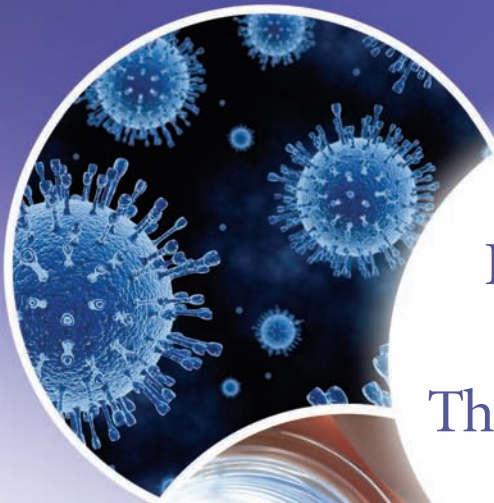


Effective Learning in the Life Sciences



How Students
Can Achieve
Their Full Potential

Editor
David J. Adams

Effective Learning in the Life Sciences

Effective Learning in the Life Sciences

How Students Can Achieve Their Full Potential

Edited by David J. Adams

UK Centre for Bioscience, Higher Education Academy

 **WILEY-BLACKWELL**

A John Wiley & Sons, Ltd., Publication

This edition first published 2011 © 2011 by John Wiley & Sons, Ltd

Wiley-Blackwell is an imprint of John Wiley & Sons, formed by the merger of Wiley's global Scientific, Technical and Medical business with Blackwell Publishing.

Registered office: John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial offices: 9600 Garsington Road, Oxford, OX4 2DQ, UK
The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK
111 River Street, Hoboken, NJ 07030-5774, USA

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com/wiley-blackwell.

The right of the author to be identified as the author of this work has been asserted in accordance with the UK Copyright, Designs and Patents Act 1988.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, except as permitted by the UK Copyright, Designs and Patents Act 1988, without the prior permission of the publisher.

Designations used by companies to distinguish their products are often claimed as trademarks. All brand names and product names used in this book are trade names, service marks, trademarks or registered trademarks of their respective owners. The publisher is not associated with any product or vendor mentioned in this book. This publication is designed to provide accurate and authoritative information in regard to the subject matter covered. It is sold on the understanding that the publisher is not engaged in rendering professional services. If professional advice or other expert assistance is required, the services of a competent professional should be sought.

Library of Congress Cataloging-in-Publication Data

Effective learning in the life sciences : how students can achieve their full potential / [edited by] David Adams.
p. cm.

Summary: "Draws on experience from a major project conducted by the Centre for Bioscience, with a wide range of collaborators, designed to identify and implement creative teaching in bioscience laboratories and field settings"—Provided by publisher.

Includes bibliographical references and index.

ISBN 978-0-470-66156-7 (cloth) – ISBN 978-0-470-66157-4 (paper)

1. Life sciences—Study and teaching (Higher) 2. Life sciences—Study and teaching (Higher)—Great Britain. 3. Creative teaching. 4. Biological laboratories. 5. Life sciences—Research.

6. Life sciences—Fieldwork. I. Adams, David J. (David James) II. UK Centre for Bioscience.

QH315.E33 2011

570.71'1—dc23

2011022847

A catalogue record for this book is available from the British Library.

This book is published in the following electronic format: ePDF: 9781119976653;
Wiley Online Library: 9781119976646; ePub: 9781119977636; Mobi: 9781119977643

Set in 9.5/11.5pt Times by Thomson Digital, Noida, India

First Impression 2011

*To my colleagues in the UK Centre for Bioscience.
It was a pleasure and a privilege to work with you all.*

Contents

List of contributors	xiii
Introduction	xix
1 Creativity	1
<i>David J. Adams and Kevin Byron</i>	
1.1 Introduction	1
1.2 Adaptors and creators	1
1.3 Defining problems	2
1.4 Accessing your creative potential	4
1.5 Creativity techniques	7
1.6 Incubation	16
1.7 Working in groups – creative environments	18
1.8 Working in groups – facilitated creativity sessions	19
1.9 How many uses for an old CD?	22
1.10 Evaluating your ideas	22
1.11 Putting your ideas into action	23
1.12 How you can achieve your creative potential	23
1.13 References	24
1.14 Additional resources	24
2 Problem solving – developing critical, evaluative and analytical thinking skills	25
<i>Tina L. Overton</i>	
2.1 What is problem solving?	25
2.2 Problem-solving strategies	26
2.3 Critical thinking	31
2.4 Critical reading	32
2.5 Using judgement	34
2.6 Constructing an argument	35
2.7 Visualisation – making representations	36
2.8 Other strategies	37
2.9 Pulling it together	38
2.10 How you can achieve your potential as a problem solver	39
2.11 References	39
2.12 Additional resources	40
3 In the laboratory	41
<i>Pauline E. Millican and David J. Adams</i>	
3.1 Introduction	41
3.2 The Scientific Method	42

3.3	Preparing for a laboratory class	44
3.4	Laboratory notebooks	45
3.5	Laboratory equipment	46
3.6	Calculations in the laboratory	50
3.7	Working in a group	58
3.8	Working on your own	58
3.9	Writing-up experiments – the laboratory report	59
3.10	Concluding comments	62
3.11	How you can achieve your potential in the laboratory	62
3.12	Acknowledgements	62
3.13	References	62
3.14	Additional resources	63
3.15	Problems associated with Koch’s postulates	64
4	Fieldwork	65
	<i>Julie Peacock, Julian R. Park and Alice L. Mauchline</i>	
4.1	Introduction	65
4.2	Fieldwork – exciting or overwhelming?	66
4.3	Planning and time management	67
4.4	Group work and social aspects of fieldwork	70
4.5	Collecting the right data	71
4.6	Technology in the field	73
4.7	Costs, sustainability and ethics	75
4.8	Safety and permissions	76
4.9	Accessibility	81
4.10	Making the most of different types of fieldwork	83
4.11	Overcoming the problems that WILL occur	85
4.12	Feedback and assessment	87
4.13	Concluding comments	88
4.14	How you can achieve your potential during fieldwork	88
4.15	References	88
4.16	Additional resources	89
4.17	Potential solutions for kick-sampling case study	90
5	In vivo work	91
	<i>David I. Lewis</i>	
5.1	Introduction	91
5.2	Animal welfare legislation	92
5.3	The principles of the 3Rs	94
5.4	Alternatives to the use of animals in the development of new medicines	96
5.5	Animal models of disease	98
5.6	Experimental design	99
5.7	Recognition of pain, suffering or ill health in animals used for research	100
5.8	Ethical review of <i>in vivo</i> studies	101
5.9	Harm/benefit analysis	105
5.10	The arguments for and against animal experimentation	105
5.11	How you can achieve your potential in <i>in vivo</i> work	108
5.12	References	108
5.13	Additional resources	109

6 Research projects	111
<i>Martin Luck</i>	
6.1 Introduction	113
6.2 Research project – role and purpose	113
6.3 Applying the Scientific Method	114
6.4 Types of project and ideas for research	116
6.5 Characteristics of good research projects	118
6.6 Working in groups	125
6.7 Writing up	126
6.8 The possibility of publication	128
6.9 How you can achieve your potential during final-year project studies	128
6.10 Tutor notes	129
6.11 Acknowledgements	131
6.12 References	131
6.13 Additional resources	131
7 Maths and stats for biologists	133
<i>Dawn Hawkins</i>	
7.1 Introduction	133
7.2 Motivation – this chapter is important!	134
7.3 Confidence – you can do it!	139
7.4 Skills – do it!	142
7.5 How you can achieve your potential in biomaths	148
7.6 Acknowledgements	148
7.7 References	148
7.8 Additional resources	149
8 E-learning for biologists	151
<i>Jo L. Badge, Jon J. A. Scott and Terry J. McAndrew</i>	
8.1 Introduction	151
8.2 Online working environment	151
8.3 Resources	154
8.4 Legal considerations	159
8.5 Protecting your work	160
8.6 Organisation	161
8.7 Developing as a professional	162
8.8 Information online	163
8.9 Working effectively	168
8.10 How you can achieve your potential using computers and online resources	171
8.11 References	172
8.12 Additional resources	172
9 Bioethics	175
<i>Chris J. R. Willmott</i>	
9.1 Introduction	175
9.2 The rise of ethics in the bioscience curriculum	175
9.3 What exactly is bioethics?	177

9.4	Putting the case for ethics education	181
9.5	Developing insight into ethical issues	185
9.6	Taking it further	186
9.7	Conclusion	190
9.8	How you can achieve your potential in bioethics	190
9.9	Tutor notes	190
9.10	References	192
9.11	Additional resources	193
10	Assessment, feedback and review	195
	<i>Stephen J. Maw and Paul Orsmond</i>	
10.1	Introduction and some definitions	195
10.2	Types of assessment	197
10.3	Marking criteria	198
10.4	Learning outcomes	198
10.5	Feedback	199
10.6	Peer support – learning from and with your classmates	203
10.7	Peer assessment	205
10.8	Self-review and assessment	207
10.9	Bringing it all together	208
10.10	How you can use assessment, feedback and review to help you achieve your potential	209
10.11	References	210
10.12	Additional resources	210
11	Communication in the biosciences	213
	<i>Joanna Verran and Maureen M. Dawson</i>	
11.1	Introduction	213
11.2	Communication skills in the undergraduate curriculum	214
11.3	Opportunities to develop communication skills	214
11.4	Written communication	216
11.5	Visual communication	219
11.6	Oral communication	226
11.7	Public engagement	228
11.8	How you can achieve your potential as a communicator	233
11.9	References	233
11.10	Additional resources	233
12	Bioenterprise	235
	<i>Lee J. Beniston, David J. Adams and Carol Wakeford</i>	
12.1	Introduction	235
12.2	Phase 1 Identifying and protecting an idea	238
12.3	Phase 2 Researching the market potential for your idea	240
12.4	Phase 3 Setting out your ideas and goals – the business plan	243
12.5	Communicating your business – the ‘Pitch’	252
12.6	Concluding comments	253
12.7	How you can achieve your enterprising and entrepreneurial potential	253
12.8	Tutor notes	254

CONTENTS

xi

12.9	References	254
12.10	Additional resources	255

Appendix	257
Index	261

List of contributors

David J. Adams
UK Centre for Bioscience, Higher Education Academy
Room 9.15, Worsley Building
University of Leeds
Leeds, LS2 9JT

Jo L. Badge
School of Biological Sciences
University of Leicester
University Road
Leicester, LE1 7RH

Lee J. Beniston
Leeds University Business School
Maurice Keyworth Building
University of Leeds
Leeds, LS2 9JT

Kevin Byron
The Learning Institute
Room 3.03A, Francis Bancroft Building
Mile End Campus
Queen Mary, University of London
London, E1 4NS

Maureen M. Dawson
c/o Centre for Learning and Teaching
Manchester Metropolitan University
2nd Floor, Cavendish North
Cavendish Street
Manchester, M15 6BG

Dawn Hawkins
Department of Life Sciences
Anglia Ruskin University
East Road
Cambridge, CB1 1PT

David I. Lewis
Faculty of Biological Sciences and Interdisciplinary Ethics Applied CETL
University of Leeds
Leeds, LS2 9JT

Martin Luck
School of Biosciences
University of Nottingham
Sutton Bonington Campus
Loughborough, LE12 5RD

Alice L. Mauchline
School of Agriculture, Policy and Development
University of Reading
PO Box 237
Reading, RG6 6AR

Stephen J. Maw
UK Centre for Bioscience, Higher Education Academy
Room 9.15, Worsley Building
University of Leeds
Leeds, LS2 9JT

Terry J. McAndrew
UK Centre for Bioscience, Higher Education Academy
Room 9.15, Worsley Building
University of Leeds
Leeds, LS2 9JT

Pauline E. Millican
c/o UK Centre for Bioscience, Higher Education Academy
Room 9.15, Worsley Building
University of Leeds
Leeds, LS2 9JT

Paul Orsmond
Faculty of Sciences
Staffordshire University
Mellor Building
College Road
Stoke-on-Trent, ST4 2DE

Tina L. Overton
UK Physical Sciences Centre
Higher Education Academy
Department of Chemistry
University of Hull
Hull, HU6 7RX

Julian R. Park
School of Agriculture, Policy and Development
University of Reading
PO Box 237
Reading, RG6 6AR

Julie Peacock
UK Centre for Bioscience, Higher Education Academy
Room 9.15, Worsley Building
University of Leeds
Leeds, LS2 9JT

Jon J. A. Scott
College of Medicine, Biological Sciences & Psychology
University of Leicester
University Road
Leicester, LE1 7RH

Joanna Verran
School of Health Care Science
Manchester Metropolitan University
Chester Street
Manchester, M1 5GD

Carol Wakeford
Faculty of Life Sciences
University of Manchester
1.124 Stopford Building
Oxford Road
Manchester, M13 9PT

Chris J. R. Willmott
Department of Biochemistry
University of Leicester
Leicester, LE1 9HN

David Adams was Director of the UK Centre for Bioscience, Higher Education Academy, from 2007–2011. Currently he is Director of Science and Research at Cogent Sector Skills Council.

Introduction

There has never been a more exciting time to study biology. We hear almost daily of major developments in new areas such as nanobiology, stem cell research or GM technology, and the popular media are forever running stories on the global impact of the biosciences. You have the chance to participate in this ongoing revolution, and if you are to make the most of this opportunity you must be prepared to think for yourself and fully engage in the learning process. If you can make this commitment then you should benefit greatly from this book.

Many of the book's contributors have interacted closely with the UK Centre for Bioscience, and its predecessors, during the last decade. Together they offer a wealth of experience and expertise in a wide range of areas of current importance in bioscience education. For the first time in a single volume, topics such as creativity, e-learning, bioethics and bioenterprise are considered, in detail, alongside more traditional elements of bioscience degree programmes such as laboratory classes and fieldwork. In addition, the book addresses areas and issues frequently identified by bioscience students as problematic. These include lack of confidence when using maths or stats in bioscience settings, difficulties when solving problems and frustration with assessment and feedback procedures. The book is designed to help you with these issues, and you will be able to access further support through an *Additional resources* section at the end of each chapter.

There is emphasis on interactivity, with inclusion of worked examples and case studies throughout. If you participate in these exercises and make the most of each chapter you will acquire a wide range of skills. These include many of the skills currently sought by prospective employers. Industrialists and university research laboratory supervisors alike indicate they want well-rounded graduates who can solve problems creatively in a wide range of settings. Enthusiastic engagement with the contents of this book should therefore help ensure not only that you benefit maximally from your time at university but also that you improve your employment prospects and achieve your true potential as a life scientist.

The book, chapter by chapter

Students are imaginative and inventive individuals, but unfortunately they are rarely given any help to achieve their true creative potential during bioscience degree programmes. A distinctive feature of this book is the inclusion of a chapter (Chapter 1) that will help promote your individual creativity and the creativity that often occurs when students work together in groups. As with creativity, students of the biosciences are given little help to develop their problem-solving abilities; in the second chapter you will therefore be shown how to approach algorithmic and open-ended problems with confidence. The next two chapters focus on practical skills in the biosciences with emphasis on students achieving their potential in laboratory and field. Continuing the practical

theme, *in vivo* work (i.e. work with animals) is an area that has been identified as of paramount importance by the UK Government, researchers and educationalists, and an unusual and useful feature of this book (Chapter 5) is the consideration of a wide range of approaches and issues associated with the use of animals in the laboratory. In the final year of your studies you are likely to be engaged in a major research project. In recent years universities have offered a wide range of formats for projects, and these are considered in Chapter 6, which should help you identify the type of project best suited to your needs. The next chapter considers issues associated with maths and stats for biologists and describes how you can build your confidence in these areas. Chapter 8 contains a state-of-the-art update on e-learning in the biosciences, with advice on the use of new technologies including mobile phones, blogs, wikis, Facebook etc. You should know about traditional, as well as the most recent and innovative, assessment procedures used in universities. In addition you should be fully aware of the sort of regular feedback you can expect during your degree programme. These issues are considered in Chapter 10. It is essential that bioscientists should be able to communicate their ideas and general scientific information to other scientists and to members of the public. Chapter 11 describes traditional and novel approaches for communication in the biosciences. Two further notable features of this book are chapters on Bioethics and Bioenterprise. These are areas of great current importance to bioscientists. A considerable amount of material already exists in the field of bioethics, and Chapter 9 will raise your awareness of current approaches in this area. Bioenterprise and Knowledge Transfer are topics that are being embraced enthusiastically by many universities and the final chapter of the book considers how students of the biosciences can achieve their enterprising and entrepreneurial potential.

Tutor notes

The bioscience knowledge base is growing at a remarkable rate, and this can lead to tutors placing great demands on students who are asked to absorb enormous amounts of information. Unfortunately this can be at the expense of course components designed to promote independent thought and real engagement with the Scientific Method. This book is intended to redress this imbalance by raising students' awareness of their own considerable potential in areas of traditional and emerging importance. It is much more than a study skills guide, in that in each of the 12 diverse chapters the authors aim to build students' confidence to the point where they can decide for themselves whether they are making the most of their time at university.

You will find *Tutor notes* throughout, or at the end of, chapters. The notes will direct you to a great deal of additional material in support of teaching in the biosciences. This includes a very wide range of online and other resources provided by the UK Centre for Bioscience, Higher Education Academy.

1 Creativity

David J. Adams and Kevin Byron

1.1 Introduction

We should start by defining the terms ‘creativity’ and ‘innovation’. *Creativity* involves original and imaginative thoughts that lead to novel and useful ideas. If you are to put these ideas to good use, you must be innovative as well as creative. *Innovation* may be defined as the exploitation of ideas in, for example, the development of new procedures or technologies. An excellent illustration of the distinction between creativity and innovation is the invention and development of the electric light bulb. Most people would identify Thomas Edison as the light bulb’s inventor, yet over 20 individuals are thought to have invented similar devices up to 80 years before Edison’s contributions. Only Edison was sufficiently innovative to refine his invention until it was a practical device that could be brought into commercial use in partnership with an electrical distribution company. You will learn how to ensure that *your* creative ideas are brought to fruition in Chapter 12.

Students of the biosciences are rarely encouraged to be truly creative or innovative (Adams *et al.*, 2009). A notable exception may arise during a final-year project, when you might be asked to come up with some novel ideas or solve a problem creatively. However, it is unlikely that you will be offered any help in generating original, imaginative thoughts or solutions. Indeed, in our view, bioscience students are rarely given the opportunity to develop anything like their full creative potential. This is a great shame because bioscience graduates will frequently be expected to be creative in a wide range of career settings.

In this chapter we consider a number of issues associated with the promotion of creativity in bioscientists. We start by inviting you to decide whether you consider yourself to be a ‘creator’ or whether your natural inclination is to be more of an ‘adaptor’. The outcome of this exercise will help you make the most of the subsequent sections that deal with how to define problems, then solve them creatively as an individual or as a member of a team.

1.2 Adaptors and creators

It would seem that some people are naturally more inclined than others to take risks, challenge assumptions and be creative. Indeed, the psychologist Michael Kirton suggests that we can each be placed on a continuum based on our inclination to ‘do things better’ or to ‘do things differently’ and

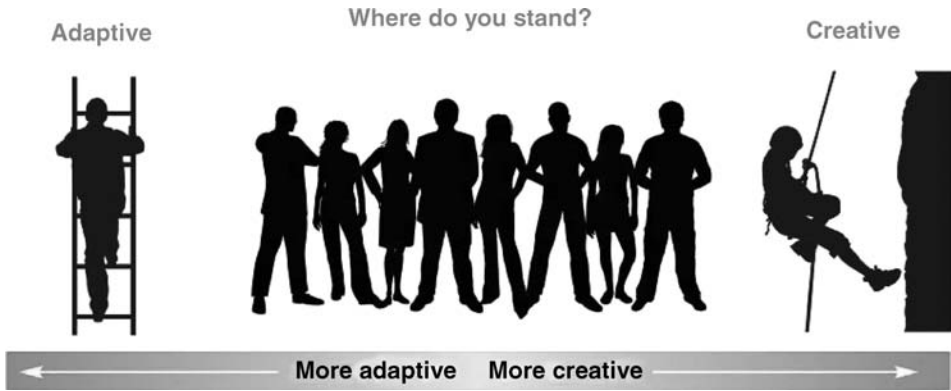


Figure 1.1 The adaptor–creator continuum (figure courtesy of Vitae, UK)

Table 1.1 Some of the characteristics associated with individuals located at the extremes of the adaptor–creator/innovator continuum

Adaptors	Creators/innovators
Seek solutions to problems in tried and tested ways	Willing to challenge the rules/assumptions and approach a task from an unusual angle
Risk averse	Like to take risks
Plagued by self doubt and always inclined to seek consensual view	Have low self doubt and pay little regard to the views of the majority
Focused, efficient, organised, disciplined with ability to concentrate on a task for a long period	Capable of detailed, routine work for only short periods
More likely to persist with a project and ensure outcomes delivered	May be poor at pursuing a project to fruition and ultimately making things happen

he labels the opposite ends of this continuum *adaptive* and *innovative*, respectively (Figure 1.1; Kirton, 1976). You may find it useful to consider where you fall on such a scale (Table 1.1). If you feel you are more of a creator/innovator than an adaptor then you are likely to benefit most from the problem-defining and problem-solving frameworks outlined in Section 1.3 of this chapter. On the other hand, adaptors should find of most value the techniques designed to promote creativity (Sections 1.4–1.9).

1.3 Defining problems

1.3.1 The 5Ws and 1H tool

Before committing a great deal of time and energy to creative problem solving you should make sure that you are entirely clear about the nature of the problem you wish to solve. The **5Ws and 1H** questioning tool may be used to help define and clarify the nature of the challenge.

Rudyard Kipling expressed this idea in verse:

*I keep six honest serving-men
(They taught me all I knew);
Their names are **What** and **Why** and **When**
And **How** and **Where** and **Who**.*

Consider the example of a first-year bioscience student who is trying to decide whether she should apply for a placement in industry during degree studies. Perhaps most importantly, she begins by asking herself **Why?** she wants to do this, and concludes that she wants to acquire new skills, new perspectives on the science she is studying, contacts in industry and experience that will make her CV stand out in the crowd. Next she considers **What?** sort of work she would like to do and realises she would really like to work in a research laboratory. She wonders **Who?** will be affected by any decision to spend up to a year on a placement, perhaps hundreds or even thousands of miles from home, and realises that such a placement will have a major impact on friends and family. As a result, when she thinks about **Where?** she might spend the placement, she realises that this need not be in a large and distant company in the UK or abroad but could be in one of the much smaller companies located closer to home. She now thinks carefully about **When?** the placement should take place and compares the benefits of a formal, one-year placement with much shorter periods of summer or other vocational work. Finally she considers **How?** she can arrange for a placement ideally suited to her needs, and realises that she must build up a network of ‘contacts’ who can help her, including friends, family, her tutor and the University Careers Service. She also realises that she must ‘target’ companies engaged in the sort of research work she finds interesting and stimulating.

By weighing up all of the issues in this way, the student has defined, much more clearly, the problem she wants to solve. She now realises that she definitely wants the experience of working in industry during her three-year degree programme, but decides that she can obtain all the benefits she wants from interaction with industry by working during her summer vacations in one or more of the local ‘spin off’ companies associated with the universities located close to her home. The original problem: ‘Should I apply for a placement in industry during degree studies?’ has been redefined as ‘How can I arrange for summer work in local biotechnology companies?’ Her in-depth consideration of the issues means she is already well on her way towards solving this problem. However, now that she is clear about the real problem she wishes to solve, she may also benefit from engagement with the creativity techniques described in Sections 1.4–1.9.

1.3.2 Problem-solving frameworks

Various authors have devised fairly elaborate frameworks for creative problem solving, and perhaps the best known of these is the Osborn–Parnes creative problem solving (CPS) process illustrated in Figure 1.2. You will note that this framework has six steps involving objective, fact, problem, idea, solution and acceptance finding, and that each involves a period of ‘divergent’ thinking followed by a ‘convergent’ thinking phase. These terms should be defined at this stage.

If you are to be creative and have ideas, you must think *divergently* by using your imagination, challenging assumptions, rearranging information and examining it from new perspectives (see Section 1.4). Students of the biosciences are likely to be much more familiar with *convergent* thinking. It involves rational and logical reasoning that leads to convergence on the best solution to a problem. Convergent thinking is therefore essential when you wish to evaluate the ideas generated during a divergent thinking phase. In Section 1.3.1, the student who pondered how she might gain experience of industry was initially thinking divergently as she asked a series of questions,

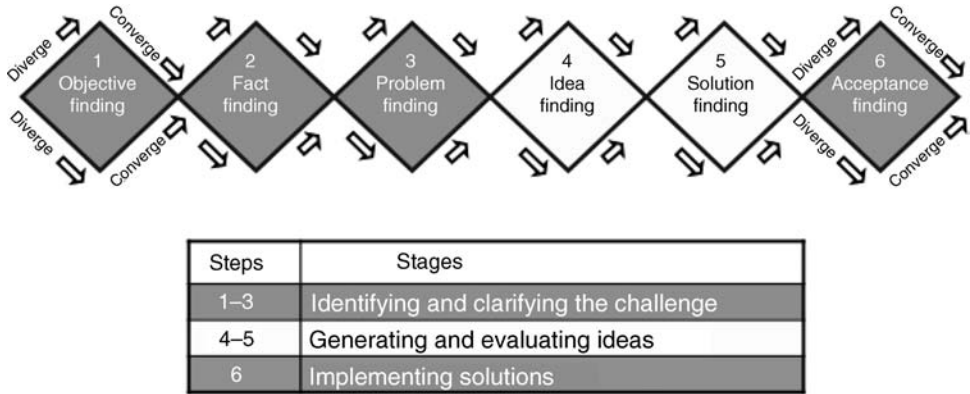


Figure 1.2 Osborn–Parnes creative problem solving

rearranged and re-examined information, and used her imagination. She then began to converge on the solution to her problem.

Creative problem solving is dependent upon an effective combination of divergent and convergent thinking: creative frameworks like the Osborn–Parnes CPS process (Figure 1.2) are designed to ensure that a period of divergent thought is always followed by convergent thinking as problems are defined, and ideas generated and evaluated. You can find out more about these structured approaches to problem solving elsewhere (see Section 1.14, Additional resources). We will return to convergent thinking towards the end of this chapter when we consider how you might evaluate your ideas. However, we will now focus on divergent thinking and the approaches you can use to generate the ideas you will need to solve problems creatively.

1.4 Accessing your creative potential

The approaches and techniques described in this section will help build the confidence you need to have ideas and solve problems creatively. If you are to be successful in this you will need to be bold and ready to move out of your ‘comfort zone’. For example, you should be prepared to:

- (1) **Welcome the unexpected:** Alexander Fleming noted a mould contaminant growing on his plated culture of bacteria. Instead of simply throwing away the plate, he looked more closely and observed inhibition of growth of the bacterium close to the fungal contaminant. He was curious about this effect and published his observation. During the next two decades Fleming’s publication prompted others to isolate and develop penicillins as the first and, ultimately, most successful group of antibiotics. If, during research project studies, you notice something unusual, take the time to consider the implications of your observation.
- (2) **Challenge assumptions:** during the 1968 Olympic Games, the American, Dick Fosbury, challenged the effectiveness of the popular ‘straddle’, ‘scissors’ or other high-jump techniques, and introduced the ‘Fosbury flop’ that involves the athlete jumping ‘back first’ over the bar. His willingness to challenge assumptions revolutionised the sport and helped win him a gold medal. A good and recent example of the importance of challenging assumptions in biology is provided by non-coding DNA. More than 98% of human genomic DNA does not encode proteins. Most of

these sequences have no obvious role and until recently were often referred to as ‘junk’ DNA. However, during the last few decades, many biologists have questioned the idea that such abundant, non-coding DNA should make no contribution to cellular activities in humans and other organisms. Their curiosity and investigations have been rewarded by the identification of an increasing number of diverse roles for non-coding sequences in gene expression, meiosis and chromosome structure, while additional lines of evidence indicate that other ‘junk’ sequences have essential but as yet unidentified roles in cells.

Unfortunately, students of the biosciences frequently require a great deal of encouragement before they will challenge assumptions. You should bear in mind that information provided by academics is not necessarily written on tablets of stone! This is of particular importance during lectures and seminars that involve cutting-edge developments in biology. In these situations you should keep an open mind and consider alternative interpretations and models that might be built around the data presented. Hold on to the curiosity about the natural world that probably led you to study biology in the first place, and don’t be afraid to ask lots of questions!

- (3) **Shift perspective:** when we shift perspective we change from one way of looking at things to another. In the illustrations in Figure 1.3 it is likely that initially you will be aware of only one interpretation. For Figure 1.3a you may see only a young woman wearing a feather boa, but if you look at the image in a slightly different way can you also see a much older woman? In Figure 1.3b you may see a pair of twins or a vase, but don’t stop there. You might see a whale fin, a key hole, two cars parked bumper to bumper, a seal, a coat hanger etc. These are simple examples of what it feels like to shift from a single to an alternative, or multiple, perspective(s). If you develop the capacity to shift perspective then it is likely you will be more creative. The Hungarian biochemist Albert von Szent-Györgyi underlined the importance of shifting perspective in scientific research when he said ‘Discovery consists of seeing what everybody has seen and thinking what nobody has thought’. He won a Nobel prize for his work on the isolation and characterisation of vitamin C, and another excellent quote attributable to this inventive scientist is ‘A vitamin is a substance that makes you ill if you don’t eat it’! Next time

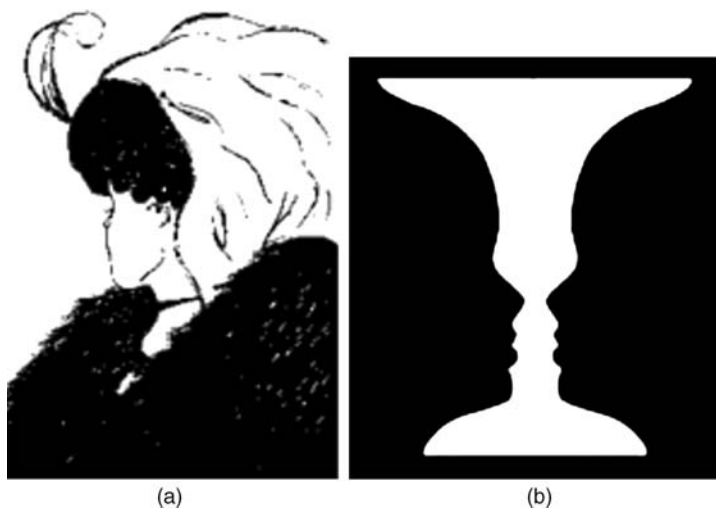


Figure 1.3 Shifting perspective

you have a problem to solve, try viewing the situation by looking at it from a different angle. For example, ask yourself how someone from another planet might solve the problem. Or, if you had unlimited money and resources, how that might make a difference to your approach. The new perspectives you adopt will hopefully help you be more creative.

- (4) **Make connections:** look out for opportunities that will enable you to meet and talk with colleagues from other disciplines, e.g. chemistry, engineering. If a creative environment is designed carefully (see Section 1.7), it ought to facilitate this sort of interaction. You can then exchange ideas and perhaps identify unexpected connections between the problems you are trying to solve and what appear to be unrelated phenomena. An excellent illustration of the creativity that can emerge following the interaction of individuals with markedly differing backgrounds and expertise is provided by the Ultracane, a mobility aid for the visually impaired (Figure 1.4). It employs an echolocation technique similar to that used by bats (it therefore also provides a very nice illustration of ‘bioinspiration’ – see Section 1.5.3.4). The Ultracane came about through interdisciplinary brainstorming sessions involving Dean Waters, an expert on bats, Deborah Withington, a biomedical scientist with expertise in human aural physiology, and Brian Hoyle, an engineer and expert on intelligent sensing.



Figure 1.4 The Ultracane mobility aid: ultrasound transducers convert echoes from objects to vibrations in ‘tactors’ in contact with the fingers of the hand holding the cane. This, in turn, enables the brain to build a spatial map of the immediate surroundings (Figure courtesy of Professor Brian Hoyle, University of Leeds.*)

* www.soundforesighttechnology.com

Another good way to broaden your horizons and make connections is to attend obscure seminars that may appear, on the face of it, to be of only peripheral interest and relevance. You will be amazed by the new perspectives and insights these experiences can generate.

Fortunately, there are literally hundreds of techniques available that can promote creativity by encouraging individuals to challenge assumptions, shift perspective and, perhaps most importantly, make connections between what often appear to be unrelated phenomena. We describe a selection of these techniques in the following section and you will find many more in the books listed in Section 1.14, Additional resources, at the end of this chapter.

1.5 Creativity techniques

Well-managed, interactive group sessions (Section 1.8) can be extremely effective in generating ideas and suggesting novel approaches to problem solving. However, in a group, the views of the more dominant team members can rapidly prevail, and the potentially valuable thoughts and ideas of the more shy and reticent participants may be lost during discussions. In this section we therefore place emphasis on the generation of ideas by individuals *prior* to structured group sessions.

1.5.1 Case study *Creativity in the Biosciences website*

The freely available *Creativity in the Biosciences* website (Figure 1.5; www.fbs.leeds.ac.uk/creativity) uses a research-led teaching approach for the promotion of creativity in students working as individuals and in teams.

The screenshot shows the 'Creativity in the Biosciences' website. At the top left, it says 'Creativity in the Biosciences FACULTY OF BIOLOGICAL SCIENCES'. To the right is the 'UNIVERSITY OF LEEDS' logo. Below the header, a user is logged in as 'David Adams (micdja)'. The main content area is titled 'Inspirational Researchers' and features a video player with a man speaking. Below the video, it says 'The Future of Antibiotics' and 'Featuring Alex O'Neill'. On the right side, there is a 'Menu' section with a list of steps: Step 1 Introduction, Step 2 Cutting Edge Research, Step 3 Creative Approaches, Step 4 Idea Incubation, Step 5 Submitting Ideas, Step 6 Group Sessions, View Tutor Notes, Chat Room, and My Notes. At the bottom right, there is a logo for 'The UK CENTRE FOR bioscience' and a quote: 'Discovery consists of seeing what everybody has seen and thinking what nobody has thought.' by Albert Szent-Gyorgyi. The footer contains the copyright information: 'Copyright © 2007-2010 University of Leeds | Profits'.

Figure 1.5 *Creativity in the Biosciences* website