我国近海海洋综合调查与评价专项成果
“十二五”国家重点图书出版规划项目

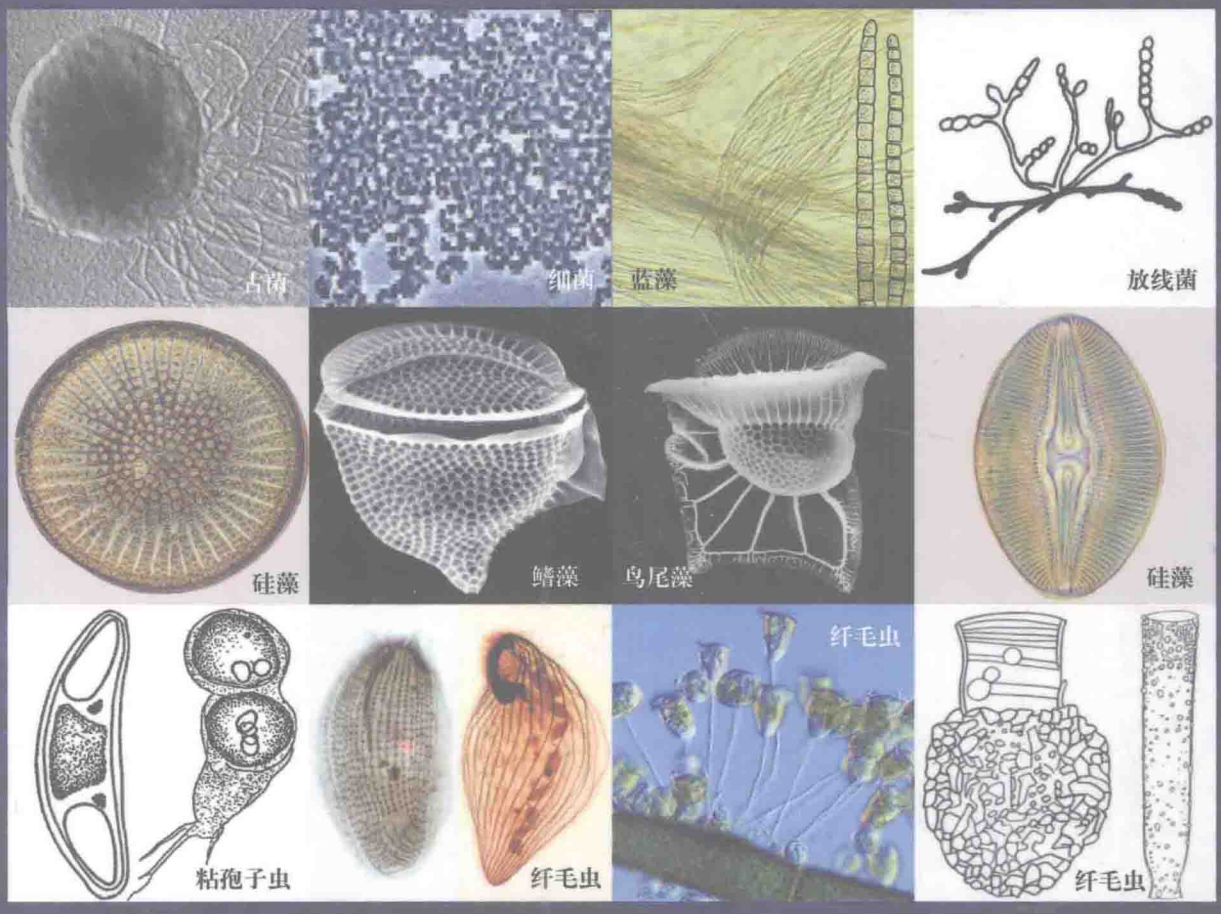
中国海洋物种和图集　下卷

中国海洋生物图集

主编　黄宗国　林　茂

第一册

原核生物界　原生生物界(1)



海洋出版社

中国海洋物种和图集　下卷

The Living Species and Their Illustrations in China's Seas (Part II)

中国海洋生物图集

AN ILLUSTRATED GUIDE TO SPECIES IN CHINA'S SEAS

主编　黄宗国　林　茂

Editors-in-Chief　Huang Zongguo　Lin Mao

第一册

Vol. 1

原核生物界　原生生物界(1)

海洋出版社

2012年·北京

内 容 简 介

《中国海洋物种和图集》是“我国近海海洋综合调查与评价”（908专项）成果集成任务（908-ZC-Ⅱ-02）的成果，也是《中国海洋生物种类与分布》（1994年初版、2001年英文版、2008年增订版）的延续与深入；是至今收录中国海洋物种最多、图文并茂的书；是国内外44家单位的112位专家共同劳动结晶。

这部书分上、下两卷。上卷《中国海洋物种多样性》，含28 000余种物种，分上、下两册。下卷《中国海洋生物图集》，含1.8万物种的原色图或黑白图，分8册。按五界分类编排，与上卷的物种相呼应。供海洋、水产及涉海人员参考应用。

“The Living Species and Their Illustrations in China's Seas” is the achievement of the “Chinese Offshore Investigation and Assessment” and is also an expanded continuation of “Marine Species and Their Distributions in China's Seas” (first published in 1994, English version in 2001, revised and expanded version in 2008), covering the largest number of marine species and is the best illustrated and most comprehensive among similar works in China. This book is the product of the collective effort of 112 people (national and international experts) from 44 organizations participated.

This treatise comprises two parts. Part I , “The Living Species in China's Seas” , covers more than 28 000 species in two volumes. Part II , “ An Illustrated Guide to Species in China's Seas” , comprises 8 volumes of color and black and white illustrations of 18 000 species arranged according to the five-kingdom classification scheme, with correspondence to the species list published in Part I . This 10-volume book intended for reference by personnel in the marine, aquaculture and maritime industries.

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序

《中国海洋物种和图集》这部书，分上、下两卷10册。

上卷《中国海洋物种多样性》，记载2.8万余种，分上、下两册。

下卷《中国海洋生物图集》，刊出1.8万物种的形态图，分8册。

上卷是《中国海洋生物种类与分布》1994年初版、英文版和2008年增订版的继续和深入。由原有的2.2万余种增加至2.8万余种，每种包括原有的中名、学名、订名人、地理分布和参考文献号；本书增加了订名年份、联合国粮农组织的英文名以及在下卷的相应图号。

下卷《中国海洋生物图集》刊载1.8万物种的（2.5万种次）原色或点线形态图和部分生态生物学图。从原核生物界至动物界，约2 800个图版。每种力求刊出颜色和形态等的分类特征，便于鉴定分类使用，同时顾及到美观和节省篇幅。8个分册独立编页码、图号和属名及中名索引，便于查找。

这部书体现了全面、科学和实用；收集了19世纪以来国内外已记录的中国海洋物种，尽量删除淡水种和化石种。用当今最经常应用的生物五界分类法编排，界或门以下的分类阶元，尽量尊重各门类专家的意见，求同存异；也注意连续性和稳定性。本书力求对物种分类、鉴定，生态生物学研究，环保和外贸、商检人员有帮助。

这部书图文并茂，在国内是首次，国际上也不多见；以往各大门类中已有一些图鉴及名录，但本书集成出版和未出版的各门类名录和形态图，是创新的体现。

这部书是国内外专家集体劳动的结晶：主持单位多年来深入开展这项研究，并组织了国内外许多专家共同研究。这次就有112位编委，包括中国内地、台湾、香港及英国和澳大利亚的专家。

这部书的出版，将进一步促进中国海洋物种多样性的研究，推动这个领域的科技进步。

中国科学技术协会副主席
中国工程院院士
中国水产科学院、黄海水产研究所名誉院、所长、研究员

2010年7月19日

Preface

"The Living Species and Their Illustrations in China's Seas" comprises 10 volumes in two parts.

Part I, entitled " The Living Species in China's Seas" , reports more than 28 000 species in two volumes.

Part II, entitled "An Illustrated Guide to Species in China's Seas" , comprises 8 volumes and publishes morphological diagrams and plates covering 18 000 species.

Part I is the in-depth continuation of "Marine Species and Their Distribution in China's Seas" (first published in 1994), its English edition and the revised and improved edition published in 2008. The total number of species reported has increased to more than 28 000, with the original Chinese name, scientific name, authority, geographical distribution and references provided for each species. Also in this version, the date of first description and the English common name adopted by the United Nations Food and Agricultural Organisation are reported, together with a plate number for cross-referencing with part II.

Part II presents colour plates and line drawings of the morphological and selected ecological habit at illustrations of 18 000 species, with a total of 25 000 species. Twenty-eight hundred illustrations describe organisms from prokaryotic kingdom to animal kingdom. To facilitate identification and taxonomic research, distinguishing features including colouration and morphology of each species are highlighted, while consideration is also given to overall presentation and economy of space. Separate page and plate numbering as well as indices to scientific name of genus and Chinese names of species are provided in each of the eight volumes to aid searches.

This comprehensive book is comprehensive and has high scientific and practical values. All marine species recorded from China's Seas by the national and international literature since the 19th century have been incorporated, while effort is made to remove fossil species. Taxonomic arrangement follows the popular five-kingdom approach; Taxonomic units adopted below kingdom or phylum are the result of considered decisions based on the views of the respective authorities, with particular reference to the issues of continuity and stability of nomenclature. This book strives to be a valuable asset to species identification and taxonomy, ecological research, as well as personnel involved in environmental protection, foreign trade and quarantine work.

This comprehensive and well-illustrated treatise is not only the first one in China, but also a rare effort internationally. While there exist pictorial guides and checklists for the major groups, this collation of published and unpublished checklists and morphological diagrams of the various groups is an embodiment of innovation.

This treatise also crystallizes the collective effort of national and overseas experts, bearing the fruit of many years of in-depth research by the coordinating unit as well as the collaboration of many national and international experts. This effort is reflected by the 112-member editorial team, which includes experts from the mainland, Taiwan, Hong Kong, as well as Britain and Australia.

The publication of this book will further enhance research on the marine biodiversity of China and promote the progress of science and technology in this field.

Professor Tang Qi-sheng

19th July 2010

前 言

在“我国近海海洋综合调查与评价”(908专项)成果集成任务（908-ZC-II-02）的支持下，来自两岸三地44家研究所、院校和相关海洋机构的112位科学家，基于908专项调查研究成果，共同完成了《中国海洋物种和图集》上卷和下卷的编纂。《中国海洋物种和图集》上卷由《中国海洋物种多样性》上册和下册组成；《中国海洋物种和图集》下卷由《中国海洋生物图集》第一册至第八册组成。这部书也是《中国海洋生物种类与分布》（1994年初版、2001年英文版、2008年增订版）的延续与深入，体现了全面、科学和实用。

《中国海洋生物图集》中的每个物种以形态图为主，少数种还辅以生态和生物学自然景观图；物种形态图含原色图和黑白点线图，两者异曲同工，都是为了实用，也注意美观。除原核生物界以生化（DNA、RNA、同功酶等）为主要手段进行分类鉴定、仅给出部分图外，其他4个界，从科以上阶元都有形态图。若该分类阶元物种数少，或者是经济种和有害种，尽量全部编图。有些物种，还同图刊载原色图和分类特征图。

采用了国内外已出版的大量论文和著作，包括已出版的《中国动物志》和《中国海藻志》以及一些专科论著，如：金德祥1965年、1982年和1991年的中国海洋硅藻，曾呈奎1983年的中国常见海藻原色512种。齐钟彦等的中国海贝1661种原色图。徐凤山等2008年的中国海产双壳类图志916种原色图。陈天任等1986年的台湾原色对虾图鉴、1993年的龙虾、2007年的寄居蟹、2008年的虾蛄、2009年的蔓足类等。刘锡兴2001年的污损苔虫1190种电镜图。沈世杰等1993年的台湾鱼类志2028种原色图。马敬能（Mackinnon, J.）2000年的中国鸟类野外手册。也参考了日本的几本图志：濑川宗吉1974年的原色日本海藻图鉴、内海富士夫1964年的原色日本海岸动物图鉴、山路勇1976年的日本海洋浮游生物图鉴、Sakai 1976年的日本及附近海蟹类、时冈隆等2000年的新日本动物图鉴。

在各大类的图集前，包括界、门、纲及部分目，都有中、英文简介，概述其进化地位、主要形态特征、经济意义，列表展示各类图件的种数、图号和页码，便于读者概览和查找。列出全部图件使用的文献名称和网址，以尊重作者的开创性劳动。图版按五界分类系统、从低等到高等、分8册，各册独立编排图版号、页码和属名及中名索引。各册的原色图和黑白图按分类系统混合编排。查找物种，可通过各册索引，也可通过上卷各物种后面的图号。鉴定物种时还可通过所列文献进一步查找原始文献。

图件的初步编排由黄晓松和吴小柳执行，正式图版由史劲松完成。英文翻译由张肇坚、李成业负责。

对入编图件的所有作者、绘图和摄影者深表谢意，有这些图件才有本图集。因主编学识所限和影像讯息的时代限制，存在缺点敬希指正。

主 编

2010年10月于厦门

Introduction

" The Living Species and Their Illustrations in China's Seas" including two parts is the achievement of the "Chinese Offshore Investigation and Assessment". This effort is reflected by 112 contributors from 44 organizations participated, which includes experts from the mainland, Taiwan, Hong Kong, as well as Britain and Australia. Part I, entitled "The Living Species in China's Seas", comprises 2 volumes. Part II, entitled "An Illustrated Guide to Species in China's Seas", comprises 8 volumes. "The Living Species and Their Illustrations in China's Seas" is also an expanded continuation of "Marine Species and Their Distributions in China's Seas" (first published in 1994, English version in 2001, revised and expanded version in 2008). This compendium embodies comprehensiveness, as well as scientific rigor and application values.

In"An Illustrated Guide to Species in China's Seas", morphological illustration forms the main description of each species, but complementary ecological and biological natural history illustrations are also provided for selected species. Both black and white as well as colour diagrams are included, with the common goal of high practical and aesthetic quality. Apart from a reliance on biochemical (DNA, RNA, allozymes, etc.) traits as the main approach to classifying and identifying prokaryotic kingdom (thus only a limited number of illustrations for this kingdom), taxa above family in the other four Kingdoms are all illustrated with morphological diagrams. Effort was made to ensure diagrams are available for species-poor, commercially important, or pest taxa. Colour plates and illustrations showing distinguishing taxonomic features are included in the same diagrams for selected species.

A large number of journal articles and other published works from national and international sources have been consulted, including published volumes of " Fauna Sinaca" and Flora " Algarum Marinarum Sinicarum" , and specialised treatises.

Chinese and English introductions summarising the evolutionary position, major morphological features and economic value precede the illustrated guide for every kingdom, phylum and class, and selected order for all major taxa. Tables display the number of species, plate and page numbers for each plate to assist browsing and searching by the reader. All references cited in the guide are listed to acknowledge the innovation effort of all authors. The 8-volume guide is arranged from the low to high taxa according to the five-kingdom classification scheme. Independent plate numbers, page numbers, scientific name of genus and Chinese names of species are provided in each volume. Colour and black and white diagrams are arranged in mixed order in each volume. Searches for individual species can be made using the index to each volume, or the plate numbers provided with taxa descriptions in the part I . Relevant primary literature can be found in the reference list for species identification.

This illustrated guide owes its existence to the plates and illustrations drawn and photographed by many authors, to whom gratitude is acknowledged. Comments on any shortcomings and errors due to the editor-in-chief's lack of knowledge or historical constraints in imaging technology would be appreciated.

Editors-in-Chief

Xiamen, October 2010

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五界分类系统 FIVE KINGDOMS

根据生物的形态、不同水平的生理功能，用各种手段和方法，对生物进行分类，至今已知地球上有270万种生物。

1969年，美国生态学家魏特克(R. H. Whittaker)在《Science》杂志上发表了《生物界级分类的新观点》，即至今广泛采用的生物五界分类系统（图）。

这一系统根据细胞的核的结构，首先把细胞生物分为二大类群：细胞核不具核膜者为原核生物（prokaryotes）、具核膜者为真核生物（eukaryotes）。原核生物为一个界，即原核生物界 Kingdom Monera。真核生物再根据细胞的多少，把单细胞生物定为原生生物界 Kingdom Protista; 多细胞生物根据营养型又分为真菌界 Kingdom Fungi、植物界 Kingdom Plantae、动物界 Kingdom Animalia。不含病毒。

Margulis L. Schwartz (1982) 出版了五界系统：插图说明了地球上各界生物（Five kingdoms）。各界门数是：原核生物界16个门，原生生物界27个门，真菌界5个门，植物界9个门，动物界32个门。

五界分类系统的提出至今仅40年。在这之前，有二界、三界和四界分类系统。在这之后，有六界系统，将病毒（Vira）另立一界；又有将原生生物界分为原生动物界(Protozoa)和色素界 (Chromista)。

20世纪90年代末，C. R. Woese 对微生物进行16S /18S rRNA的核苷酸测序，提出了三域分类系统（Three domains theory）：细菌域（Bacteria）、古细菌域（Archaea）和真核域(Eukaryota)。三域系统和五界系统最大的差别是把原核生物界分二个域，界、门及以下的分类阶元，也有不少变化。随着分子生物学手段对物种分类进行研究，生物分类阶元或物种研究仍将进一步向自然分类和生物进化途径接近。

限于主编的学识和分类学不断进展，本书暂时还是用五界分类系统把古细菌与细菌放在原核生物界。门以下的各个分类阶元，尊重各类有关专家意见，求同存异。本套书的名录和图集都是从低等到高等排列，文图互相呼应。

关于生物的分界自1735年至今，有各种主张，台湾TaiBNET采用七界，将其分界的汇编摘录如下.

<table>
<tr><th>Carl Linnaeus</th><th>E. Haeckel</th><th>E. Chatton</th><th>H. F. Copeland</th><th>R. H. Whittaker</th><th>W. E. Balch et al.</th><th>T. Cavalier–Smith</th><th>C. R. Woese et al.</th><th>TaiBNET</th></tr>
<tr><td>1735</td><td>1866</td><td>1937</td><td>1956</td><td>1969</td><td>1977</td><td>1981</td><td>1990</td><td>采用</td></tr>
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According to the morphology and different levels of physiological functions, various techniques and methods have been used to classify living organisms. Until now, more than 2.7 million species have been found in the world.

In 1969, an American ecologist R. H. Whittaker published an article: New concepts of kingdoms of organisms. Evolutionary relations are better represented by new classifications than by the traditional two kingdoms in Science to introduce his five – kingdom system which is now widely accepted.

This system classifies all the living organisms into two main groups according to the structure of the nucleus in a cell. Those organisms of which the nucleus lacks a nuclear membrane are prokaryotes whereas those with a nuclear membrane are eukaryotes. All prokaryotes are belonged to a single Kingdom: Kingdom Monera. For eukaryotes, single–

celled organisms are grouped under Kingdom Protista. Multicellular organisms are classified into Kingdom Fungi, Kingdom Plantae and Kingdom Animalia according to their modes of nutrition.

In 1982, Margulis and Schwartz published the five kingdom system with all the phyla illustrated. There are 16 phyla under Kingdom Monera, 27 phyla under Kingdom Protista, 5 phyla under Kingdom Fungi, 9 phyla under Kingdom Plantae and 32 phyla under Kingdom Animalia.

The five – kingdom system was proposed 40 years ago. Before that, two–kingdom, three–kingdom, and four–kingdom systems had been proposed. Other systems have been proposed after the five–kingdom system. These include the six–kingdom system which classifies vira as a separate kingdom. Another system has further divided Kingdom Protista into Kingdom Protozoa and Kingdom Chromista.

At the end of 1970's, based on the nucleotide sequence of 16S/18S rRNA of microorganisms, C. R. Woese proposed the Three Domains Theory and classified living organisms into Domains Bacteria, Archaea and Eukaryota. The main difference between the five–kingdom system and Three Domains theory is the division of Kingdom Monera into two domains. A lot of changes also occurred in Kingdom, Phylum, and hierarchies below. With the advancement of techniques in molecular biology for researches on species classification, the hierarchy of biological classification and study of species will be a step further towards the natural classification and evolutionary pathway.

Owing to the progress of taxonomy and the limited knowledge of Chief Editor, this atlas adopts the five–kingdom system and places Archaea and Bacteria in the Kingdom Monera. For classification hierarchies including Phylum and below, advices from experts from relevant fields have been sorted. The name lists and illustrations are arranged from lower to higher organisms.

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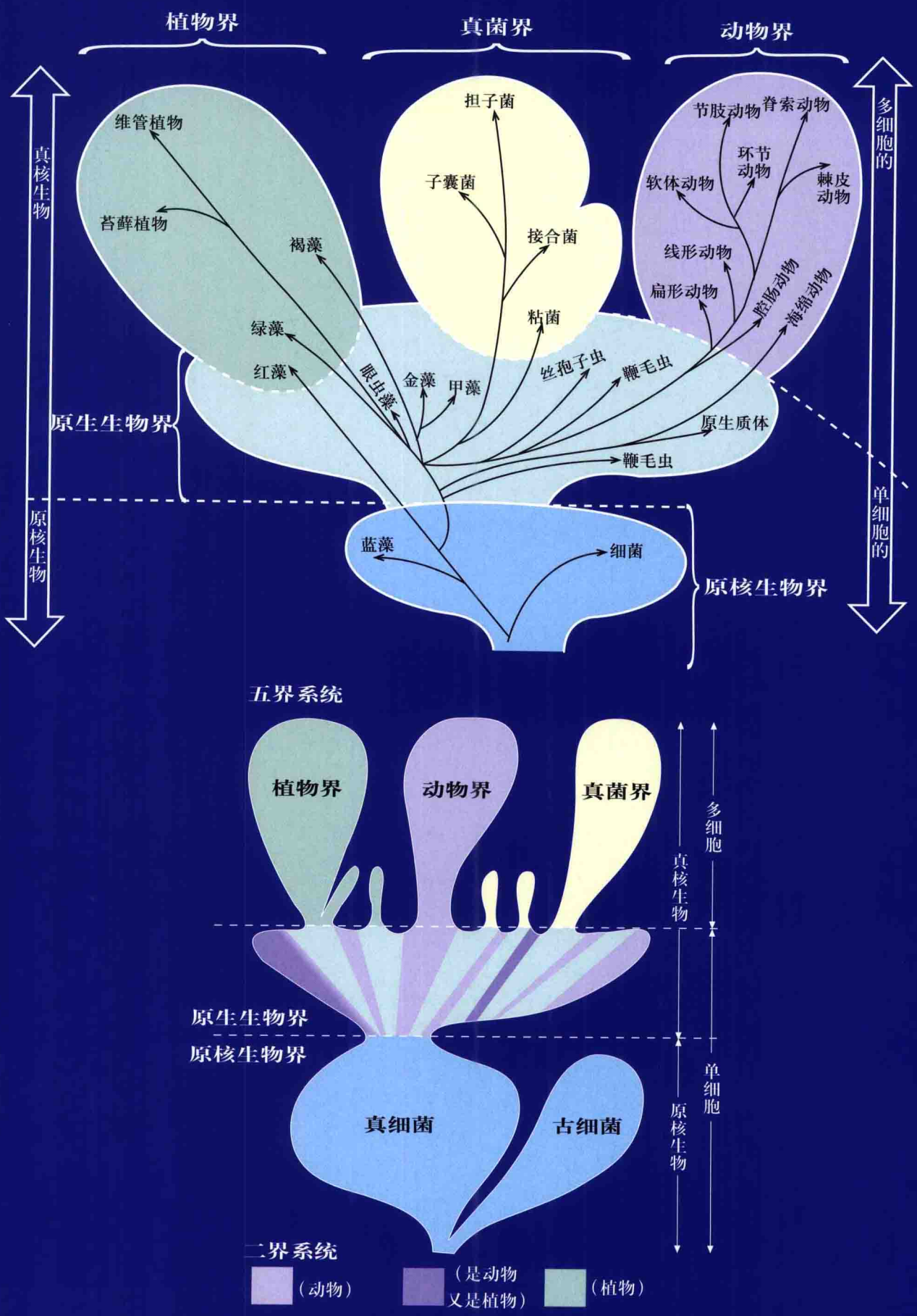

Whittaker(1969) 五界分类系统(上) 及Barnes等(1993)的动植物二歧分支(下)

原核生物界 Kingdom MONERA

原核生物界是细胞生物，原核细胞具细胞形态，有核质而无核膜。细胞质中没有线粒体、叶绿体和高尔基体。只能进行无丝分裂生殖。有细菌、古菌、放线菌、蓝藻、原绿藻和海洋原绿球藻等类群。用分子生物学进行DNA、RNA测序，将使分类有更大变更。

细菌(Bacteria)：绝大多数是单细胞、结构最简单并能独立生活的细胞生物，细胞核是原核、没有核膜、不含组蛋白。细菌是原核生物中种类最多、数量最大、分布最广的类群。其形状大致分为杆菌(bacillus)、球菌(coccus)和螺旋菌(spirilla)。营养方式分光能自养(photoautotroph)、光能异养(photoheterotroph)、化能自养(chemoautotroph)和化能异养(chemoheterotroph)。海洋细菌分布于水体、沉积物和动植物体上，是生态系统的主要还原者，是水产养殖的病原菌。浮游细菌主要是异养菌，对生源要素的再循环起着重要作用。

古菌(Archaea)：1977年才发现这一生物类群。1996年Woeses 根据16s/18s rRNA 基因序列，将生命分为三域(Domain)，细菌域(Bacteria)、古菌域(Archaea)和真核域(Eukaryota)。古菌细胞通常小于1μm,膜中含有独特的化学成分异戊二烯链。古菌不仅存在于极端环境，在海洋中也几乎无处不在，是深海浮游细胞的主要成分，其丰度可达总原核生物量的40%，对海洋碳氮循环有重要意义。

放线菌(Actinomycetes)：呈丝状生长和以孢子繁殖的革兰氏阳性菌，菌落大多数呈放射状。分布在有机质较丰富和呈微碱性的土壤中，红树林泥滩就有其分布，中国已报道24种。至今的近万种抗生素中，约70%由放线菌所产生，如链霉菌(*Streptomyces*)产生的链霉素。

蓝藻：细胞中央有核物质，但外围无膜包住。色素散布在周围的原生质中，未形成叶绿体，除普通的叶绿素a、叶黄素和胡萝卜素外，还含有丰富蓝藻蛋白（ phycocyanin ）的藻胆素（ phycourobilin ）和藻胆红素(phycoerythrobilin)。

海藻学家（ 李伟新 1982，曾呈奎 1962、1983 ）将其独立成蓝藻门(Phylum Cyanophycophyta)。形态多样化，包括单细胞、群体以及多细胞丝状体。分布极广，有水生、陆生和气生3类，有浮游、固着、附生、共生和寄生等生活方式。已知160属1 500多种，分5个目；中国海已记录130多种，如聚球藻 (*Synechococcus*)、颤藻(*Oscillatoria*)、束毛藻(*Trichodesmium*)、螺旋藻(*Spirulina*)等都很常见，可作为食物，也会在水体中形成赤潮或水华，又是海洋碳循环和初级生产力的贡献者之一。

微生物学家把蓝藻（ blue algae; blue–green algae ）改称为蓝细菌(Cyanobacterium)(周庆德 2002，杨苏声 2004，焦念志 2006)。1979年发现的聚球藻(*Synechococcus*)，是最近几年我国海洋浮游微型生物的研究热点。这种藻一般是单细胞，光捕获色素主要是藻胆蛋白（ phycobiliprotein ），这种蛋白分为红色的藻红蛋白（ phycoerythrin, PE ）和蓝色的藻蓝蛋白（ phycocyanin, PC ），前者大洋和近岸都有、含量最丰富，后者都见于近岸。用流式细胞仪和分子生物学技术表明，在我国海区普遍存在，近海多于外海，近岸水体可达105 cells/mL，到外海降至103 cells/mL 或更低，是仅次于原绿球藻(*Prochlorococcus*) 的海洋碳循环和初级生产力的贡献者。

原绿藻门(Prochlorophyta)和海洋原绿球藻(*Prochlorococcus marinus*)：曾呈奎、周百成等（ 1985 ）在广东及海南潮下带上部的珊瑚礁、海鞘等动物及海藻上发现附着的原绿藻，该藻单细胞、绿色，细胞扁平、直径8—12μm，含叶绿素a及b，没有藻胆素（ phycopilin ）。海洋原绿球藻是1992年才正式定名的超微型产氧原核光能自养生物，具有独一无二的光合色素二乙烯基叶绿素（ divinylchlorophyll a、b ），可以捕捉极微弱的光，在海洋真光层底部进行高效的光合作用。它分布于南北纬40° 之间的大洋表层到真光层底部。除渤海和北黄海海域以及东海、南海河口海域无海洋原绿球藻外，中国其他近岸和远岸海域都有，且数量很大，如南海海盆和东海黑潮流域，在超微型自养生物中，对碳的贡献达35.8%–79.8%。

Kingdom Monera are cellular organisms which contain nuclear materials but without nuclear membrane. Cytoplasm does not contain mitochondria, chloroplast and Golgi body. Reproduction is through mitosis. This Kingdom includes bacteria, archaea, actinomycetes, blue–green algae, prochlorophytes and *Prochlorococcus*. Taxonomy of this group will subject to big changes after molecular techniques such as DNA and RNA sequencing are employed.

BACTERIA: Most of them are unicellular with simple structure and can live independently. The nucleus does not have the nuclear membrane and histone. Bacteria is the group which is the most diverse, abundant and widely distributed in the kingdom. According to body shape, they can be classified as bacillus, coccus or spirilla. Based on mode of nutrition, some are photoautotrophs, others include photoheterotrophs, chemoautotrophs and chemoheterotrophs. Marine bacteria are distributed in the water column, sediments or plant and animal bodies. They are major decomposers in the ecosystem and pathogens in aquaculture. Planktonic bacteria are basically heterotrophic and assume an important role in the recycling of essential biological resources.

ARCHAEA: They were first discovered in 1977. Based on the gene sequence of 16s/18s rRNA, Woeses classified life into three domains including Bacteria, Archaea and Eukaryota in 1996. The cells of archaea are commonly smaller than 1 μm and the cell membrane contains a specific chemical. Archaea not only survive in extreme environments, but occur almost everywhere in the ocean. They are the major component of deep sea planktonic cells and occupy the total moneran biomass by 40%. They assume an important role in the cycling of carbon and nitrogen in the ocean.

ACTINOMYCETES: Gram–positive bacteria which have a filamentous growth pattern and reproduce by spores. Most of the colonies are radiating form. They are distributed in organically–rich and slightly alkaline soil such as mangrove mudflat in which 24 species have been reported in China. More than 70% of about ten thousand kinds of antibiotics are produced by actinomycetes, e.g., streptomycin produced by *Streptomyces*.

BLUE–GREEN ALGAE (OR BLUE ALGAE): Nuclear material is present in the centre of the cell that is not enveloped by a nuclear membrane. Pigment is distributed in the protoplasm without forming chloroplast. In addition to common pigments including chlorophyll a, xanthophyll and carotenoids, blue–green algae also contain phycocyanin, phycourobilin and phycoerythrobilin.

SEAWEEDS BIOLOGISTS (Lee 1982, Tseng 1962, 1983) have put blue–green algae into a separate Phylum Cyanophycophyta. This phylum has diversified morphologies which include unicellular, colonial and multicellular filamentous forms. They are widely distributed and can be waterborne, landborne or airborne. Life styles include planktonic, sedentary, epiphytic, symbiotic and parasitic. More than 1500 species under 160 genera and 5 orders were found with more than 130 species of them being recorded in China which includes common ones such as *Synechococcus*, *Oscillatoria*, *Trichodesmium*, and *Spirulina*. These groups may serve as food, and form red tides or water blooms in water bodies. They are a major contributor of carbon cycling and primary production in the oceans.

Recently, microbiologists have renamed blue–green algae as cyanobacteria (Zhou 2002, Yang 2004, Jiao 2006). *Synechococcus* discovered in 1979 is a recent research hotspot in the study of marine planktonic microorganisms in China. This group of algae is unicellular with phycobiliprotein as the major light capturing pigment. This pigment is divided into the red pigment phycoerythrin (PE) and the blue pigment phycocyanin (PC). The former is more abundant and commonly found in the oceans and nearshore waters where the latter can also be found. Using flow cytometry and molecular biology techniques, it was found that cyanobacteria is more commonly found nearshore than offshore. The concentration can reach to 105 cells/mL in nearshore waters but decrease to 103 cells/mL or lower in offshore waters. They are a major contributor of carbon cycling and primary production in the oceans after *Prochlorococcus*.

PROCHLOROPHYTA AND *Prochlorococcus marinus*: Prochlorophyte was discovered by Tseng et al. (1985) on seaweeds and sea squirts in the coral reefs of the upper part of the lower intertidal in Hainan as well as in

Guangdong and (Xisha IslandsParacel Islands.) This alga is unicellular and green. The cells are flat with a diameter of 8 to 12 μm and contain chlorophyll a and b but without phycopilin. *Prochlorococcus marinus* was named in 1992 and is an ultramicro oxygen-producing autotrophic moneran with unique light pigments divinylchlorophyll a and b which can capture light under very low irradiance and carry out efficient photosynthesis in the lower end of the euphotic zone in the ocean. It is distributed from the surface waters to the lower end of the euphotic zone between 40oS and 40oN. It occurs abundantly in nearshore and offshore waters throughout China such as the South China Sea oceanic basin and the drainage area of the Kuroshio Current in the East China Sea but is absent in the Bohai Sea, North Yellow Sea, East China Sea, and the estuary of the South China Sea. Its contribution to carbon is 35.8% to 79.8% among all the ultramicro autotrophic organisms.

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焦念志 JIAO Nian-zhi

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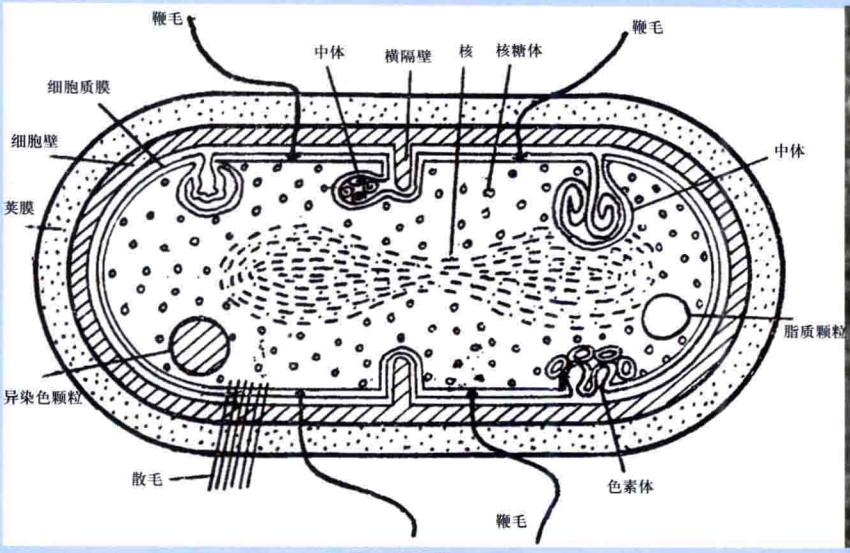
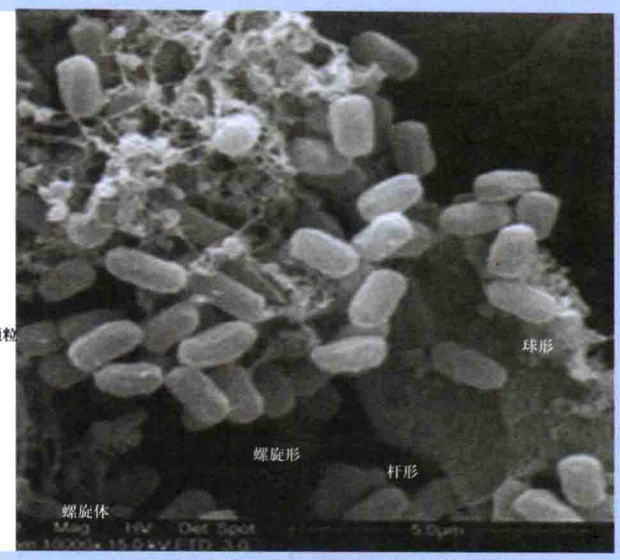
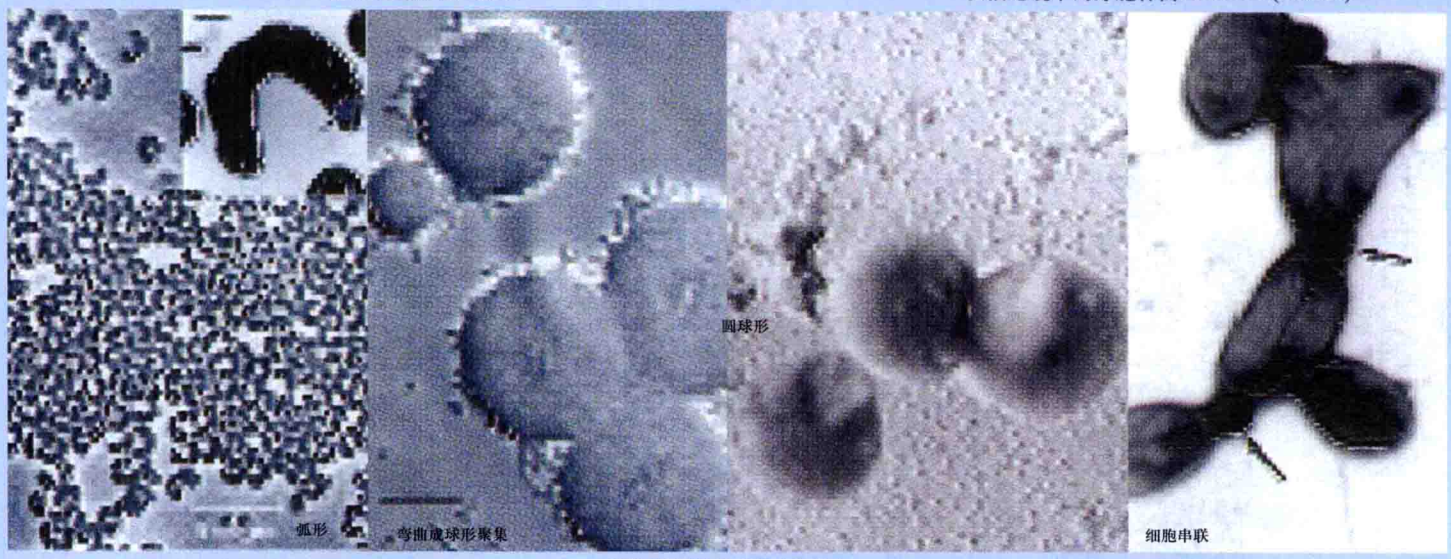
黄宗国 HUANG Zong-guo



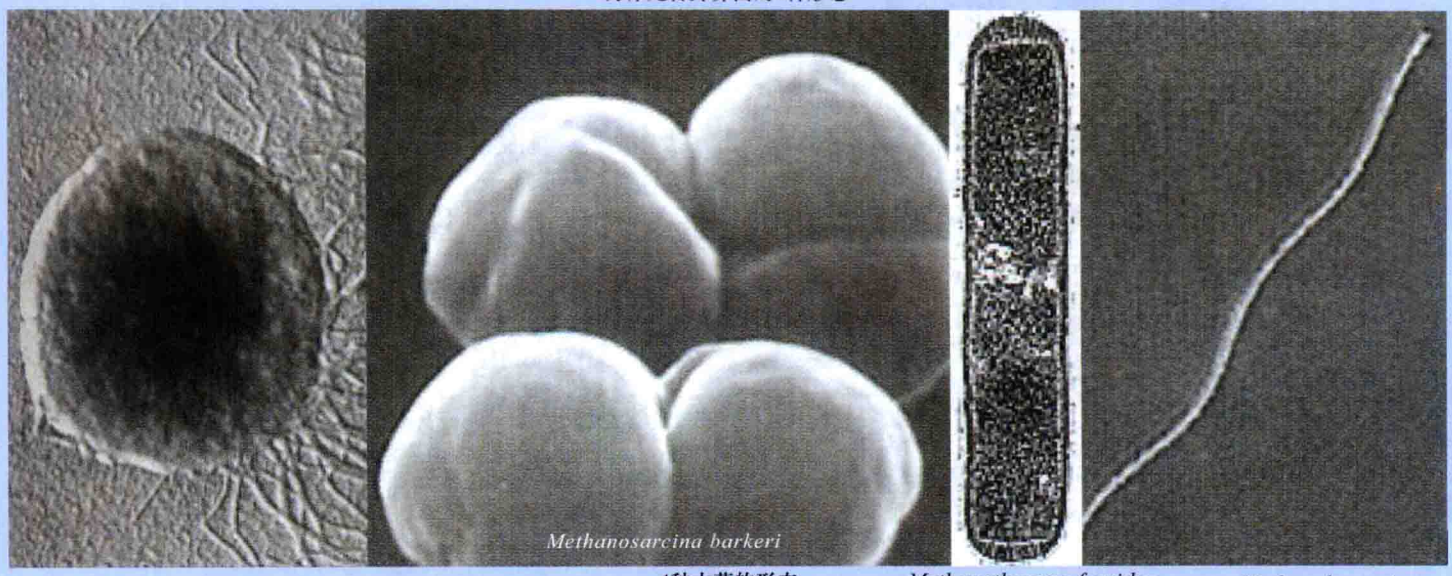
细菌细胞的模式结构



扫描电镜下的芽胞杆菌 *Bacillus* (X10000)



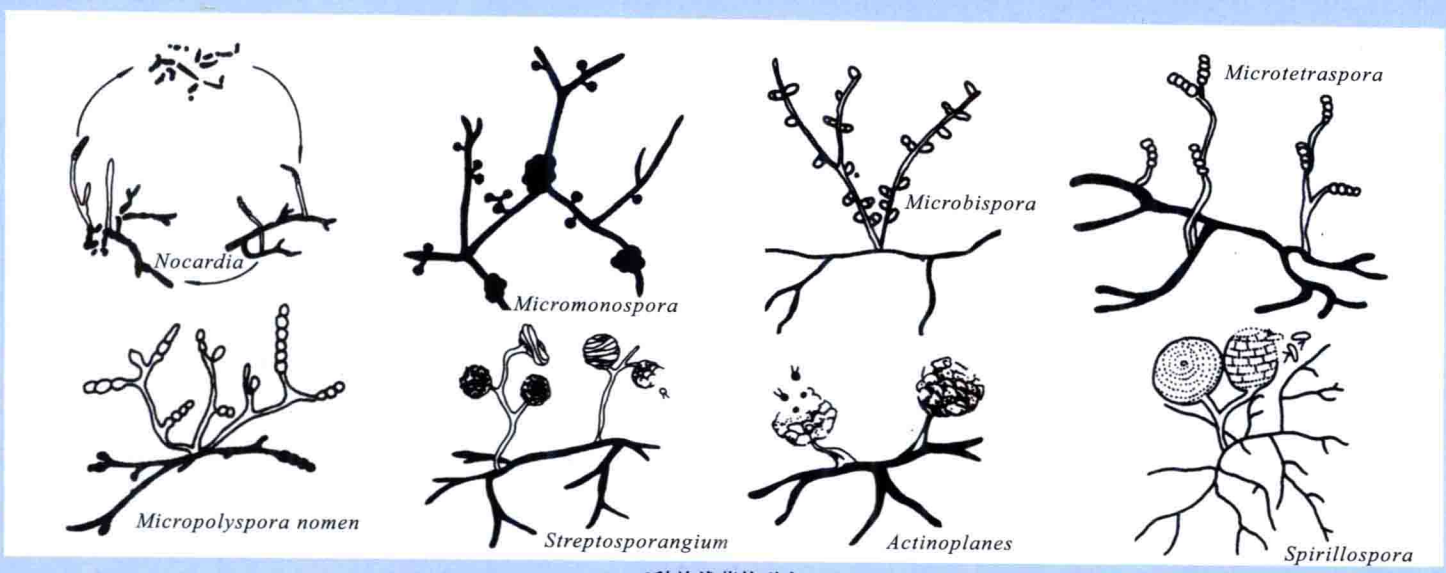
海洋光合异养菌的4种形态



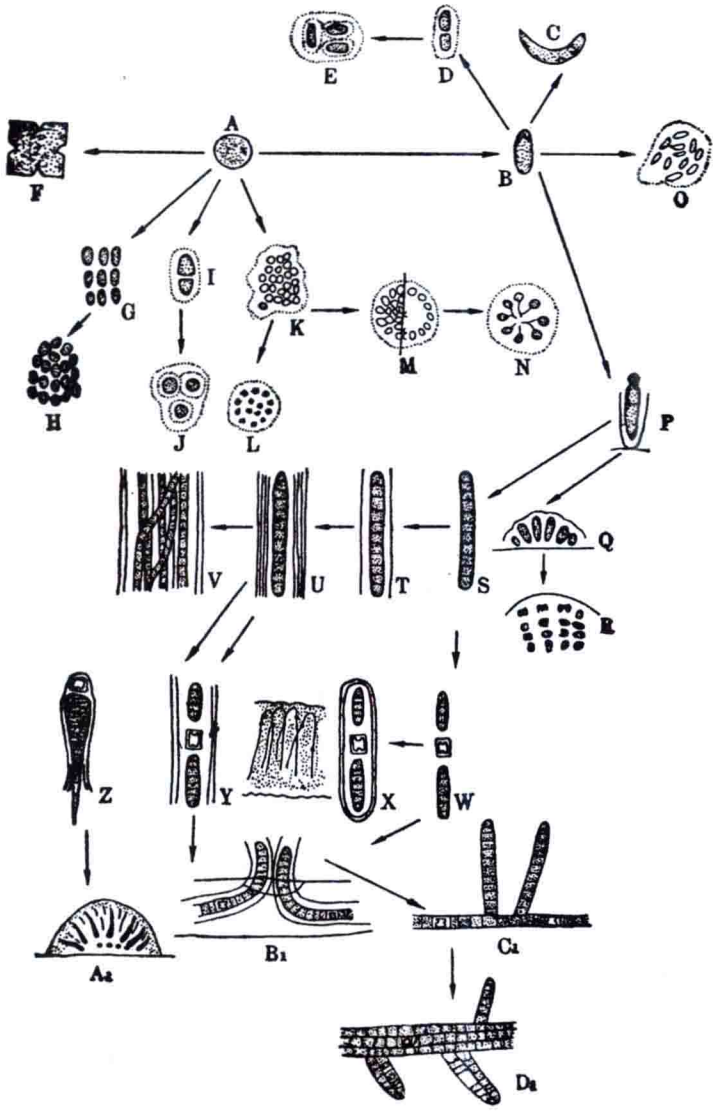
Methanococcus janaschii　　4种古菌的形态　　*Methanothermus fervidus*　　*Methanobacterium thermoautotrophicum*

图1.1 原核生物界 古菌与细菌（仿田清涞等 1986；焦念志等 2006）

Archaea and Bacteria



8种放线菌的形态



A. 聚胞藻属 *Synechocystis*
B. 聚球藻属 *Synechococcus*
C. 蓝纤维藻属 *Dactylococcopsis*
D.E. 粘杆藻属 *Gloeothece*
F. 四角藻属 *Tetrapedia*
G. 平裂藻属 *Merismopedia*
H. 立方藻属 *Eucapsis*
I. 色球藻属 *Chroococcus*
J. 粘球藻属 *Gloeocapsa*
K. 微囊藻属 *Microcystis*
L. 隐球藻属 *Aphanocapsa*
M. 腔球藻属 *Coelosphaerium*
N. 束球藻属 *Gomphosphaeria*
O. 隐杆藻属 *Aphanothece*
P. 管孢藻属 *Chamaesiphon*
Q. 皮果藻属 *Dermocarpa*
R. 瘤皮藻属 *Oncobyrsa*
S. 颤藻属 *Oscillatoria*
T. 席藻属 *Phormidium*
U. 鞘丝藻属 *Lyngbya*
V. 微鞘藻属 *Microcoleus*
W. 鱼腥藻属 *Anabaena*
X. 念珠藻属 *Nostoc*
Y. 管链藻属 *Aulosira*
Z. 眉藻属 *Calothrix*
A1. 胶须藻属 *Rivularia*
B1. 双歧藻属 *Scytonema*
C1. 软管藻属 *Hapalosiphon*
D1. 真枝藻属 *Stigonema*

单细胞、群体和多细胞丝状体蓝藻的形态和演化

图1.2 原核生物界 放线菌与蓝藻（仿周德庆 2002；李伟新 1982）
Actinomycetes and Cyanophyta