植物学实验指导（双语教材）

Botany Laboratory Manual

马三梅　王永飞　孙小武　主编

科学出版社

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内 容 简 介

本书为双语教学配套教材，包括16个实验，分别涉及显微镜，植物的细胞、组织、根、茎、叶、花、果实、种子和幼苗，藻类，菌类和地衣，苔藓植物，蕨类，裸子植物，被子植物，校园植物调查等内容。这些实验较好地涵盖了植物形态、解剖和系统分类的基本内容。每个实验包括实验材料、实验目的和要求、实验内容和步骤、实验作业和复习思考题等内容。着重培养学生的基本知识和基本实验技能；同时以实验为载体促进学生动手动脑，培养和提高学生的科学思维、创新意识与创新能力及对科学的自主探究精神，提高学生发现问题、分析问题、解决问题的能力；为实验课程教学改革构建了英语教学平台，有利于提高学生的科技英语水平，并通过英语教学培养学生具有国际合作意识、国际交流与竞争能力。每个实验前附有一段简短的中文导读以利于学生理解和掌握实验的内容和知识。书后附录是植物分类检索表和植物学常用专业术语中英文对照表，为使用本教材的师生提供便利。

本教材适合生命科学各专业的植物学实验教学使用，也可供师范、农业、林业、中医药等院校有关专业师生使用和参考。

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前　言

实验教学是高等院校最基本的教学形式之一。实验教学可以培养和提高学生的自主学习、创新意识与创新能力，促进学生动手动脑，培养学生科学思维能力和实践创新精神，对全面推进素质教育有着重要的作用。

飞速发展的科学技术已成为主导社会进步的重要因素。高等院校必须不断更新教学内容，以学科发展的前沿知识充实实验课程内容。而植物学实验是学习和探究植物学知识，培养植物学科学素养必备的基础。植物学实验作为专业基础课被列入了高等院校生物学各专业、植物生产类各专业、生态学及中药学等专业的教学计划中，并单独作为一门课程开出。

随着经济、信息的全球化和我国加入世界贸易组织，高校如何培养既懂专业知识又精通外语的复合型人才，已成为所有教育机构和教育工作者面临的问题。因此，实施双语教学是培养学生成为具有国际合作意识、国际交流与竞争能力的国际化人才的重要途径。目前国内已出版了多种版本的植物学实验教材，但尚缺乏具有相应教学内容的英文教材，从而阻碍了该课程双语教学的开展。

此外，在传统学科课程教学学时普遍减少、实验课时压缩的背景下，为了提高实验教学质量和教学效率，编写反映本学科特色，更具科学性、系统性、基础性和实用性的实验教材，是教师的一项艰巨而又紧迫的任务。

为了紧跟学科和时代的发展，培养具有创新思维和创新能力的卓越人才，以及配合双语教学的实施，我们根据教学大纲和课程学时要求，在参阅了大量相关资料和学习兄弟院校教学经验的基础上，结合编者多年的教学和科研体会，以英文原版教材和公开发表的相关论文为素材，经过精心筛选和提炼，编写了本书。

本书包括 16 个实验，分别与显微镜(The Microscope)，植物的细胞(The Plant Cell)、组织(The Tissues)、根(Roots)、茎(Stems)、叶(Leaves)、花(Flowers)、果实(Fruits)、种子和幼苗(Seeds and Seedlings)，藻类(Algae)，菌类和地衣(Fungi and Lichens)，苔藓植物(Bryophytes)，蕨类(Ferns)，裸子植物(Gymnosperms)，被子植物(Angiosperms)，校园植物调查(Campus Field Trip: Botany)相关。这些实验较好地涵盖了植物形态、解剖和系统分类的基本内容。每个实验包括实验材料(Materials)、一些建议的学习目标和要求(Some Suggested Learning Goals and Requirements)、实验内容和步骤(Experiment Contents and Procedures)、上交的绘图作业(Drawings to Be Submitted)和复习思考题(Review Questions)等内容。着重培养学生的基本知识

和基本实验技能；同时以实验为载体促进学生动手动脑，培养和提高学生的自主学习、科学思维、创新意识与创新能力及对科学的自主探究精神，提高学生发现问题、分析问题、解决问题的能力。每个实验前附有一个简短的中文导读以利于学生理解和掌握实验的内容和知识。书后附录是植物分类检索表及植物学常用专业术语中英文对照表，为使用本教材的师生提供便利。

本书由马三梅、王永飞、孙小武、李万昌、李宏业、屈红霞、王亚琴、白润娥、曹水良和方堃共同编写。具体分工如下：实验 1 由孙小武编写，实验 2～3、实验 11～14 由李万昌编写，实验 4 由李宏业编写，实验 5 由屈红霞编写，实验 6 由王亚琴编写，实验 7～8 由白润娥编写，实验 9 由曹水良编写，实验 10 由方堃编写，实验 15 由马三梅编写，实验 16 和附录由王永飞编写。孙小武、李万昌、李宏业和屈红霞负责书稿的修改工作；马三梅负责全书图片的绘制；王永飞和马三梅负责全书的统稿、审稿和定稿。感谢各位编者对本书的真诚付出。没有大家的努力，这本很有特色的书籍就不能及时出版。

本书的编写得到暨南大学、湖南农业大学、河南师范大学、中国科学院华南植物园、华南师范大学和河南农业大学的指导和关心。本书的出版得到国务院侨务办公室立项和彭磷基外招生人才培养改革基金及国家西甜瓜产业技术体系基金的资助。科学出版社对本书的出版也付出了大量的劳动。在此一并表示感谢！

教材建设是一项长期的工作。由于编者水平有限，书中错误和不当之处在所难免，敬请有关专家、同行不吝赐教，提出宝贵意见，以便修订。

编　者

2014 年 2 月

Preface

Laboratory course is one of the most fundamental teaching forms in colleges. The abilities of self-learning, creativity and innovative thinking of students can be trained through performing experiments. Students' experimental techniques, scientific thinking and innovative spirit can also be cultivated. Therefore, laboratory course is crucial in promoting education in all-around.

With the rapid development of science and technology, universities must enrich the contents of laboratory course with the latest knowledge continually. Experiments of botany will lay the foundation for further study, and is essential for the development of scientific literacy. Thus, experiments of botany are regarded as a main basic course for college students majoring in life science, plants production, ecological and pharmacy. And it gradually became an independent course.

Considering the globalization of information and economy, the question of how to cultivate interdisciplinary talents who are good at professional knowledge and proficient in English is faced by all education institutions and educators. Therefore, the implementation of bilingual education is an important way to train talents with the consciousness of international cooperation, international exchanges and international competitiveness. Several Chinese versions of "botany experiment" textbook have been published in domestic. But the lack of English textbooks with the corresponding teaching content in market hindered the bilingual teaching of this course.

In addition, teaching hours are becoming more limited for traditional courses. To improve teaching quality and efficiency of the experiments, compiling a scientific, systematic, fundamental and practical laboratory textbook will be more arduous and urgent for teachers.

In order to keep up with the development of disciplines, to train talents with innovative thinking and excellent creativity, we have read a lot of relevant books and learned teaching experience from other universities to compile this book. This English version textbook of botany experiments is based on original English textbooks and relevant papers published and a product of careful selection.

There are 16 experiments containing in this laboratory manual, namely the microscope, the cell, the tissues, roots, stems, leaves, flowers, fruits, seeds and seedlings, algae, fungi and lichens, bryophytes, ferns, gymnosperms, angiosperms and campus field trip for botany.

This textbook is co-compiled by San-Mei Ma, Yong-Fei Wang, Xiao-Wu Sun, Wan-Chang Li, Hong-Ye Li, Hong-Xia Qu, Ya-Qin Wang, Run-E Bai, Shui-Liang Cao and Kun Fang. Their responsibilities are as follows: experiment 1 written by Xiao-Wu Sun, experiment 2~3, and 11~14 written by Wan-Chang Li, experiment 4 written by Hong-Ye Li, experiment 5 written by Hong-Xia Qu, experiment 6 written by Ya-Qin Wang, experiment 7~8 written by Run-E Bai, experiment 9 written by Shui-Liang Cao, experiment 10 written by Kun Fang, experiment 15 written by San-Mei Ma, experiment 16 and the appendix written by Yong-Fei Wang. Xiao-Wu Sun, Wan-Chang Li, Hong-Ye Li, and Hong-Xia Qu have made great efforts in manuscript revision. San-Mei Ma has drawn all the pictures of this textbook. San-Mei Ma and Yong-Fei Wang are responsible for editing, revising and finalizing the manuscript. Without our joint efforts, this book will not be published on time.

We are grateful to Jinan University, Hunan Agricultural University, Henan Normal University, South China Botanical Garden of Chinese Academy of Sciences, South China Normal University and Henan Agricultural University for suggestions and consideration. The publication of this textbook is a project approved and initiated by Overseas Chinese Affairs Office of the State Council and funded by the Lin-Ji Peng Foundation and the National Industrial System for Watermelon and Melon. Large efforts are also made by Science Press.

Editing a textbook is a long-term task. Since our level is limited, some errors and irregularities are inevitable, please let us be informed. Please give us valuable suggestions for amendments.

Author

February 2014

目　　录

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I The Microscope

【导读】本实验主要介绍显微镜的结构、使用方法、注意事项，以及临时制片的制作方法。

Materials

(1) Compound microscopes.

(2) Dissecting microscopes.

(3) Microscope slides.

(4) Cover slips.

(5) Lens paper.

(6) Dissecting needle.

(7) Other objects for viewing.

Some Suggested Learning Goals and Requirements

(1) Identify the parts of a compound microscope, and know the function of each part.

(2) Understand the differences and similarities between a compound microscope and a dissecting microscope.

(3) Know what is meant by resolution, field, and depth of field.

(4) Be able to proper use the compound microscope and dissecting microscope.

(5) Be able to calculate the magnification of each object being viewed with specific combinations of lenses.

(6) Be able to prepare wet-mounts or fresh mounts.

Experiment Contents and Procedures

Microscopes are very important tools in biology. The term “microscope” can be translated as “to view the tiny”, because microscopes are used to study things that are too small to be easily observed by other methods. The microscopes that we will be used in this lab are compound light microscope and dissecting microscope. Light microscopes can magnify the image of a specimen using light and lenses. The term “compound” means that this microscope passes light through a specimen and then through two different lenses. The lens closest to the specimen is called the objective lens, while the lens nearest to the user’s eye is called the ocular lens or eyepiece.

When you use a compound light microscope, the specimen being studied is placed on a glass slide. The slide may be either a prepared slide that is permanent and purchased from a science supply company, or it may be a wet mount or a fresh mount that is made for temporary use and is made in the lab room.

A. General Instructions

Light microscopes are expensive precision instruments that will give satisfactory service for many years if they are handled and maintained properly. Students are responsible for such handling and maintenance in the laboratory. Read and observe the following instructions carefully:

(1) Always use both hands when carrying a microscope, and always carry it in an upright position. Parts of a microscope may fall off if this rule is not followed.

(2) Dirt is the biggest enemy of optical instruments. Keep all parts of your instrument clean. Use only the lens paper provided to clean lenses. Never use facial tissue or handkerchiefs to clean the lenses. The glass of the lenses is different from window glass,which could be easily corroded by acids present in fingerprints and by other chemicals.Moreover rubbing can alter the curvature of the lens. Do not remove oculars or objective lenses. When this is done, invisible dust present in the air gets insides the microscope and then may become visible as it is greatly magnified. If dirt or fingerprints are not readily removed with dry lens paper, wet a corner of the lens paper with clean water and rub gently in a circular motion. Immediately wipe off anything (including water) that spills on your microscope.

(3) Never force any of the adjustments. If something does not work smoothly, call the instructor.

(4) Inspect your microscope carefully each time you use it. Report any missing or

damaged parts to your instructor before you start to use the instrument. You will be held responsible if you fail to do so.

(5) Before returning a compound microscope to the microscope cabinet, be sure the scanning objective (or lowest-powered objective) is in place.

B. Compound Microscopes

1. Parts of a Microscope

Several brands and types of microscopes may be in use at your institution. Locate the following parts on your compound microscope.

1) Base

This is usually made of heavy mental and is more or less U-shaped. Your microscope has either a lamp or a mirror located between the arms of the U.

2) Arm

Arm is upright metal structure attached to the base. Several other parts attach to it.

3) Barrel or drawtube

This is a cylindrical metal tube with a moveable ocular inserted at the top end.

4) Ocular or eyepiece

This is a short metal cylinder with a glass lens towards each end. It may have a hair or line inside that serves as a pointer and moves with the ocular as it is rotated. Most oculars by themselves magnify an object 10 times.

5) Revolving nosepiece

This usually loosely resembles a small, metal pancake sandwich with three to several shotgun shells stuck in it. Note that as you rotate the nosepiece, the metal-cased objective lenses must be "clicked" into place for an object to be visible.

6) Objective lens

There are usually three and often four in research microscopes. But there may be as many as five or six. The magnification achieved by each objective lens is indicated on its side. Common values are 10 × for a low-power lens and 40 × for a high-power lens. The total magnification of a viewed object is calculated by multiplying the magnification of the ocular by the magnification of the objective lens.

For example, the magnification of the object being viewed with a high-power (40×) objective lens in place would be as follows:

$$10 \times \text{(ocular)} \times 40 \times \text{(objective)} = 400 \text{ times}$$

7) Stage

This is a platform on which a glass slide to be viewed is placed. The stage has a central hole through which light can pass. The stage may be mechanical, with knobs and clamps for moving slides in four directions, or it may have two flexible metal spring clips, each with one end attached to the stage. The spring clips hold a microscope slide in place.

8) Condenser

This is a lens system located beneath the hole in the stage. The condenser either is fixed in place, or can be adjusted by means of a knob. It functions in concentrating light in the plane of the object being viewed. If your condenser is adjustable, turn the knob so that the top lens of the condenser is as close to the stage as it will go, then back it off not more than millimeter, and leave it there. At this setting, the maximum amount of light passed through the microscope. Check each time you use your microscope to make sure the condenser is properly adjusted. This is important because improper adjustment can significantly reduce the resolution of objects.

9) Iris diaphragm

This is a series of overlapping, thin metal plates that form a hole through which light can pass. The iris diaphragm is located on or within the condenser; it regulates the amount of light passing through an object. It is adjusted with the little lever protruding from the side of the condenser. You will find you need less light for objects viewed under high power. You will also find that the smaller the hole formed by the iris diaphragm, the greater will be the depth of focus (the distance between two adjacent objects, or parts, or parts of an object that are both in focus at the same time). Always use the iris diaphragm to adjust the amount of light reaching your eye. Never move the condenser up or down to do this. You can reduce the light intensity by moving the condenser downward, but by doing so you will reduce the resolving power of your microscope. This is especially important when viewing objects at higher magnifications.

10) Coarse adjustment

This adjustment changes the focus relatively rapidly and is controlled by a knob usually located toward the base of the arm of a microscope. It should be used only with a low-powered objective lens in place. Always complete focusing with the fine adjustment.

11) Fine adjustment

In some microscopes, this adjustment is brought about by turning a knob separate from the coarse adjustment knob. In other microscopes, the fine adjustment knob may be combined in various ways with the coarse adjustment knob. When there are two distinct knobs, the fine adjustment knob is usually smaller.

12) Lamp or Mirror

This is located at the base beneath the condenser. The lamp usually has a knoblike switch that should be rotated clockwise to turn it either on or off. The mirror has a flat surface on one side and a concave surface on the other. It should be adjusted to focus the maximum amount of light available on the lower end of the condenser.

2. Using the Microscope

(1) Place the microscope squarely in front of you and just far enough from the edge of the table to be able to look through it without becoming uncomfortable. Also, if necessary, adjust the height of your seat.

(2) Gently clean all optical surfaces with lens paper.

(3) Place the provided slide on the stage and make sure the material is centered over the hole in the middle of the stage. If you have a mechanical stage, center the slide with the stage adjustments; if you have spring clips, place them over the edges of the slide.

(4) Switch the low-power objective in place, and bring the objective as close as possible to the slide with the coarse adjustment. Always begin examination of a slide with the scanning or low-power objective. The high-power objective is longer than the lower-power objectives, which may potentially crack the slide as well as be damaged if used incorrectly.

(5) Turn on the lamp. If you have a mirror, line up the separate lamp provided so that the maximum amount of light comes through the hole in the stage. Note that the mirror is flat on one surface and concave on the other.

(6) Keep both eyes open, focus carefully with the coarse adjustment until the material is roughly in focus. If you do not see anything with both eyes open, cover one eye with your hand but do not close one eye. Then sharpen the focus with the fine adjustment.

(7) Adjust the amount of light reaching your eye with the iris diaphragm. This is important as you cannot see detail with light that is either too intense or too dim for your particular eye.

(8) Once the material is in focus, move the slide slightly and note that the material moves in the opposite direction. Note also that the image of the material is inverted. Now swing the high-power objective into place and refocus with the fine adjustment. You may need to recenter the material after switching lenses.

(9) Completely clean objectives and oculars, clean slides, proper focusing, and

correct light intensity are all necessary for maximum resolution, which is the capacity of the microscope to separate tiny, closely adjacent objects.

3. Wet Mounts or Fresh Mounts and Prepared Slides

1) Wet mounts

Living material is often observed in a preparation called a "wet mount". This basically means that the living material is either in water, or is covered with water before adding a coverslip. Because water is the primary constituent of living cells, this technique is necessary to be able to observe living material without the damaging effects of dehydration.

The general procedures for making a wet mount are described below.

(1) For wet specimens: put a drop of your liquid culture (mixed) directly on the slide; For dry specimens and living specimens: put a drop of water on the slide, then add a small sample.

(2) Hold a coverslip at an angle to the slide and touch one side of it to the edge of the drop of water. This will cause the water to spread out along the place where the coverslip touches the slide. Now, gently drop the coverslip over the water on the slide. This should result in a minimum of air bubbles under the coverslip.

(3) Dry your slide before you put it on the stage.

(4) Try to find the objective under low power. When you think you have one, change to the next higher power, and finally, the highest power.

2) Fresh mounts

Fresh mounts of biological material may involve whole organisms, free-hand sections cut with a razor blade. The material is placed in a drop of physiological saline or water in the center of a clean slide. Some care must be taken in lowering the cover slip in order to avoid trapping air bubbles. The difficulty is overcome by first allowing only one edge of the cover slip to rest on the slide and, while supporting the cover slip with a needle, slowly lowering it over the preparation. Since this type of preparation will dry up, a drop of saline or water must occasionally be added along one edge of the cover slip. Alternatively you can reduce evaporation by ringing the edges of the cover slip with a thin film of vaseline.

Note:

(1) The key to making a good slide is thinness of the sample. If your sample is too thick the coverslip will not sit correctly and will "wobble". Also, light will not pass through!

(2) Try to get the thinnest piece as possible as you can; it should be thinner than paper. It might help if you take a thicker piece and bend it until it snaps into two pieces. After it snaps, there is usually a very thin connection remaining between the two pieces. This thin connecting layer can be peeled off and placed on a microscope slide for viewing.

3) Prepared slides

Prepared slides consist of whole organisms, or sections (thin slices) of organs or tissues. In the case of sectioned material, an organ or piece of tissue is first killed and 'fixed' in a preserving material. It is then infiltrated and embedded in paraffin or plastic. The resulting block is cut into thin sections (usually 4~10mm thick) on a microtome and the sections are mounted on glass slides. The paraffin is removed and the material is stained usually following a specialized technique to emphasize a particular structure or substance. Finally, the preparation is covered with a thin layer of Permount and a cover slip is placed on top.

C. Dissecting Microscopes

A dissecting microscope is used for viewing objects that are too thick for light to pass through. It also allows for the examination of much bulkier objects than is possible with a compound microscope (Fig.1-1). The dual lens system provides a stereoscopic view; magnifications obtained are not as great as those possible with a compound microscope.

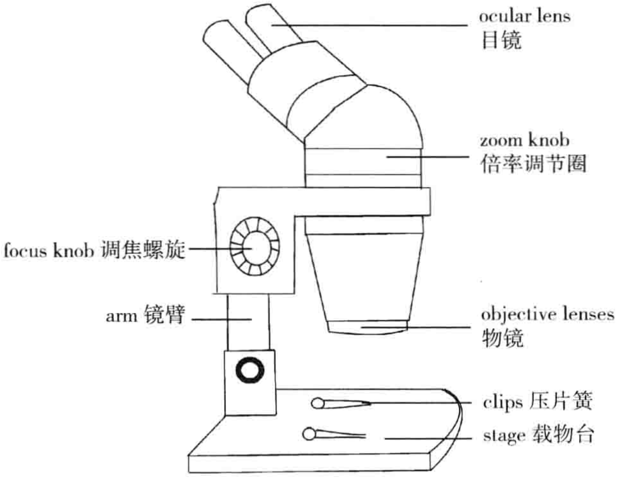

Fig. 1-1 A dissecting microscope