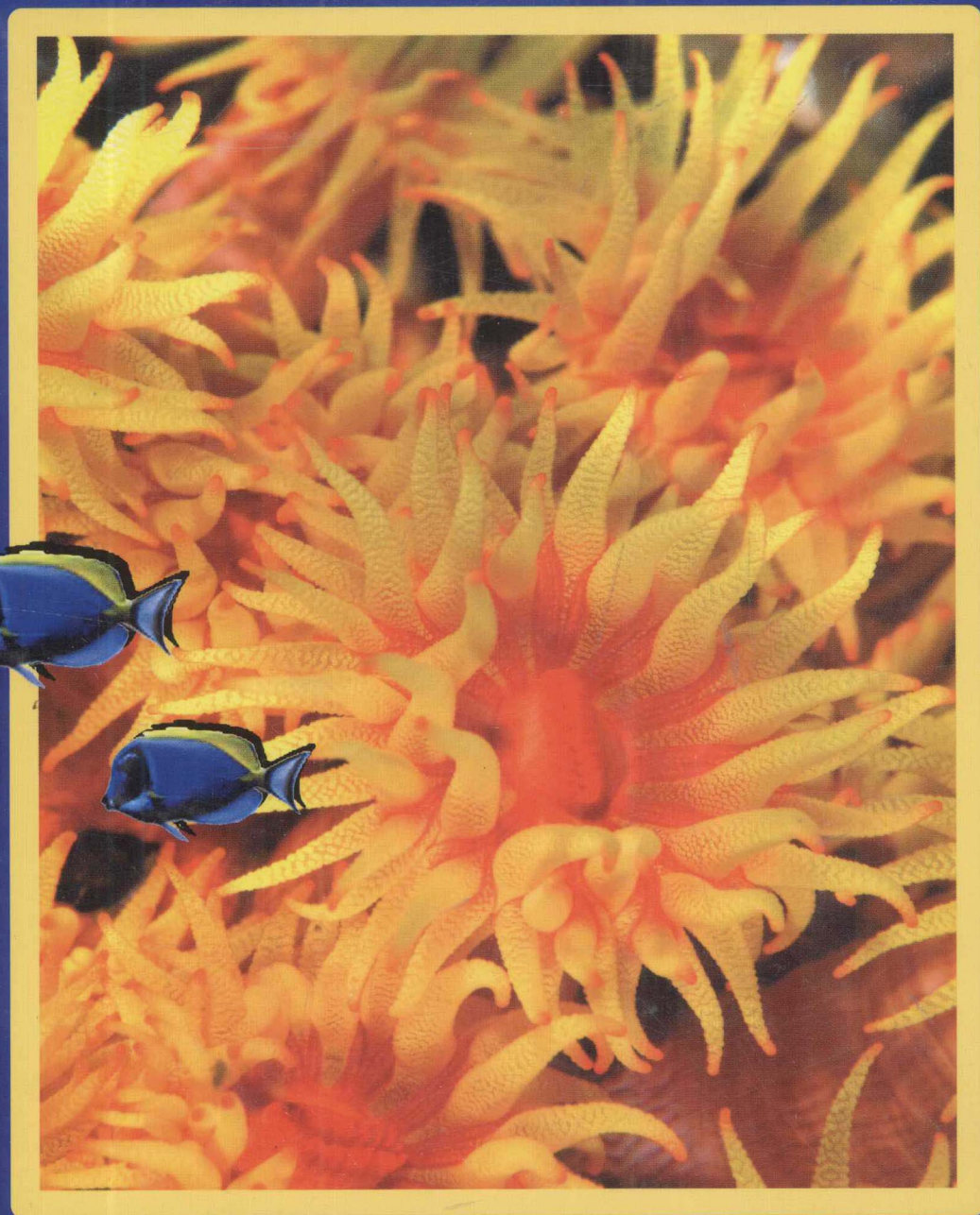


Marine Biology (sixth edition)



海洋生物学

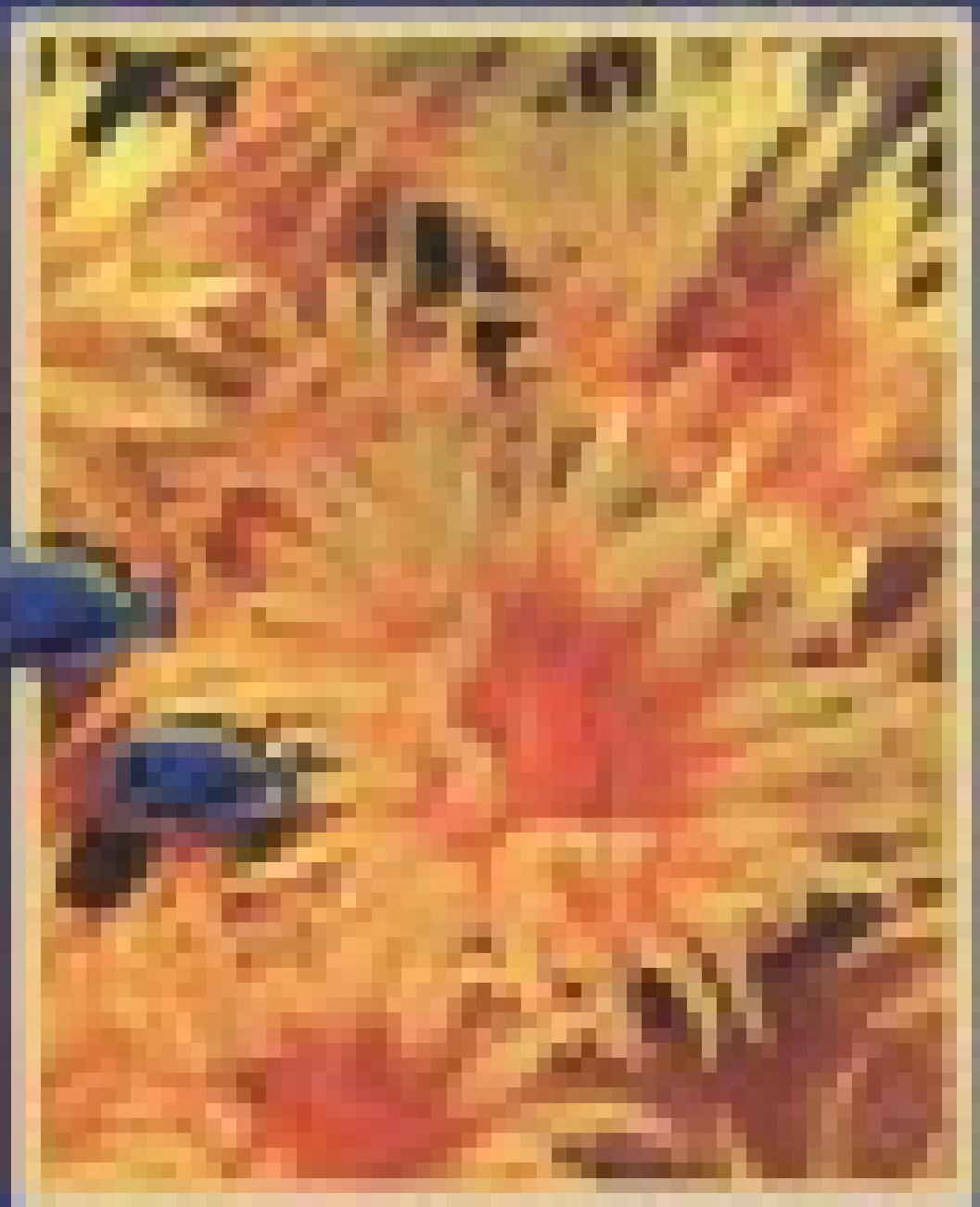
Peter Castro Michael E. Huber

第6版



北京大学出版社
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Advanced Biology



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第 6 版

[美] Peter Castro Michael E. Huber 著

茅云翔 主译 隋正红 周红 胡景杰 朱明 孔凡娜 译



北京大学出版社
PEKING UNIVERSITY PRESS

北京市版权局著作权合同登记号: 01-2007-3417

图书在版编目(CIP)数据

海洋生物学: 第6版/(美) Peter Castro, Michael E. Huber 著; 茅云翔等译. —北京: 北京大学出版社, 2011. 1

ISBN 978-7-301-16013-8

I. 海… II. ①P…②M…③茅… III. 海洋生物学—教材 IV. Q178.53

中国版本图书馆 CIP 数据核字(2009)第 187708 号

Peter Castro, Michael E. Huber

Marine Biology

0-07-321577-5

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书 名: 海洋生物学(第6版)

著作责任者: [美] Peter Castro Michael E. Huber 著 茅云翔 等译

责任编辑: 黄 炜

标准书号: ISBN 978-7-301-16013-8/Q · 0121

出版发行: 北京大学出版社

地 址: 北京市海淀区成府路 205 号 100871

网 址: <http://www.pup.cn> 电子信箱: zpup@pup.pku.edu.cn

电 话: 邮购部 62752015 发行部 62750672 编辑部 62752038 出版部 62754962

印 刷 者: 北京大学印刷厂

经 销 者: 新华书店

889 毫米×1194 毫米 16 开本 31.75 印张 965 千字

2011 年 1 月第 1 版 2011 年 1 月第 1 次印刷

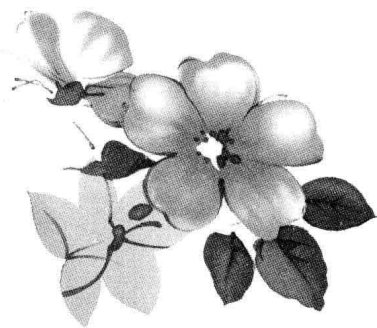
定 价: 65.00 元

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献给所有未来的海洋生物学家
—Peter Castro—

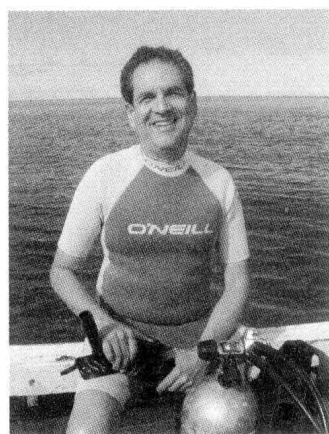


感谢 Mason, Erin 和 Kerry 全心的帮助,感谢我父母的不懈支持
—Michael Huber—

作者简介

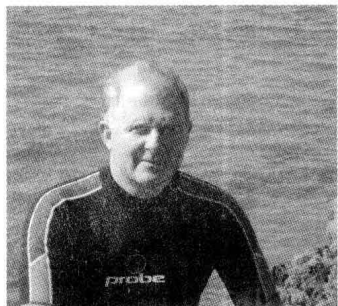
彼得·卡斯特罗(Peter Castro)博士

卡斯特罗博士的家乡是加勒比海岛国波多黎各,高中时代的一次珊瑚礁实地考察使他意识到自己志向是成为一名海洋生物学家。在波多黎各马亚古兹(Mayaguez)的波多黎各大学获得生物学理学学士学位后,卡斯特罗离开了温暖的加勒比海来到气候同样温暖的夏威夷,在位于檀香山玛诺亚(Manoa)的夏威夷大学从事海洋动物学研究并获得了哲学博士学位。随后,卡斯特罗博士来到加利福尼亚斯坦福大学霍普金斯海洋研究站(Hopkins Marine Station)从事博士后研究,在那里他首次体验到了寒冷的海水。目前,卡斯特罗博士在位于波莫纳(Pomona)的加利福尼亚州立工业大学(California State Polytechnic University)担任教授。其间,他历时18年利用业余时间获得了其家乡学校的历史与艺术史文学学士学位。卡斯特罗博士能流利地使用5种语言,曾作为富布赖特基金会专家(Fulbright Scholar)在前苏联用英语和西班牙语讲授海洋生物学课程。由于卡斯特罗博士的专业研究方向是珊瑚礁共生甲壳动物及其他无脊椎动物,在世界各地哪有温暖的海水,哪儿就可以见到他潜水的身影。在过去的10年中,卡斯特罗博士还致力于深海蟹类系统分类研究,其工作地点主要在法国巴黎。



迈克尔·胡伯(Michael Huber)博士

迈克尔两岁的时候从阿拉斯加的湖泊中抓到了他的第一条大马哈鱼,水生生物立刻迷住了他。在整个学生时代,他对海洋生物学的兴趣不断增加。进入位于西雅图的华盛顿州立大学后,他接连获得了动物学理学学士和海洋学理学学士两个学位。然后,他整个冬季在阿拉斯加管理一个与穿越阿拉斯加石油管道项目相关的实验室。随后,他进入了位于圣迭戈的加州大学斯克里普斯海洋研究所(Scripps Institution of Oceanography)研究生院。1983年,迈克尔获得博士学位,其研究内容是与珊瑚共生的蟹类。迈克尔博士留在斯克里普斯海洋研究所继续其生物学研究,这期间他研究的内容十分广泛,从单细胞藻类的遗传学、细胞生物学到中间水层生物的生物发光现象都有所涉及。1988年,他到了巴布亚新几内亚大学生物系并担任了该大学 Motupore 岛研究站的主任,并有机会研究世界上最蔚为壮观的珊瑚礁。他还逐渐涉入海洋环境科学的研究,尤其关注于珊瑚礁、红树林、海草床,以及其他热带环境系统。1994年,迈克尔博士离开巴布亚新几内亚,担任了澳大利亚詹姆斯·库克大学(James Cook University)俄耳甫斯岛研究站(Orpheus Island Research Station)的科学指导,该站坐落于澳大利亚大堡礁,此时他对海洋环境科学的兴趣愈发浓厚。1998年,迈克尔博士成为一名专职的环境顾问,负责就海洋环境议题和制订环境保护计划向国际机构、各国政府和私人企业提供科学资讯和建议。迈克尔博士目前担任 GESAMP 主席,该机构是一个负责就海洋环境议题向联合国系统提供建议的科学组织。目前该机构正在协助建立一个常设的联合国机构,以便对全球海洋环境状况进行评估并向各国政府报告。



迈克尔博士现在与他的妻子和两个孩子居住在澳大利亚布里斯班。他兴趣广泛,喜欢垂钓、潜水、游泳、爵士和摇滚音乐,还喜欢阅读和园艺。

前 言

美丽神秘、汹涌澎湃的海洋使全世界的人为之着迷,其中当然也包括那些参与海洋生物学课程学习的大学生。海滨游览、器械潜水、休闲垂钓、水族观赏和观看关于海洋的优秀电视纪录片,引发了人们对海洋生物的兴趣,因此许多学生选修海洋生物学课程是这些兴趣的自然流露。许多学生还十分关注人类对海洋生态系统不断增加的影响。第六版《海洋生物学》的写作目的在于向读者提供严谨的海洋生物学科学知识介绍,同时巩固和提升读者们对海洋生物的兴趣。

本书的使用者是高中生、本科生、研究生、成教学生以及其他领域的不参加正规课程学习但也对海洋生物感兴趣的人们。令人欣慰的是,甚至一些专业海洋生物学家也发现了本书的价值。在满足这些读者需求的同时,我们的写作内容还尽量满足学院和大学中那些更低层面、非理科专业学生的需求。对这些学生而言,海洋生物学仅是一门第三层次的选修课程,常常是为了满足其通识教育的要求。因此,我们仔细筛选了一些可靠的基本科学知识,包括科学研究方法、物理科学和基础生物学的基本原理。本书目的是致力于将这些基本科学与激动人心、最新的海洋生物学进展有机结合为一个整体。我们希望这种方式能表明从物理科学到生物科学都是平易实用的,所有的学科都不令人望而生畏。为了达到这一目的,我们采用了一种通俗的写作风格,更着重于对概念的理解,而不过分强调对细节和术语的把握。

我们知道并不是所有海洋生物学课程都需要介绍一般的科学知识,要么是课程不是为了满足通识教育的需要,要么就是学生们已经具备了相关的科学背景知识。有些海洋生物学课程要求先修生物学或其他课程,而有些则不必。为了平衡教师面对这两种情况时的不同需要,本书在基础科学材料的使用,标题呈现的顺序,以及重点内容和叙述方式等方面进行了最大限度的灵活设计。考虑到海洋科学相关职业的需要,我们努力满足从综合器械潜水专业到生物学专业等不同专业学生的需求和期望。当然除了大学生外,我们希望各类读者也能发现本书的价值并能从中享受到乐趣。

本书从前至后贯穿四大主题:第一个主题对海洋环境研究所需的基础科学进行了概述(前面已提到);第二个主题关注于生命自身及广泛的多样性,这种多样性不仅体现在物种分类上,而且在于其结构、结构和生态方面。第三个主题是关于生态系统方法,利用这种方法将生命形式多样性与自然环境和生物环境影响之间的关系有机结合为一个整体。最后一个主题是关于人类与海洋环境相互作用,不论这种作用是正面的还是负面的,但是两者之间的相互联系正逐年增强。

《海洋生物学》第六版强调了用全球化的视野来认识海洋,全世界的海洋是一个统一的整体,不能像看待自家后院那样理解这个整体。对许多学生而言,这是一种全新的视角。实现这一目标的整体策略之一就是书中包含了许多经过认真筛选的实例,这些实例来自全世界许多不同的地区和不同的生态系统,并不仅仅局限于北美洲,从而使尽可能多的学生能够在书中发现一些与他们本地区或曾去过的地方相关的事情。我们希望通过这种方式激发学习者思考这样一个问题,即自家所在的海边和对我们生活影响巨大的整个海洋之间所存在的千丝万缕的联系。

第六版中的变化

我们已经介绍过《海洋生物学》第六版中一个新的特点,即每章中都包含了一个“放眼科学”模块,这是一篇关于正在进行或计划进行的科学研究中某一特殊方面的小品文。这篇小品文并不是为了简单地呈现事实资料和总结性结论,其重点在于使学生能够管窥科学家们实际上是在做什么——所提出的科学

问题、其重要性所在以及一个科学家或研究团队是如何着手解答这些问题的。我们希望通过这些小品文使科学不再显得遥不可及,并使学生们更好地了解科学探索的日常运作方式。

与以前的版本一样,为了反映最近的事件、最新的研究和观点的变化,也为了包含书评人要求添加的资料,我们对本书内容进行了全面的更新。以下列举了部分本书修订和添加的内容:

- 描述了美国探险行动(the United States Exploring Expedition),即威尔克斯探险(Wilkes Expedition)在海洋生物学上的重要性,这次探险比“挑战者”号探险还要早;
- 选用2004年12月发生在印度洋海啸的深度报道材料对“杀人浪”阅读模块进行了改写;
- 对叶绿体内共生起源的叙述进行了更新;
- 对表示原核生物代谢的表5.1进行了全面修改,使之更简洁、更宏观、更易理解;
- 一张新的脊椎动物和无脊椎动物两大类群内系统发生关系的分支图;
- 对表示不同种类鲸的图9.18进行了扩展;
- 一个关于深海珊瑚礁群落以及人类对其影响的新的阅读模块;
- 关于海葵-小丑鱼共生关系有益于宿主的新发现;
- 关于营养能级的补充信息;
- 描述了卡特里娜飓风的影响。

除此之外,我们还照常更新了论据和数据,改正了错误,将一些章节进行重组织,以使内容更加均衡,逻辑上更流畅。在每一次修订,我们都设法增加一些插图和照片,在第6版中,我们采用了更多开放式的内部设计,我们认为这将更好地吸引学生,使他们对海洋生物更加入迷。

内容组织

本书的所有内容被划分为四大模块。由第1章至第4章构成的第一模块向学生们概述了海洋生物学及其学科基础。第1章的内容是介绍海洋生物学的历史,同时阐述了科学研究的基本原则和方法。通过这样一种特定的方式,我们想强调科学是一种循序渐进,不断发展的人类事业。我们认为十分关键的一点,就是让学生们明白科学研究是怎样进行的,以及科学研究的目的是什么,同时还要了解科学的局限性,知道科学研究永无止境。第2章和第3章是对海洋地质、海洋物理和海洋化学等学科基本知识的介绍。《海洋生物学》中包含了大量的这些方面的信息,但与其他书相比,其重点是强调它们对理解海洋生态系统的重要性。在这两章中,我们尽可能言简意赅地系统概述海洋环境中与生物学最为密切的众多非生物因子。例如,将浪波折射现象与潮间带群落(第11章)有机联系,将河口循环作为河口生态系统(第12章)的一部分内容进行讨论。这种强调物理、化学环境对生物有机体重要性的撰写方式在本书中贯穿始终。同时,考虑到通识教育的需求,对先修课程的要求,以及学生知识背景等方面的因素,本书为教师有效地使用相关材料提供最大的灵活性。第4章“生物学基础”简要地回顾了一些生物学的基本概念。在概述基础生物学时,我们努力平衡不同知识背景学生的需要,因为有些学生可能对生物学知识知之甚少,未受过大学教育,而有些学生已经学过了多门生物学课程。根据学生水平的差异,教师们可以选择性地对第4章内容进行讲解,既可以全面讲授,也可以作为复习阅读材料,甚者省略本章内容而依靠后续章节中“正文术语”中的条目来让学生回忆一些关键词的定义。

第二模块(第5章至第9章)从有机体生物学的角度概述了海洋生物的多样性。与第一模块相似,我们首先提供了介绍性的信息,随之在后面的章节中对其进行了回顾和扩展。在讨论各种各样的分类单元时,我们着眼于功能形态学、生态与生理适应,以及经济上的重要性和其他对人类的意义方面。尽管在书中介绍了一幅为人们广泛认可的关于无脊椎动物和脊椎动物系统发生关系的进化分支图,但我们并未着力强调分类和系统发生。与书中其余部分相似,我们从世界各地选择生物用于照片、素描和彩图等图例,但更多的还是着眼于北美洲的生物。书中提到生物体时使用的是其最被广泛认可的普通名称。当一章中首次出现某一类群生物时,会在括号中注明一两个常见属或重要属的属名,我们并未尝试提供涵盖各

属的目录表。本书所涉及的生物类群已被《FAO 物种目录》(FAO Species Catalog)以及《物种鉴定指南》(Species Identification Guides)等参考资料覆盖,因此书中物种命名绝大部分遵照这些资料。

本书的第三模块(第 10 章至第 16 章)以海洋生态学一些基本原理的介绍(第 10 章)为起点,带领读者对世界大洋主要环境进行了一次生态之旅。与第 4 章一样,第 10 章中一些重要的概念也在其他章节“正文术语”中进行回顾复习。在第三模块的其余六章中,从近岸到离岸,从浅海至深海,依次描述了每一种环境的物理特征以及生活其中的生物对环境的适应和环境与生物之间的相互作用。这种公认的、人为设定的顺序与绝大多数本书评阅人的授课顺序是一致的,但在设计章节时使其能够调整顺序,从而满足教师们的各种风格和需要。大多数章节都包括了用标准研究编码的一般性食物网,以表明营养关系的属性。

最后的第四模块(第 17 章至第 19 章)将着眼点放在了人类与全球海洋间相互作用的方方面面,即我们对海洋环境的利用和影响,以及海洋对人类经验的影响。这一部分针对许多学生共同关心和关注的问题,系统性地呈现了最新的、综合性的观点。第 17 章的内容是关于海洋资源利用,在其中我们不仅关注了传统的渔业和海水养殖资源,而且还包括了更加现代化的资源利用,例如海洋天然产物在药学上的应用,以及将基因工程技术应用于海水养殖等方面。第 18 章讨论了人类活动造成的海洋环境退化问题,同时探讨了海洋保护和生境恢复等应对策略。本书以一篇关于海洋与人类文明之间关系的短文(第 19 章)作为全部内容的结束,希望能够激发学生们认真思考整个海洋在过去和未来对于我们人类命运的重要性。

致谢

Bill Ober 和 Claire Garrison 为本书的插图带来了全新的面貌,感谢他们再一次的精彩工作。Jamie O'Neal 的全新设计使我们每个人都感到欣喜。还要感谢很多人为本书增添大量新图片所作出的贡献,特别是对提供了许多精彩照片的 A. Charles Arneson 表达谢意,同时感谢 LouAnn Wilson 在查找新图片时所付出的辛勤劳动。我们感谢 McGraw-Hill 出版社的全体本书编辑,特别是发行人 Margaret Kemp、策划编辑 Debra Henricks、项目经理 Joyce Watters 和校审编辑 Karen Dorman,感谢他们在处理本书大量细节时的耐心、帮助和有效的工作。

还要特别感谢我们的学生、朋友、同事、恩师和审稿人,他们帮我们解决疑难、指出错误、提出建议,大大提高了本书的质量。尽管如此,书中的错误和不足仍在所难免,我们愿意承担全部责任。

我们还要特别感谢提供资料和图片的科研人员,以及在本书的新模块“放眼科学”编辑过程中提供帮助的人们,他们是:

David Crewz 博士	佛罗里达圣彼得堡鱼类与野生生物研究所
Kerstin Fritsches 博士	澳大利亚昆士兰大学
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James Lindholm 博士	加利福尼亚州 Pflieger 环境研究所
Michael Moore 博士	马萨诸塞州伍兹霍尔海洋研究所
Peter Rona 博士	新泽西州罗格斯大学
K. Timmis 博士/教授	德国国家生物技术研究中心

评阅人

以下专家对本书的第五版进行了批评指正,并对第六版的编写提纲提出了宝贵的建议。他们是:

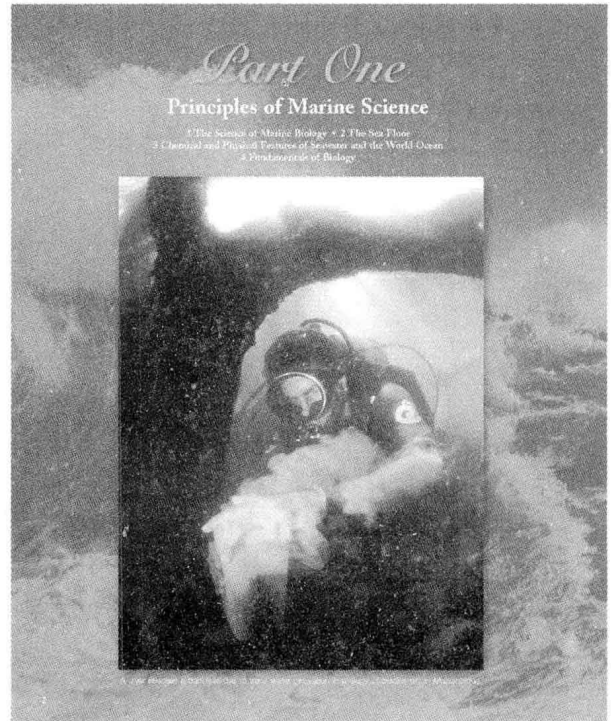
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坦帕大学
南佛罗里达社区学院

本书的学习体系

章：全书各章节被划分成四大模块。为使教师们在选择讲授的题目更加方便，各章节在写作时采用了短小精炼、便于利用的单元形式。



重要概念阐述：对最重要的术语和观点在各段落之后进行重点介绍。

Scientific Theory A hypothesis that is accepted as "true" for the time being because it has passed test after test and is supported by a large body of evidence.
 • Chapter 1, p. 10

拓展阅读：“大众关注”部分所列的文章主要发表在《科学美国人》、《发现》和《国家地理》等期刊上，适合于已掌握初级科学背景知识的学生；“深度阅读”部分的材料面向的则是希望对某一主题进行深入详细研究的学生。海洋生物学在线学习中心可以提供部分文章的可用链接。

Deep-Water Coral Communities

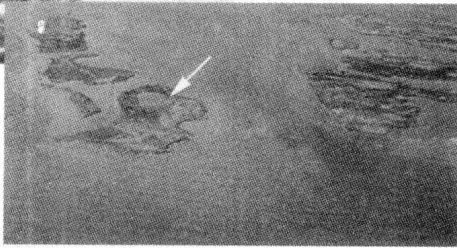
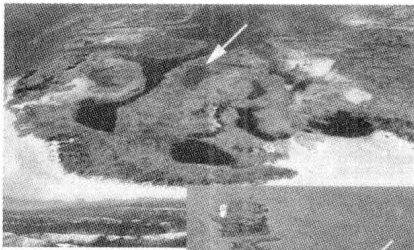
The corals that build tropical coral reefs bask in the sunlight of shallow water, but more than 700 species of corals live in the perpetual cold and darkness of deep water. Deep-water corals occur in all the world's oceans to depths of over 6,000 m (20,000 ft). They do not harbor zooxanthellae, which in the absence of sunlight would be of no use to the hard coral. They feed by capturing zooplankton with their tentacles, and generally grow where there are strong currents to bring in food.

About 20 species of marine corals appear to contribute to reef mounts on the sea floor known as oolites. The mounts are raised along on the continental shelf and on seamounts and other underwater features. The oolites are composed of the skeletal remains of a plan forams, for example, this occur in water as shallow as 40 m (130 ft). These structures are often called "coral reefs" but the term "reefs" was originally a misnomer for areas of hard bottom inshore around for reefs 40 m high, and the geological definition of coral reefs refers to a coral reef system. The term "reef" is not usually applied to coral mounts. Coral mounts contain large amounts of calcium carbonate, and they are mostly made of calcium carbonate. It also appears that the mounts are not so much because of coral growth as because of water circulation. It seems that the four sediment accumulation. Scientists have also reported that the mounts might form around coral species and rely in part on

The largest known deep-water coral mounds, dominated by the branching coral *Leprosyllis verticillata*, are found in the northeastern Atlantic

off the coast of Belize and Guatemala. Individual mounds grow to a height of more than 30 m (100 ft) above the surrounding muddy bottom, with a base more than 5 km (3 mi) in diameter. Mound components can extend for as far as 45 km (30 mi). Whether you visit these oral reefs or not, Lophelia mounds support rich and diverse communities. The reefs are also important for the local economy, as they provide a surface versus other aquatic species can attach. Unfortunately, the reefs about 25% obsolete, and known to jeopardize with Lophelia mounds, but so far, no individuals have found more than 1,300 live Lophelia species. The reefs will be lost. Lophelia mounds in the northeastern Atlantic have been known since the 19th century, but until recently, they studied themselves only; in the last two decades when improvements in deep-sea exploration technology revealed that they extend and diversify. Mound reefs by Lophelia and other deep-water corals occur in most of the world's oceans and support similarly diverse communities, and new research now regularly documents an deep-sea exploration continues.

Like shallow communities (see "Biodiversity in the Deep Sea," p. 444), deep-water coral communities on the continental slope are increasingly threatened by trawling. Many shallow-water fisheries are depleted, forcing trawlers into deeper waters. The trawls scatter the fragile corals and dig great gouges in the sea bed. A number of countries have prohibited trawling in areas of known coral mounds, but unfortunately many of these diverse communities remain unprotected.



Effects of Hurricane Katrina, August 2005 (bottom) on barrier island off the Louisiana coast.



intact *Lophelia pertusa* mound



Trail damage to a *Lepomis* mound

新！ 放眼科学：这一模块介绍了海洋生物学领域的最新科学研究和技术进展。列举的题目包括：海洋观测系统，深海钻探，乌贼的雄性拟雌，海草床修复，寻找大王鱿等等。

EYE ON SCIENCE

Ocean Observing Systems

The ocean is constantly changing, and what happens in one place often has far-reaching impacts on the rest of the planet. Unfortunately, researchers lack the info and equipment to give us a picture of a particular time and place, and though remote sensing can give us a series of snapshots we still don't get an unobstructed picture. Satellite provides a more continuous view, but only of the very surface. To really understand the ocean, we need to know what's going on just below the surface. Thus, an integrated ocean observing system is a must. The ocean observatory, now, is technology has already been developed. Satellites, moored and drifting instrument buoys, waterborne instruments, ROVs and AUVs, underwater cameras, and other devices are already in use (see "Marine Ecology Today," p. 16). Some of these have been deployed on a very regular basis, but the data they collect is often limited to a few temperature and salinity are scattered throughout the globe. Dropped below a ship or airplane, each float descends to a depth of 2,000 m (6,600 ft) after which the current by itself takes it, and surfaces to transmit data via satellite before sinking to start a new cycle. The cost for the float is about \$10,000, and the cost of a 2,000-ft float will be the exact same. But the payoff is in data and in the ability to track the ocean

Most ocean observation systems so far, however, cover only a very small part of the ocean, and these are often limitations. Surface buoys can be powered by solar panels and transmit raw data by satellite, but neither of these options work underwater. Subsurface instruments have to be regularly retrieved to recharge batteries and download data. Data can also be transmitted underwater by sound waves but only over relatively short distances, so instruments that communicate by sound must be tended by ships or located near hydrophones connected to shore. As one scientist has said, one of the big problems in studying the ocean has been the lack of "electronic outlets and phone jacks on the seafloor."

All that is set to change. Today marine scientists arrive on large-scale ocean observations. Networks of cable will bring power and communications to a variety of equipment on the sea floor and in the water column. In addition to permanent instrumentation, there will be docking stations where free-ranging AUVs can charge batteries and download

photographs and data, junction boxes where additional instruments can be plugged in as new experiments are designed and new technology becomes available, and hydrophones to gather data from below and even instruments attached to animals, all augmented by ship- and satellite-based systems.

institutions of open portfolios, the Long-term Ecological Observation (LEO) list of the coast of New Jersey, commenced in 1994. Another, the Havesi-2 Observatory (H2O), was established in 1998 when a junction box with several instruments was attached to a decommissioned telephonic cable midway between California and Hawaii. Another example is the Monterey Accelerated Research System (MARS), established off Monterey, California, in 2005. These and other observatories at locations around the world cover relatively small areas but are the leading sources of ocean data. Systems being planned: the North East Pacific; Three-dimensional Observing System for the Tropics (TOST); and the Tropical Atlantic Observing System (TAOS). The latter is established a system of the west coast of North America and extends to the Gulf of Mexico, the Caribbean Sea, and the Atlantic Ocean. Columbia by Oregon. Similar systems are being developed in Europe and Japan. Dozens of countries have agreed to one day network these larger systems into a single Global Ocean Observing System (GOOS) that will provide a continuous window on the entire world ocean.

These ambitious plans will take decades to come to fruition but ocean observing systems will greatly improve our understanding of the ocean and have many practical benefits. Students and teachers around the world will be able to learn firsthand what's going on in the sea. We will have ocean-internal weather forecasting and better warning systems for earthquakes, tsunamis, and storms. Style of all kinds will have detailed, reliable forecasts of sea conditions. Scientists hope not only to monitor fish populations but also to predict their reproductive success and food supply. There are many other benefits of ocean observatories: studies one day save both lives and money, and help fishermen make wiser use of the oceans—and indeed the entire ocean realm.

For more information, explore the links provided on the Myriad Genetics Online Learning Center.

The diagram illustrates a coastal system with the following components:

- House:** A small building on the left side of the land.
- Storm basin:** A curved line representing a breakwater or barrier.
- Meteorological mast:** A vertical pole with a sensor at the top, located on the right side of the land.
- Undersea node:** A sensor located on the seabed, connected to the meteorological mast by a cable.

The diagram also shows the following data and parameters:

- Data and power transmission:** A line connecting the undersea node to the meteorological mast.
- Currents, pressure, salinity:** Parameters measured by the undersea node.
- Salinity, temperature, Oxygen, CO₂:** Parameters measured by the meteorological mast.
- Turbidity and fluorescence:** Parameters measured by the undersea node.

Some components of ocean observing systems being installed or planned around the world.

The diagram illustrates the AUV system components and deployment. A cable connects the 'Surface buoy' and 'Tagged whale' to the 'Subsurface buoy'. The 'Subsurface buoy' is connected to the 'Dock' and 'AUV'. The 'AUV' is connected to the 'Free float', 'Hydrophone', 'Current meter', and 'Nadir meter'. The 'Free float' is connected to the 'Junction box'. The 'Junction box' is connected to the 'Dock' and 'AUV'.

Cameras and lights

Borehole seismometer

Diagram illustrating various monitoring methods:

- Ship based monitoring
- ROV
- Glider
- Sensory

because they allow scientists to rapidly analyze huge amounts of information. Space technology has also aided the study of the sea. Satellites peer down at the ocean and because they are so far away can capture the big picture, viewing broad areas of the ocean all at once (Fig. 1.14).

With the aid of computers, scientists use the information gathered by satellites to measure the temperature of the sea surface, track ocean currents, determine the

abundance and kinds of organisms present, and monitor human impacts on the ocean. Much of our knowledge of large-scale features like ocean currents has been provided by this **remote sensing** technology, or technology used to study the earth and its oceans from afar. The technology is also being applied to smaller scales. For example, satellites are used to track the migrations of whales, fish, and other organisms that have been fitted with miniature trans-

mitters. Electronic buoys released at oil spill sites drift along with the oil and are tracked by satellite to monitor the path of the spill. These are just a few of the many and ever-increasing applications of remote sensing.

be learned, however, and the oceans remain a realm of great mystery and excitement.

The Scientific Method

Marine biology is an adventure, to be sure, but it is also a science. Scientists, including marine biologists, share a certain way of looking at the world. Students of marine

biology need to be familiar with this approach and how it affects our understanding of the natural world, including the ocean.

We live in an age of science. Advertisers constantly boast of new "scientific" improvements to their products. Newspapers regularly report new breakthroughs, and many television stations have special science reporters. Governments and private companies spend billions of dollars every year on scientific research and science

education. Why has science come to occupy a position of such prestige in our society? The answer, quite simply, is that it works! Science has been among the most successful of human endeavors. Modern society would be impossible without the knowledge and technology produced by science. The lives of almost everyone have been enriched by scientific advances in medicine, agriculture, communication, transportation, and such modern, useful fields.



Exploration

The Marine Biology Online Learning Center is a great place to check your understanding of chapter material. Visit www.mhhe.com/castrohuber6e for access to interactive chapter summaries, key terms, and quizzes! Further enhance your knowledge with marine biology videoclips and web links to chapter-related material.

Critical Thinking

1. In unusually cold winters the northern Black Sea sometimes freezes while the nearby Adriatic Sea usually doesn't even if it is just as cold. Freshwater runoff gives the surface of the Black Sea a low salinity of about 18‰. What would you guess about the salinity of the Adriatic?
2. Just for the fun of it, someone in Beaufort, South Carolina, throws a message in a bottle into the sea. Some time later, someone in Perth, on the west coast of Australia, finds the bottle. Referring to Figure 3.20 and fold out map of this book, can you trace the path the bottle probably took?
3. If you owned a inside home and a bad storm brought heavy winds and high surf to your coastline, would you prefer it to be during a new moon or a quarter moon? Why?
4. Most tsunamis occur in the Pacific Ocean, as indicated by the map in the "Waves That Kill" boxed reading (see p. 62). How would you explain this?

For Further Reading

Some of the recommended reading may be available online. Look for live links on the Marine Biology Online Learning Center.

General Interest

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Kuring, R., 2001. The physics of... deep-sea animals: They love the pressure. *Discover*, vol. 22, no. 8, August, pp. 26-27. Deep-sea organisms feel the squeeze under the pressure of the deep.

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Mathewes, R., 1997. Wacky water. *New Scientist*, vol. 154, no. 2087, 21 June, pp. 40-43. Plain water, so familiar to us, still holds secrets.

Steele, R., 2004. Rogue Waves. *Discover*, vol. 25, no. 7, pp. 48-55. July. Rogue waves are almost impossible to catch in the real ocean so a team of oceanographers tries to understand them in the laboratory.

In Depth

Clarke, P. U., N. G. Pisau, T. F. Stocker, and A. J. Weaver, 2002. The role of the thermohaline circulation in abrupt climate change. *Nature*, vol. 415, no. 6874, pp. 863-869.

Johnson, G. C., R. M. Siayan, W. S. Kessler, and K. E. McTaggart, 2002. Direct measurements of upper ocean currents and water properties across the tropical Pacific during the 1990s. *Progress in Oceanography*, vol. 52, no. 3, pp. 31-61.

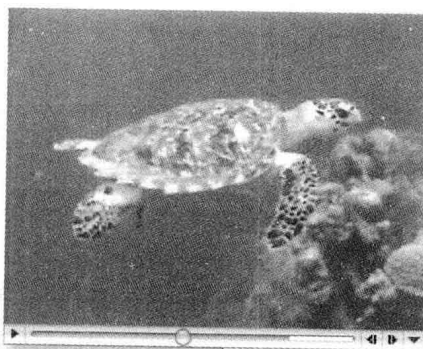
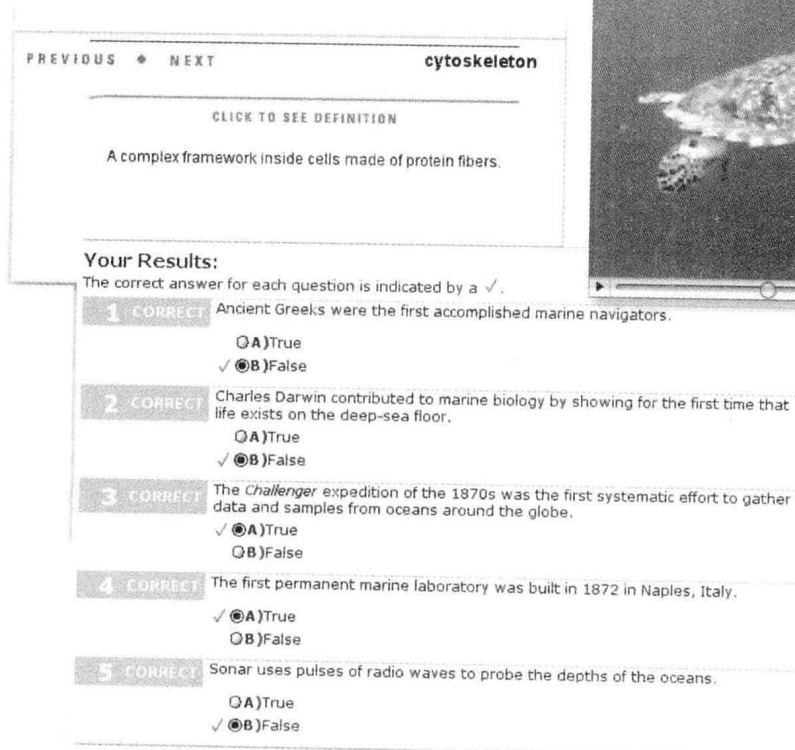
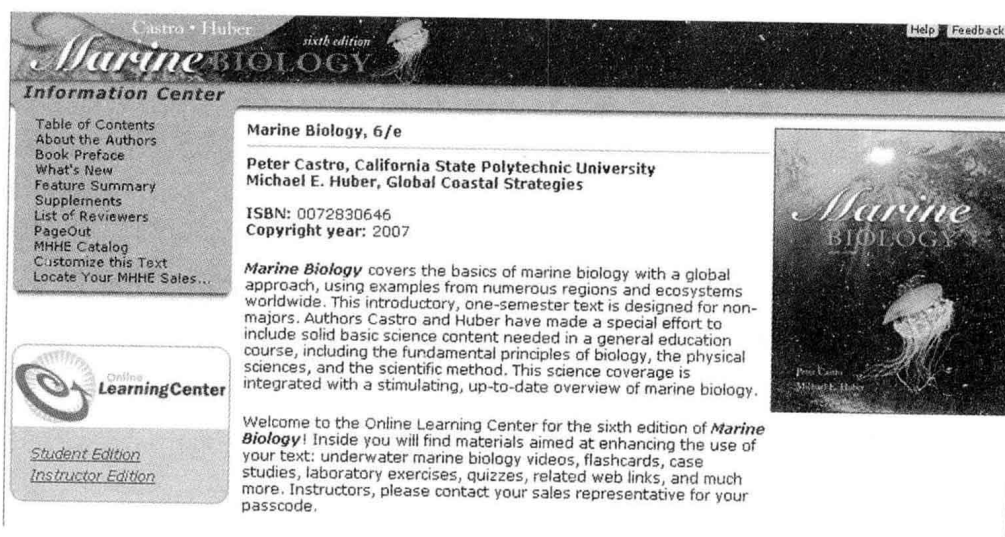
Koehn, W. and H. W. Ducklow, 2001. JGOFS synthesis and modeling: The North Atlantic Ocean. *Deep Sea Research Part II: Typical Studies in Oceanography*, vol. 48, no. 10, pp. 2191-2154.

新！ 交互探索：各章最后的互动探索模块可与海洋生物学在线学习中心链接。鼓励学生们访问网址 www.mhhe.com/castrohuber6e，在网站上可以进行章节测验、互动式章节总结，可以获得关键词教学卡片、海洋生物学视频剪辑和各章节相关材料的网络链接。

熟练运用《海洋生物学》在线学习中心

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教师会很欣赏有密码保护的教师手册, 含有书中所有照片和图像的 Powerpoint 图片库, 实验练习以及其他许多东西。

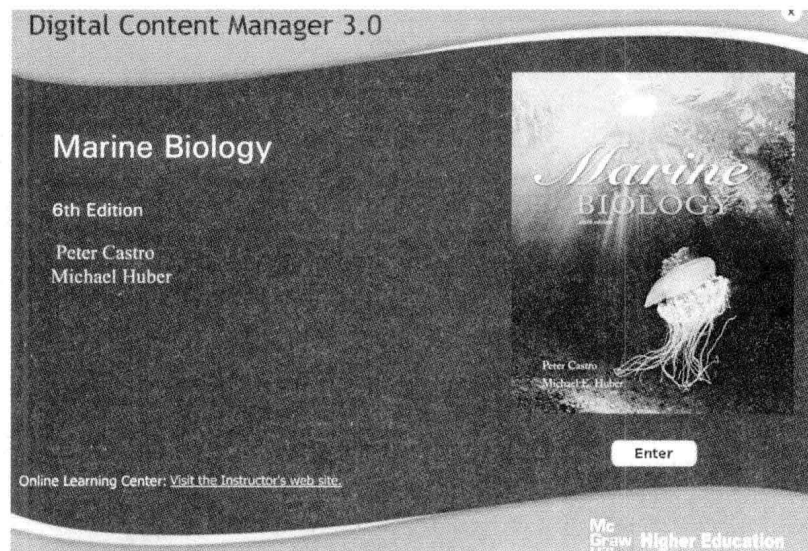


学生将从交互式测验、关键术语抽认卡和网上链接中受益。另外还有水下视频片段、海洋动物以及它们的行为和生态系统的特色镜头。

附 属 材 料

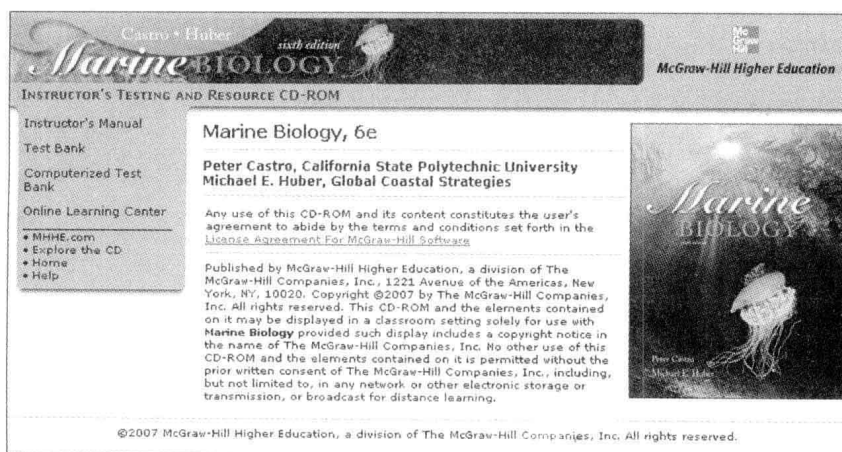
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这个有用的工具包含教材中所有的图像、照片和表格,可用于多媒体。还包括来自于 Scripps 技术研究所的视频片段,还有其他海洋生物学视频片段和照片。



教师手册

由彼得·卡斯特罗博士准备,这个有用的手册包含每一章的大纲和总结、视听材料和软件的清单以及对书中批判思考的答案。教师从中还可以得到关于向学生进行概念讲述以及课上材料组织的建议。教师手册可通过海洋生物学网上学习中心中有密码保护的部分得到,也可以通过教师试题资源 CD-ROM 获得。

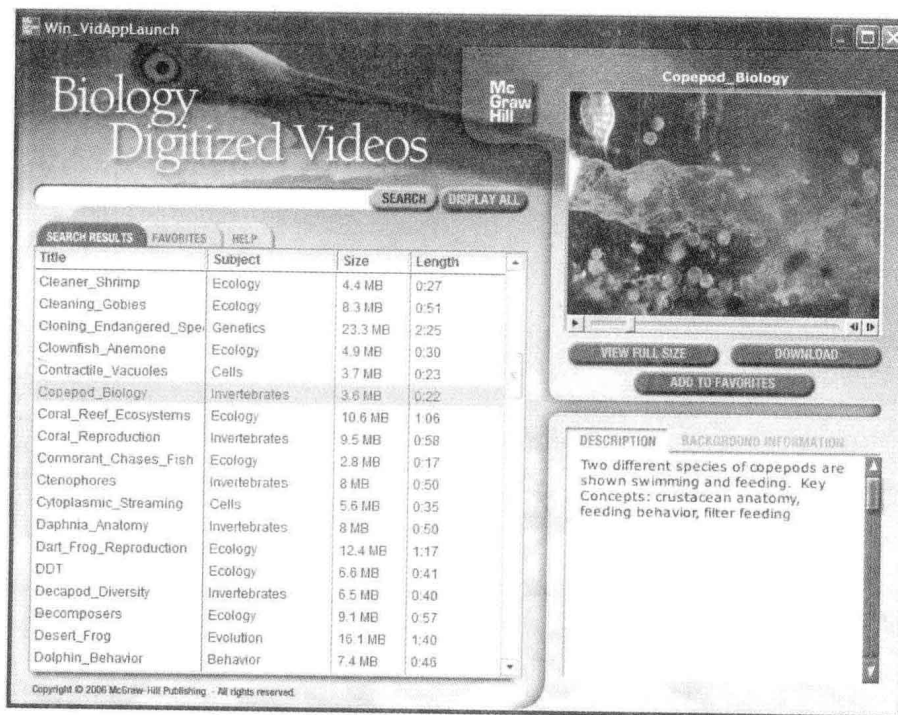


教师试题和资源 CD-ROM

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新! 麦格劳-希尔:生物数字视频片段

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