



Comprehensive Bilingual
Experimental Textbook of Genetics

遗传学综合双语实验教程

(第 2 版)

◎ 李卫东 主编

 北京理工大学出版社
BEIJING INSTITUTE OF TECHNOLOGY PRESS

遗传学综合双语实验教程

第2版

李卫东 主 编

王沛政 李成奇 副主编



北京理工大学出版社

BEIJING INSTITUTE OF TECHNOLOGY PRESS

版权专有 侵权必究

图书在版编目 (CIP) 数据

遗传学综合双语实验教程 / 李卫东主编. —2版. —北京: 北京理工大学出版社, 2019.1

ISBN 978-7-5682-6662-8

I. ①遗… II. ①李… III. ①遗传学-实验-双语教学-教材
IV. ①Q3-33

中国版本图书馆CIP数据核字 (2019) 第013917号

出版发行 / 北京理工大学出版社有限责任公司

社 址 / 北京市海淀区中关村南大街5号

邮 编 / 100081

电 话 / (010) 68914775 (总编室)

(010) 82562903 (教材售后服务热线)

(010) 68948351 (其他图书服务热线)

网 址 / <http://www.bitpress.com.cn>

经 销 / 全国各地新华书店

印 刷 / 涿州市新华印刷有限公司

开 本 / 710 毫米 × 1000 毫米 1/16

印 张 / 11

字 数 / 179千字

版 次 / 2019年1月第2版 2019年1月第1次印刷

定 价 / 35.00 元

责任编辑 / 梁铜华

文案编辑 / 梁铜华

责任校对 / 杜 枝

责任印制 / 施胜娟

图书出现印装质量问题, 请拨打售后服务热线, 本社负责调换

前言

内容简介:

本书涉及经典遗传学、细胞遗传学、分子遗传学、群体遗传学和数量遗传学等内容, 合计 23 个实验, 基本上体现了基础遗传学实验教学的需求。全书内容和结构编排新颖, 实验设计有实验原理、实验记录、实验报告等基本要求; 具体实验内容设计了实验原理、基本材料、实验步骤、结果辨析、注意事项等内容。这些是培养学生具备缜密思维和分析能力不可缺少的途径。

Brief Introduction:

This book relates to classical genetics, cytogenetics, molecular genetics, population genetics and quantitative genetics and other content and has a total of 23 experiments. Basically, It reflects the teaching demand of the fundamental genetics experiment. The content and structure arrangement was new, and the experimental design includes principles, test records, test reports and other basic requirements. The concrete experiment content designing has the experiment principles, basic materials, experimental steps, analyses of results, matters needing attention. These are the necessary approach of cultivating students with gentry densely thinking and analytical skills.

前 言

遗传学是介绍孟德尔遗传、染色体和分子基础的一门课程。实验室操作主要强调基本遗传技术动手操作经验，其技术包含一些生物遗传杂交的构建与分析、染色体材料的制备和分析，DNA 的检测以及通过凝胶电泳对 DNA 序列变化的分析。很多的实验材料都包括果蝇，果蝇是遗传学实验中经典的生物体。本书包括四部分共 23 个实验，每个实验的实验原理已构建好，可以让您熟悉遗传学这门课。

本书实验数目较多，还包括一些分子水平上的实验技术，而实验时间有限，不可能都做，所以可以根据具体情况，酌情选择。限于时间，有些实验未收集，有待以后补充。

此次编写是双语教材编写的尝试和探索，疏漏和错误在所难免，愿遗传学同道在格式、思路以及实验本身方面不断提出宝贵意见，以期再版时不断完善。

本书编写具体分工情况：李卫东老师（海南热带海洋学院）编写第一部分。王沛政老师（海南热带海洋学院）编写第二部分和第三部分，李成奇老师（河南科技学院）编写第四部分。

本书由海南热带海洋学院资助出版。

编 者

2018 年 11 月

Preface

Genetics is an introductory course that deals with the laws of Mendelian inheritance and their chromosomal and molecular basis. The major laboratory investigations emphasize hands-on experience with basic genetic techniques, including construction and analysis of genetic crosses with several organisms, preparation and analysis of chromosome material, examination of DNA and calculation and analysis of patterns of DNA sequence variation by electrophoresis. Many of the exercises involve *Drosophila melanogaster*, the classic organism of experimental genetics. This book includes four aspects and a total of 23 experiments, of which the principles have been established to acquaint you with Genetics.

The number of experiments in this book is large. Moreover, this book includes experimental techniques based on some molecular level. The time for doing experiments in class is limited, so all of the experiments can not be done. Therefore, you can make appropriate choice according to the specific circumstances. Due to the limitation of time, some experiments are not collected, which need to be added in future.

This book is an attempt and exploration of bilingual textbook, so omissions and mistakes can hardly be avoided. We welcome your comments and suggestions on the format, presentation of ideas, and experiments themselves in order to improve in the next edition.

In this book, Dr Li Weidong (Hainan Tropical Ocean University) wrote the first part, Dr Wang Peizheng (Hainan Tropical Ocean University) wrote the second and third part and Dr Li Chenqi (Henan Institute of Science and Technology) wrote the last part.

This book is sponsored by Hainan Tropical Ocean University.

目 录

第一部分	1
实验一 洋葱(大蒜)根尖有丝分裂标本的观察	2
<i>Experiment 1 Looking at the Mitosis Using Onion (Garlic) Roots</i>	5
实验二 减数分裂标本的制作与观察	8
<i>Experiment 2 Preparation and Observation of Meiosis Specimens</i>	10
实验三 永久片的制作	13
<i>Experiment 3 Preparation of Permanent Microscopic Slides</i>	15
实验四 果蝇形态及生活史的观察	18
<i>Experiment 4 Observation on Drosophila and Its Life Cycle</i>	23
实验五 果蝇唾腺染色体的观察	29
<i>Experiment 5 Observation on Drosophila Polytene Chromosomes</i>	31
实验六 果蝇的伴性遗传	34
<i>Experiment 6 Sex-linked Inheritance of Drosophila Melanogaster</i>	36
第二部分	39
实验七 人类染色体的识别与核型分析	40
<i>Experiment 7 Identification and Karyotype Analysis of Human Chromosomes</i>	43
实验八 人体性染色质体的观察	47
<i>Experiment 8 Observation of the Human Sex Chromatin</i>	49

实验九 ABO 血型 and 人类 Rh 因子	52
<i>Experiment 9 ABO Blood Grouping and Rh Factor in Humans</i>	54
实验十 人类 ABO 血型的群体遗传学分析	57
<i>Experiment 10 Population Genetic Analysis of Human ABO Blood Types</i> ...	60
实验十一 卡方分析	63
<i>Experiment 11 Chi-Square Analysis</i>	66
实验十二 数量性状的遗传分析	69
<i>Experiment 12 Genetic Analysis of Quantitative Traits</i>	72
第三部分	75
实验十三 孟德尔遗传实验	76
<i>Experiment 13 Mendelian Inheritance</i>	78
实验十四 植物多倍体的诱发及鉴定	80
<i>Experiment 14 Induction and Identification of Plant Polyploid</i>	83
实验十五 植物有性杂交技术	87
<i>Experiment 15 Sexual Hybridization of Plants</i>	91
实验十六 灭菌操作技术	96
<i>Experiment 16 Aseptic Culture Techniques</i>	98
实验十七 从大肠杆菌中小规模制备质粒	101
<i>Experiment 17 Small Scale Plasmid Preparation Through E. Coli</i>	105
实验十八 MS 培养基的准备	110
<i>Experiment 18 Preparation of MS Medium</i>	113
第四部分	117
实验十九 脱氧核糖核酸 (DNA) 的鉴定——孚尔根 (Feulgen) 反应 ...	118
<i>Experiment 19 Identification of Deoxyribonucleic Acid (DNA)</i> —Feulgen Reaction	121

实验二十 植物基因组 DNA 的提取	124
<i>Experiment 20 Extraction of Plant Genome DNA</i>	126
实验二十一 利用紫外光谱测定 DNA 的浓度和纯度	129
<i>Experiment 21 Determination of Concentration and Purity of DNA by UV Spectroscopy</i>	133
实验二十二 聚合酶链式反应	137
<i>Experiment 22 The Polymerase Chain Reaction (PCR)</i>	140
实验二十三 用琼脂糖凝胶电泳法检测 DNA	143
<i>Experiment 23 Detection of DNA by Agarose Gel Electrophoresis</i>	147
附: 实验报告格式	153
Appendix: The Format of the Laboratory Report in English	158
参考文献	163

实验一 洋葱（大蒜）根尖有丝分裂标本的观察

一、实验目的

- (1) 制作洋葱根尖细胞有丝分裂的标本，并能观察到有丝分裂的每个时期。
- (2) 更好地理解有丝分裂的过程和阶段。
- (3) 分析并估计有丝分裂每个阶段的相对时间。

二、实验原理

真核生物中，DNA 的复制通常伴随着有丝分裂的过程。有丝分裂保证了每个子细胞都得到一份复制的染色体。染色体在有丝分裂过程中经历以下几个阶段：前期、中期、后期和末期。细胞质的实际分裂叫作胞质分裂，发生在末期。胞质分裂之前的每个阶段及特定的事件有助于已经复制的染色体的有序分布。

三、实验材料

洋葱根尖、复式显微镜、洋葱载玻片样片、拨针、载玻片、盖玻片、镊子、滤纸、刀片、乙酸、地衣红、1 mol/L 盐酸、卡诺氏固定液（乙醇混合物：冰醋酸 = 3 : 1 或 9 : 1）、10% 的冰醋酸、蒸馏水或去离子水溶液以及卡宝品红。

四、实验步骤

（一）压片制作的准备程序

- (1) 用剪刀剪下两段长约 1 cm 的洋葱根尖，转移到离心管中。
- (2) 用卡诺氏固定液固定 12 h。

(3) 倒掉卡诺氏固定液, 往离心管中加入 $2/3$ 体积的 1 mol/L 的 HCl 。(注意: HCl 是强酸, 小心操作)。

(4) 将离心管置于 60°C 水中水浴, 让根尖孵育 12 min , 然后移出离心管。

(5) 用镊子小心地将根尖移到载玻片上。

(6) 用滴瓶冲洗根尖 3 次。

(二) 染色

(1) 冲洗 3 次后, 添加卡宝品红染液或乳酸—乙酸—地衣红染液。

(2) 在染液中孵育 12 min 。在此期间, 根尖开始变红。

(3) 倒掉染色液并冲洗根尖 3 次。

(三) 制作根尖压片

(1) 将根转移到一个洁净的载玻片上, 滴一滴水。

(2) 用刀片切掉根尖未染色部分并丢弃。

(3) 用盖玻片盖住根尖, 然后在盖玻片覆盖的一面小心地用解剖探针末端下压, 用力但不要扭动或侧向推动。根尖应被展开至直径为 $0.5\sim 1\text{ cm}$ 。

(4) 在显微镜下检查有丝分裂的各个阶段。

五、结果

观察洋葱根尖压片, 在 10 倍镜下寻找目标。寻找区域具有与细胞相比较大的细胞核。在这些细胞中将会发现各时期的有丝分裂。转换到 40 倍镜仔细观察。由于前期和前中期很难区分, 因此将其划分为前期。

绘制你所观察到的图像, 并说明是哪一个时期的有丝分裂。

问题:

(1) 为什么要使用洋葱根观察有丝分裂?

① 洋葱根很容易生长, 并能很快大量增殖。

② 根尖细胞分裂旺盛, 便于查看各时期的有丝分裂。

③ 可以将染色体染色, 使它们更容易被观察到。

(2) 有丝分裂各阶段特点是什么?

前期:

中期:

后期：

末期：

（答案略。）

附录：

乳酸—乙酸—地衣红染液：一份 A 液 + 一份 B 液 + 一份水。

地衣红冰醋酸溶液（A）：约 2 g 地衣红 + 100 mL 冰醋酸，加热（谨防沸腾），充分溶解后过滤。

地衣红乳酸溶液（B）：约 2 g 地衣红 + 100 mL 乳酸，加热（谨防沸腾），充分溶解后过滤。

卡宝品红：约 0.3 g 地衣红 + 90 mL 石碳酸酚（5%）+ 11 mL 冰醋酸 + 11 mL 甲醛（37%），充分溶解。

二、实验原理

真核生物中，细胞分裂分为有丝分裂和减数分裂。有丝分裂是体细胞增殖的主要方式，其过程可分为四个阶段：前期、中期、后期和末期。细胞质的实际分裂叫作胞质分裂，发生在末期。有丝分裂之前的每个阶段及特定的事件有称：已复制的染色体分离为姐妹染色单体。

四、实验步骤

（一）压片制作的准备步骤：将洋葱根尖放入卡诺氏固定液中固定 24 h。

（1）用剪刀剪下两段长约 1 cm 的洋葱根尖，并放入卡诺氏固定液中。

（2）用卡诺氏固定液固定 24 h。

Experiment 1 Looking at the Mitosis Using Onion (Garlic) Roots

I . Experimental Objectives

- (1) Prepare your own specimens of onion roots with which you can visualize all of the stages of the mitosis.
- (2) Better understand the process and stages of the mitosis.
- (3) Apply an analytical technique by which the relative length of each stage of the mitosis can be estimated.

II . Experimental Principles

DNA replication in eukaryotes is accompanied by the process called mitosis which assures that each daughter cell receives one copy of the replicated chromosomes. During the process of mitosis, the chromosomes pass through several stages known as prophase, metaphase, anaphase and telophase. The actual division of the cytoplasm is called cytokinesis and occurs at telophase. During each of the stages prior to cytokinesis, particular events occur, which contributes to the orderly distribution of the replicated chromosomes.

III . Experimental Materials

Onion roots, compound microscopes, prepared slides of longitudinal sections of onion roots, dissecting needles, slides, cover slips, forceps, filter paper, scalpel, acetic acid, acetic orcein, 1mol/L Hydrochloric acid, Carnoy's fixative (Mixture of ethyl

alcohol: glacial acetic acid in proportions of 3 : 1 or 9 : 1), 10% solution of glacial acetic acid, distilled or deionized water, and carbol fuchsin.

IV. Experimental Procedures

Preparing root tip squashes:

- (1) Using scissors, cut 2 root tips about 1 cm long, and transfer them into a plastic micro-tube.
- (2) Treat them with Carnoy's fixative for 12 h.
- (3) Drain the Carnoy's fixative and fill the centrifuge tube to about 2/3 full with 1 mol/L HCl (Caution: work with the HCl carefully. It is a strong acid).
- (4) Place the centrifuge tube into a 60°C water bath, and allow the roots to incubate for 12 minutes. After that remove the tube from the water bath.
- (5) Carefully transfer the root tips to a small petri plate using forceps.
- (6) Rinse the root tips 3 times with the water, using the dropper bottle.

Staining the chromosomes:

- (1) Cover the root with the Carbol fuchsin stain/Lactic acid, acetic and orcein dye.
- (2) Incubate the roots into the stain liquid for 12 minutes. During this process the very tip of the root will begin to turn red.
- (3) Remove the stain and again rinse the roots 3 times with water.

Making the root tip squash:

- (1) Transfer a root to a clean microscope slide and drip a drop of water on it.
- (2) Using a razor blade, cut off the unstained part of the root, and discard it.
- (3) Cover the root tip with a cover slip, and then carefully push down the cover slide with the wooden end of a dissecting probe. Push hard, but do not twist or push the cover slide sideways. The root tip should spread out to a diameter of 0.5–1 cm.
- (4) Examine the stages in mitosis.

V . Experimental Results

Observe the onion root tip squash under the 10× objective. Look for the region that has larger nuclei relative to the size of the cell. The cells will display stages of mitosis. Switch to the 40× objective to make closer observations. Prophase and prometaphase are difficult to distinguish, so all these cells are classified as prophase.

Record your observations in the table provided. Draw the image of what you have observed, and describe which stage it is in the mitosis.

Questions:

(1) Why do we use onion roots to view the mitosis?

- ① The onion root can grow easily and large numbers of roots will be got soon.
- ② The cells at the tip of the roots divide actively so it is easier to check the

periods of mitosis.

③ Chromosomes can be stained to make them more easily observable.

(2) What is the distinguishing visible feature in each stage of mitosis?

Prophase:

Metaphase:

Anaphase:

Telophase:

(The answer is omitted.)

Appendix:

Lactic acid, acetic and orcein dye: an A solution, a certain quantity of B solution and a certain quantity of water.

Aceto-orcein stain (A): about 2 g orcein stain +100 mL glacial acetic acid, heating (not boiling), fully dissolving, then filtering.

Orcein-lactic acid stain (B): about 2 g orcein stain +100 mL lactic acid, heating (not boiling), fully dissolving, then filtering.

Carbol fuchsin: 0.3 g orcein stain + 90 mL carbolic acid (5%) +11 mL glacial acetic acid+11 mL formaldehyde (37%), fully dissolving.

实验二 减数分裂标本的制作与观察

一、实验目的

研究减数分裂对了解细胞的正常分裂是很必要的。在这个实验过程中, 学生将识别雄性蝗虫不同阶段的减数分裂。将活体蝗虫解剖后, 取出精腺并染色观察。

二、实验原理

减数分裂是子细胞染色体数目减半(从二倍体到单倍体)类型的细胞分裂, 比如配子。减数分裂包含两个阶段: 减数分裂 I 和减数分裂 II。减数分裂 I 时期同源染色体相互分离。减数分裂 II 时期染色体均等分离并形成 4 个子细胞。在减数分裂阶段, 细胞学观察要准备的材料主要有精腺小管细胞或花蕾和花药中的花粉母细胞等。

三、实验材料

雄性蝗虫(无产卵器)、复式显微镜、蝗虫载玻片样片、拨针、载玻片、盖玻片、镊子、滤纸、刀片、50% 乙酸、2% 醋酸地衣红以及卡宝品红。

四、实验步骤

- (1) 洗手并戴上手套和护目镜。
- (2) 收集设备材料。
- (3) 准备工作区。
- (4) 从卡诺固定液中取出一个雄性蝗虫。
- (5) 取下附属肢体。