What Skills & Knowledge to Improve Molecular Life Science Education

Francesco (Frank)Michelangeli
FEBS Education Committee
Biochemical Society Education Committee

What do We want to achieve in our students ?

- Have good subject-specific knowledge
- Be able to recall scientific facts correctly.
- Ability to think logically & scientifically
- Able to analyse scientific data appropriately
- Have competent laboratory skills.

What do We Really want!

- Good PhD Students
- Nurture the next generation of top scientists

What do Students want to achieve from their university education?

- Good Job prospects
- Graduate level employment
- Fulfilling career
- Good career progression opportunities

What do students Really want!

- A very well paid job
- Job security

>75% of all science graduates DO NOT go into science-based careers

›

What do Employers want from our graduates?

Confederation of British Industry
Education & skills report 2010

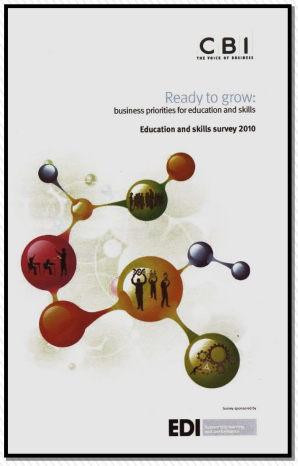


Exhibit 19 CBI definition of employability skills

Self-management – readiness to accept responsibility, flexibility, time management, readiness to improve own performance

Teamworking – respecting others, co-operating, negotiating/persuading, contributing to discussions

Business and customer awareness – basic understanding of the key drivers for business success and the need to provide customer satisfaction

Problem solving – analysing facts and circumstances and applying creative thinking to develop appropriate solutions

Communication and literacy – application of literacy, ability to produce clear, structured written work and oral literacy, including listening and questioning

Application of numeracy – manipulation of numbers, general mathematical awareness and its application in practical contexts

Application of information technology – basic IT skills, including familiarity with word processing, spreadsheets, file management and use of internet search engines

›

Some findings from the CBI report……

Why employers like STEM graduates

Exhibit 30 Reasons employers value STEM-skilled employees (%)

	Con-struction	Science, hi-tech & IT	Manu-facturing	Energy & water	Banking, finance & insurance	All
Technical competence	85	83	80	81	45	73
Analytical skills	63	69	73	88	90	69
Problem-solving skills	77	58	66	81	50	61
Numeracy skills	54	53	50	75	65	51
Intellectual rigour	44	50	40	63	50	42

STEM= Science / Technology/ Engineering/ Maths

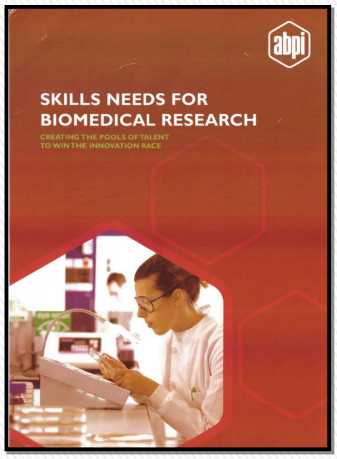
Problems recruiting STEM graduates

Exhibit 33 Reasons for problems in recruiting STEM graduates (%)

	Science/ hi-tech/IT	Energy & water	Manu-facturing	Banking, finance & insurance	Con-struction	All
Lack of workplace experience	38	33	44	44	50	46
Graduates lack employability skills	58	42	38	67	54	45
Lack of graduates applying for positions	46	50	44	22	36	41
Content of degree not relevant to our business	42	42	36	22	32	32
Poor practical or laboratory skills	13	0	12	11	14	11
Degree not accredited by relevant professional bodies	4	8	5	0	18	7

What about Pharma / Bioscience Employers?

Skills Report (2009)
Assoc. Brit. Pharma Industry



Skills issue	a major concern	a concern	less of a concern now	not a problem	number of responses	% concerned
Practical experience	27	13	5	1	46	87%
Application of scientific and maths knowledge	21	20	5	0	46	89%
High level maths knowledge	13	21	4	4	42	81%
Scientific knowledge	9	28	4	1	42	88%
Communication skills	7	15	12	13	47	47%
Team-working skills	4	9	18	13	44	29%

Do we really equip our students for successful graduate level employment either within the science sector or within the other sectors?

3 KEY AREAS OF IMPORTANCE

Transferable Skills & Employability

Subject-Specific Practical Skills

Subject-Specific Knowledge

Explored views of >100 academics during group discussion sessions in Cambridge, Paris Education workshops

Transferable Skills

- Mathematical competency. Being able to use and manipulate simple equations.
- Being able to plot and interpret data in the form of graphs and tables.
- Statistics and its uses. Being able to ulitilize statistical software, i.e. Excel, SPSS, Minitab, etc.
- Communication skills, oral presentations and in writing.
- Scientific writing, how to write a scientific report or paper.
- Problem solving skills – i.e. critical analysis, experimental design and setup.
- Team working skills.
- Independency and time management.
- Leadership and managerial skills.

Careers and improving employability prospects

- Have an extensive period of workplace experience as part of the degree (for some students). This could take the form of a "sandwich year" where the students spend one academic year working in an industrial setting such as for a pharmaceutical company.
- Individual or small group coaching and mentoring.
- Helping with CV writing.
- Helping to develop interview skills.
- Employ or utilize specific careers officers within the university to help students with applications.
- Organise careers fairs for the students and invite past graduates to talk about their careers following graduation.

Subject-Specific Practical Skills

- Making buffers, solutions and being able to understand concentrations.
- Using a pH meter and adjust pH of buffers.
- Knowing how to dilute solutions.
- Training in good laboratory practice (especially lab safety)
- Keeping a detailed lab book.
- Designing an experiment to test hypothesis and consideration of control and replicates.
- Being able to perform and analyse the results from SDS PAGE (including Western blots, etc)
- Being able to perform and analyse the results from DNA agarose gels.
- Concepts of protein purification, i.e. size exclusion and ion exchange chromatography.
- UV-vis spectrometry and use of calibration curves.
- Enzyme assays and following rates of reactions.
- Microscopy & cell handling / imaging
- Basic microbiology techniques also possible expose to other model organism systems
- Basic molecular biology ie Undertaking PCR reactions and analyzing products.
- Searching scientific literature data bases.

Subject-Specific Knowledge

- Proteins
- DNA / RNA / Genetics
- Enzymes
- Metabolism
- Regulation
- Cell biology
- Molecular biology
- Bio-energetics
- Membranes
- Cell signalling
- Biotechnology
- Microbiology
- Molecular pharmacology

RESULTS FROM WORKSHOPS IN BELGRADE (SERBIA) & DEBRECEN (HUNGARY)

TRANSFERABLE SKILLS
1)Team working
2)Time management
3)Communication
4)Public understanding
5)Mathematics
At Post graduate level
1)Writing a scientific paper
2) High level statistics
3) Project writing
4) Fund management

PRACTICAL SKILLS
1)laboratory safety
2)Pipetting
3)Making solutions, pH, etc
4)Spectrophotometry
5)chromatography
6)Microscopy
At postgraduate level
1)PCR
2)Electrophoresis and immunochemistry
3)HPLC
4)MS
5)Cell flow cytometry, etc

SUBJECT SPECIFIC KNOWLEDGE
Cells structure
Membranes & energy
Cell signalling
Gene expression / regulation
Biomolecules
Enzyme properties
Metabolism
Appropriate chemistry &physics

We are ALL saying the same things across Europe (East & West)

ALL of US have major Issues regarding interpretation and implementation of the Bologna system!!!. This could be due the subject.

In the UK Learned Societies have been involved in setting standards and criteria of many science degrees

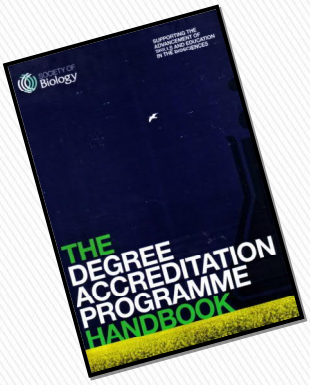
Royal Society of Biology

Accreditation of:
3yr & 4yr BSc/MSci in Biosciences

Focus on practical, employability, (subject-specific) skills & knowledge, critical thinking and creativity

(Input from pharma)

RSB criteria are not very overly prescriptive



Key point: once the student has learned the core material, the more advanced material should reflect the expertise of the academics.

Molecular Aspects of Biology criteria

These learning outcomes are in addition to the criteria for accreditation listed on pages 10-11.

On completion of the degree, students should be able to demonstrate the following:

— An in-depth and practically-grounded knowledge of the principal ideas, concepts and analytical methods associated with the molecular biosciences

— An appreciation of the role and limitations of all aspects of analysis within the molecular biosciences through appropriate application and evaluation

— The ability to employ, independently and appropriately, a range of experimental approaches in modern research while demonstrating knowledge and appreciation of, and adherence to, accepted procedural protocol, conduct and performance

— An application of the molecular principles underlying biological processes that are appropriate for the degree subject

The following examples are recognised by the Society of Biology as providing relevant opportunities and experiences to enable students to fulfil the learning outcomes listed above to the required levels of independence and competency.

— Molecular bioscience – opportunities to develop appropriate levels of knowledge and critical application of key biological and chemical concepts, to include:

- atomic and molecular structure, including sufficient bio-inorganic, organic and physical chemistry necessary for the degree subject
- chemical, molecular and analytical methods appropriate for the degree programme
- macromolecular structure and function, which should be in relation to biological processes where appropriate, and include gene function, macromolecule interaction and genome architecture
- cellular organisation and processes, for example metabolism

— Laboratory practice – opportunities to demonstrate competence in a range of appropriate practical procedures and techniques including experimental design, execution and interpretation, risk assessment, and good laboratory practice

— Analytical skills – through practical experiences and skill applications students could be afforded opportunities to embed theory, hone practical skills, and enhance the use of analytical methods and procedures, for example:

- critical analysis of literature
- mathematical application
- data collation, representation, interpretation
- effective use of statistics

Promoting Molecular Life Sciences Education in a Wider Europe: A Potential FEBS EU Project

Possible Objectives

- Building networks
- Defining skills and knowledge
- Addressing standards
- Developing a core curriculum
- Enabling mobility
- Encouraging more life science students