom to publish	Yes, publish or perish	No, generally study data can only be published at request of client, but historical data and techniques/methods papers can be published	Stimulating work in a multidisciplinary team	Yes; if patent/competitor situation is no problem, but is not a key task	Limited
Relation between routine work and true scientific work	Usually good, if not involved in heavy administrative duties	Generally very varied and interesting tasks Often alone	Generally a lot of routine	Highly scientific (e.g. in investigative toxicology), to a lot of routine (e.g. as study director for regulatory studies)	A lot of routine reading and meetings
External interactions, generally global	Some universities offer sabbaticals Often international co-operation	Interactions are essential for good business Generally a lot of travelling needed	Interactions with senior clients and colleagues in other countries International assignments occur	Interactions with regulators and colleagues in other countries International assignment not infrequent	Interaction with senior industry people and other regulators Possibility to work for example for EMEA etc.
Job security	Low if not in a tenured position Inability to obtain extramural funds might affect job security	Amount of contract work can vary significantly Easy to lose reputation	Amount of contract work can vary significantly Environment quite volatile	Not bad, but environment has become more volatile (mergers, acquisitions, outsourcing)	Generally high Environment generally quite stable
Particular challenges	Working in a scientifically very competitive environment	Output = earnings Not infrequently in a sandwich position between the client's need/expectations and the facts/conclusions or the working capacity	High/increasing pressure on output	Risk/benefit assessment is crucial and often difficult	Risk assessment, management and communication
Other features	Bureaucratic rules of university administration may limit research performance Still regarded as highly prestigious	Own boss, no fixed hours Not easy, particularly at the beginning	Great platform for going into other areas of the private sector	Large companies tend to be quite bureaucratic Some people regard industry positions as second after academic positions	Generally perceived as quite bureaucratic, which may impact negatively on the reputation of regulators Good feeling about doing public service

^a Requires extensive experience in the regulatory field, awareness of national/international policies and developments, as well as ability to communicate risk to politicians and the general public. Regulators provide an interface between public, non-government organisations and industry

Table 6 Financial aspects regarding a job as toxicologist in academia, the consultancy business, contract research, industry and regulatory agencies (for details see text)

Financial aspect	Academia	Consultancy business (net earnings before tax)	Contract research business	Chemical and pharmaceutical industry	Regulatory agencies
Investment budget for up-to-date equipment	Requires new funds (intensive grant writing and justification needed)	Out of own pocket	If activity supports company objectives, no problem		Generally none
Starting salaries after completion of initial specialisation (approximately 25–30 years old)	20–40,000 euro in Western countries, below 20,000 euro in Eastern countries	Not applicable (unlikely to be independent at this age)	30–50,000 euro	35–65,000 euro	25–45,000 euro
Salary range after 10 years of experience (approximately 35–40 years-old; depending on position)	40–80,000 euro, more by doing consultancy (often needs permission by university and/or government)	Variable, 70–100,000 (+) euro	55–80,000 euro As manager 65–110,000 euro	60–90,000 euro (pathologists + 5–10%) As manager 65–120,000 (+) euro	45–85,000 euro
Freedom to negotiate salary with new employer	Limited Salary system regulated by government	Not applicable (output = earnings)	Significant, depends on value as a professional as perceived by employer		Limited Salary system regulated by government
Impact of professional performance on salary	Limited Mainly seniority-based	Good performance increases earnings	Significant, including bonus (some, to in excess of 30% of annual salary)		Limited Mainly seniority-based

Academia provides the greatest freedom to work on subjects of one's own interest. However, the administrative burden, including for example grant writing, can be heavy and the funds to buy, for example, the necessary scientific equipment are generally very limited. The times when toxicologists in industry had much freedom and funds to do their own research have definitely reduced during the past 10 years, although some opportunities can still arise by wisely choosing an area which is also of interest to the company. This opportunity is much less for regulatory toxicologists or toxicologists working in CROs and is generally unavailable in the consultancy business. However, toxicologists in the last three areas obtain the most interesting insight into many different scientific and regulatory issues. The possibilities for international interactions, including some international travel, are generally good in all areas.

Job security is probably highest in a regulatory agency. It used to be high for tenured positions in academia, but the picture has changed by the recent wave of closures of toxicology institutes in some countries such as Switzerland and Germany. Job security is generally less, although still satisfactory, in CROs and the industry. However, a number of competent toxicologists have lost their jobs in the private sector during the past years and have had considerable problems in finding new employment because of their age and their salary expectations. A consultant experiences the opportunities and insecurities of every entrepreneur. There can be periods without paid contract and it is important to have some financial reserves to survive them. Therefore, a future independent consultant should obtain some longer-term contracts with companies to survive the particularly difficult first 2–3 years of building up a business.

There are downsides or – more positively – challenges everywhere, ranging from a highly competitive environment in academia and the consultancy business, to high pressure because of external deadlines and customer expectations on consultants, in industry and in CROs.

Financial aspects (Table 6)

For a fair comparison salaries need to be seen in relation to the cost of living and the tax burden. On the average, salaries are highest in Switzerland and Germany but so are prices (Switzerland) and taxes (Germany); on the other hand, both salaries and the cost of living tend to be lower in Southern Europe.

These days, the private sector in particular rewards increased performance with increased pay rises and bonuses.

Overall, salaries of toxicologists are reasonable, but certainly do not match those of higher managers particularly in the information technology, legal or banking businesses.

Salaries for toxicologists in Europe are lower than those in the USA (Gad 1996, 2000). Starting salaries in

the private sector of the USA range from US\$ 55,000 to 95'000 (approximately 61,000–106,000 euro) and in the public sector range from US\$ 35,000 to 65,000 (approximately 39,000–72,000 euro). After approximately 10 years on the job, US salaries are around US\$ 100,000(+) (approximately 111,000 euro) in the private sector and around US\$ 65,000 (approximately 72,000 euro) in the public sector.

Career prospects (Table 7)

Academia, the private sector and to some extent also the regulatory agencies offer interesting career prospects.

Typical career paths in *academia* are: Laboratory Assistant → Scientific Fellow → Assistant Professor → Associate Professor → Professor → Professor and Chairman.

In *industry* a typical career can be as follows (names and steps may vary somewhat depending on the company): Assistant Study Director → Study Director → Part-Time Drug Safety Representative on moderate and, later, on high priority global development project teams → Full-Time Drug Safety Representative generally on high priority global development project teams or on mixed research/development compound selection teams (see e.g. Alden et al. 1999) → Senior Drug Safety Expert writing expert reports, providing expert opinions, etc. and frequently in contact with regulatory agencies around the world. Promotion to manager can occur anytime after having shown leadership potential and people management skills.

In *CROs* a similar progression is possible: Assistant Study Director → Study Director → Senior Toxicologist and/or Team Leader → Department Head.

Generally the last step in a distinguished career of a toxicologist in the private sector is to become a senior manager with international responsibility or to become independent and work as *toxicology consultant*. Expansion of this job consists in increasing the network and being elected to important committees. Consultants also have the option to enlarge their business and to hire associates. To be consulted by important regulatory agencies can be considered as a particular professional distinction.

Career options are somewhat limited in *regulatory agencies*. A typical career can be Junior → Senior → Expert Assessor. In addition one may take on additional responsibilities and/or management roles.

Working as a young toxicologist for a CRO or in a regulatory agency is an excellent opportunity to gain a broad experience in toxicological topics and regulatory processes and to better understand how companies handle those issues.

Alternative careers in the same organisation, e.g. by moving into other departments where toxicology expertise is also of use (e.g. registration, project management, discovery research, etc.), are possible particularly in industry. More options open up if one is

Table 7 What are typical career prospects for a toxicologist in academia, the consultancy business, contract research, industry and regulatory agencies (for details see text)

	Academia	Consultancy business	Contract research business	Chemical and pharmaceutical industry	Regulatory agencies
As toxicologist in the same organisation	Nice career ladder from lab assistant to professor and chairman of the department, but very tough competition	Enlarge business and web of connections; hire co-workers	Good opportunities: junior → senior study director etc. → management position	Very good opportunities (for details see text)	Limited opportunities as assessor and possibly later group leader or taking over international responsibility (see text)
Other alternatives without changing organisation	Low	None	Low	In large companies many opportunities, e.g. change to project management, regulatory affairs, discovery research, any type of management tasks	Low
Others	Some academics change, e.g. into industry, but industry environment is comparatively harsh and freedom to do research low, which may cause problems on both sides	Once independent, consultants generally stay independent	In particular mobility between contract and client companies		Knowledgeable regulators are in demand in industry and partly also in CROs

willing to consider pursuing careers in another company or another sector (Table 7). The single most important limiting factor is age: as in other professions the laws and regulations designed to protect the employee (old age insurance, protection against loss of working place, etc.) as well as salary expectations may reduce job prospects for people above approximately 45 years of age in Europe.

To take advantage of the career prospects summarised above, one has to actively manage one's own career. This is particularly important in the private sector with a high turnover of management and little formal and long-term career planning.

Conclusions

The workshop has shown that there is a wide range of job opportunities for toxicologists who have acquired a good education particularly in natural sciences and have specialised in one or several areas of toxicology. There is significant variation in the background of toxicologists as well as their postgraduate training across Europe. Salaries also vary widely among countries as well as within the same country in different sectors of employment. With increased mobility of people, facilitated by the creation of the EU, these differences may diminish. Overall, the number of jobs for toxicologists is expected to increase slightly. The decreased training of toxicologists in certain countries has already started to create a shortage of toxicologists. However, the workshop has also shown definitively that there is a need for a better demographic investigation of toxicologists in Europe, as well as assessment of the number and types of organisations employing toxicologists.

As in other professions, continuous training, ambition and strong work ethic are important for building a successful career in toxicology. Continuous training is particularly important as toxicology is rapidly changing with the emerging technologies. Significant challenges in toxicology are:

- Requirements for registration of new chemicals will increase further; regulations for registering genetically modified food will become more stringent and more/new regulation, e.g. for working with genetically modified animals and for pharmaceutical products of the emerging technologies, will be introduced.
- The requirements for environmental and food toxicology will increase.
- The critical attitude of the public towards perceived or real toxicity issues (see also Mertz et al. 1998) will increase.
- "In silico" investigations (toxicogenomics and proteomics) will become more important and may partly replace in vivo toxicity studies.
- Toxicologists will be asked to register as professionals and, ultimately, perhaps to obtain formal accreditation.

- Employment modalities (higher mobility, more short-term assignment and self-employment, etc.) will continue to change significantly.

Overall the profession of a toxicologist is fascinating and allows for interaction globally with scientists from many different disciplines. Toxicology is a very broad discipline and highly important for safeguarding public health and the environment.

Feedback from the readers of this article is most welcome and can be addressed to RAE at the address shown on the first page of this article. He will forward comments to the working group for further follow-up.

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