

# 桑蚕组织胚胎学图谱

A COLLECTION OF ILLUSTRATIVE  
PHOTOGRAPHS OF THE HISTOLOGY &  
EMBRYOLOGY IN THE SILKWORM (*Bombyx mori*)

吴维光 主编

Edited by Wu Weiguang

中国农业出版社

 CHINA AGRICULTURE PRESS



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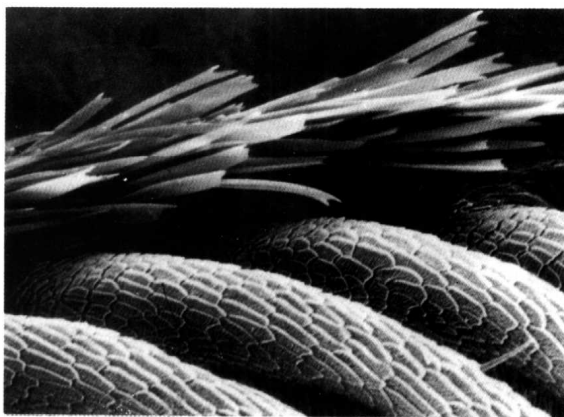
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## 内 容 简 介

本图谱配合统编文字教材——蚕体解剖生理学的内容编著。全部选用作者自己制作的样本,应用扫描电镜、透视电镜、光学显微镜、立体解剖镜系统地拍摄而成。内容包括桑蚕各个发育阶段(以幼虫为主)的各个器官、组织的显微及超微形态、构造,以及胚胎发育过程的图片共402张,其中电镜照片占75%,分外部形态、体壁、消化、循环、脂肪体、呼吸、排泄、丝腺、神经、肌肉、内分泌、生殖、胚胎发育等十三章,并加简要的中、英两种文字说明。

本图谱不仅可供蚕学专业教学上使用,同时可供昆虫学、动物学、生物学、植物保护等专业的基础教学及有关科研工作者的参考。

## ABSTRACT

This collection of illustrative photographs is meant to support the text book "Silkworm Anatomy and Physiology" in the classroom teaching. All the specimens are made by authors and taken pictures systematically by means of scanning electron microscope, electron photomicroscope, optical microscope and stereoscopic microscope. There are altogether 402 photographs, out of which 75% are electron microscopic photographs, showing micro- and ultra-morphology and structures of all the organs and tissues of the silkworm (*Bombyx mori*) in its different (including embryonic) developmental stages (with emphasis on the larval stage). It is composed of thirteen chapters with concise narration in both Chinese and English in: external morphology, integument, alimentary canal, circulatory system, fat body, respiratory system, Malpighian tubules, silk glands, nervous system, muscles, endocrine systems, reproductive system, and embryonic development.

The book can not only be used in the class of sericulture for educational purpose, but also serve as a reference for the teaching and research personnel in entomology, zoology, biology, and plant protection.

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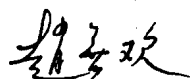
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## 序

蚕丝业起源于中国,随后传播到世界各地,这是我国古代劳动人民和科学工作者驯化野生昆虫,使之成为人类经济利益服务的一大创造,也是对世界物质文明的贡献。几千年来,我国一直是世界主要的产丝国和丝制品出口国。通过国际丝绸贸易,促进了各国科学、文化和经济贸易的交流和发展以及人民间的友好交往。“丝绸传友谊”成为千古佳话。近年来,我国进一步发展蚕业生产,生丝产量约达全球总产的三分之二。回顾过去的历史和体察今天我国蚕丝生产产业的国际地位,我国蚕业科学工作者应该倍加努力,弘扬祖国这一份宝贵的历史遗产,进一步钻研蚕业科学技术,争取作出更多更大的贡献。我很高兴地披览了吴维光教授和他的合作者编著的《桑蚕组织胚胎学图谱》,该书具有如下的几个特色:1. 选用的全部图片,均为作者们自行摄制的,其中应用电镜拍摄的超微形态、构造的图片约占75%,展示了桑蚕各个器官、组织(特别是排泄、神经、肌肉、生殖等部分)不少新的电镜照片,拓宽和加深了文字教材的内容,图片清晰,质量优良,编辑合理,体现了适用性和先进性。2. 本图谱与目前国内、外同类出版物相比,更为系统和全面。工作量大,难度较高。3. 使用中、英两国文字说明,利于促进国际学术交流和专业英语教学。

本图谱不但适用于蚕学专业教学上使用,同时也是昆虫学、生物学、动物学、植物保护等专业基础教学和有关科学研究上很好的参考书。我希望随着本图谱的问世,今后将有更多的如同本书具有我国特色的桑蚕学、昆虫学的著作出版,故乐于为此作序。

中国科学院生物学部委员  
华南农业大学昆虫学教授



1993年6月25日

## FOREWORD

Sericulture was originated in China, and then spread to different parts of the world. It is an invention by the Chinese people through generations of efforts in domestication of the wild insect to make it serve the mankind, as well as a contribution to the world civilization. Over thousands of years, China has been the major silk producer and exporter of the world. As the saying "Silk conveys friendship" goes, the international silk trade has promoted the exchange and development in science, culture and economy among different countries, and the friendship between different peoples. In the recent years, China has further promoted its sericultural production, the raw silk output has reached such a level that it accounts for 2/3 of the world's total. Looking back on the history and seeing China's position in the world silk production, our sericulturists should double their efforts in research and technical advancement so as to pass on with pride this wonderful heritage and make more contribution. I have read with keen interest "Silkworm Histology and Embryology" compiled by Prof. Wu Weiguang and his colleagues, and noticed the following characteristics. First, all the photos presented are made by the authors, out of which 75% are electron microscopic photos showing various organs and tissues (particularly in excretory, nerval, muscular, and reproductive systems) of the silkworm. Many new photos have added more knowledge to the literature of the subject. The photos are clear, and well edited, in high quality and easily applicable. Second, compared to other publications from both home and abroad of the same subject, this book is more systematic and covers more aspects. Third, both Chinese and English languages are used so that it is good for scientific exchanges with other countries, and for the teaching of the subject in English.

This book is not only important to the teaching of sericulture, but also can serve as a good reference book in other subjects like entomology, biology, zoology, plant protection, etc. I hope the publication of this book will bring about more such books in sericulture and entomology with Chinese characteristics, and I am hereby very glad to express my sincere appreciation for this book.

*Zhao Shanhuan*

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Professor of Entomology of South China Agricultural University

June 25, 1993

## 前 言

桑蚕丝是一种高级的动物性天然纤维,丝织品穿着舒适、绚丽夺目,几千年来,一直驰誉世界,素有“纤维皇后”的美称,在经济上具有重要意义。同时由于桑蚕经过长期的人工驯化和选育,易于在实验室饲养和调控,又是研究生物学、遗传学等的理想实验材料。因而国内外学者对桑蚕的研究十分广泛和深入,除饲养、选种、繁育、蚕病防治等研究外,还包括解剖学、组织学、胚胎学等领域,也有许多专著。限于当时条件,其形态、构造多属手工描绘。但是近三十年来,电子显微技术的发展,桑蚕超微构造的研究,也随着不断日益丰富,展示了许多新的内容。日本学者赤井弘在1976年所著的《昆虫的表面构造》和《昆虫超微形态学》以桑蚕幼虫为重点,详细叙述了其外部形态、体壁、气管、消化系统、丝腺等的超微结构,有很好的参考价值,但正如其本人所指出的:还有许多器官组织(如神经、肌肉、生殖、排泄等)未有编入。为了适应在大学本科、研究生教学上的要求,需要一本系统地展示桑蚕各个器官、组织的显微及超微构造的专著,但目前在国内、外尚感缺乏。本图谱正以此为目的,全部选用自行摄制的实物照片,以幼虫阶段为重点,按课程顺序,系统编辑而成。其中电镜照片占75%,辅以部分光学显微照片,并加简要的中、英文两种文字说明,以作为蚕体解剖生理学的配套教材。也可供昆虫学、生物学、植保专业教学和有关科研人员参考。由于工作量浩大和时间、条件的限制,难于求全。加上作者水平有限,不够完善及错漏处也自当不少,尚祈读者指正。

参加本图谱编著人员有:陈革副教授(华南农业大学),庄大桓研究员(中国农业科学院蚕业研究所),孔宪扬高级工程师、区超武工程师(华南农业大学)。并承蒙利翠英教授(中山大学昆虫研究所)主审,赵善欢教授(中国科学院生物学部委员)作序。

参加电镜照片拍摄的还有章潜才,伦璇(华南农业大学),马金鑫(上海昆虫研究所)。光学显微照片由黄振邦拍摄。韩辉负责英文翻译。在此,我谨向有关人员深表谢意。

主编:吴维光教授

华南农业大学,亚太地区蚕桑培训中心

1993年6月26日



## PREFACE

Silk is a high quality natural animal fiber. The garments made of silk are comfortable to the human body, and attractive in appearance. Over thousands of years, silk has been known to the world as the "queen of fiber" with considerable economic significance. Since silkworm (*Bombyx mori*) has long been domesticated and selected, it is easy to be reared and controlled in the lab; therefore it is an ideal experimental animal for the research in biology and genetics. Scientists from China and the world have undertaken extensive research on the animal, which involves not only the rearing, selection, multiplication, disease control, but also the anatomy, histology and embryology, with plenty of publications. However, due to limited conditions at the time, the morphology and structure of the silkworm were described mainly by hand drawings. In the past 30 years, along with the development of electron microscopy, research in the ultrastructure of the silkworm has gradually been pushed forward with a lot of new findings. In 1976, a Japanese scientist Akai described in detail the external morphology, and the ultrastructure of the integument, tracheal system, alimentary canal, and silk gland in his books "Surface Structure of Insects" and "Ultra-Morphology of Insects". The books surely serve us as good reference, but as the author himself pointed out, many organs such as the nerve, muscle, reproductive system, excretory system, etc. have not been covered. To facilitate the programs for undergraduates and postgraduates of the related subjects, a specially written textbook on the micro- and ultra-structures of all the organs and tissues of the silkworm is imperative. Unfortunately, it is lacking both at home and abroad. For this purpose, this book is compiled in a systematic way using all materials and photographs from the authors' institute, according to the curriculum sequence, and with the emphasis on the larval stage. 75% of the photos in the book are electron microscopic photos, plus some microphotographs, with concise narration in both Chinese and English. It can be used in the class together with the literatures of the same subject, and can serve as a reference for the teaching and research personnel in entomology, biology, and plant protection. Because of the heavy workload and limited conditions and time, it is hard for us to get it perfect. Some inaccuracies might have been overlooked. The authors sincerely welcome any comments and critics from the readers.

The authors and editors involved are : Chen Ge, Associate Professor (South China Agricultural University), Zhuang Dahuan, Research Professor (Sericultural Research Institute of Chinese Academy of Agricultural Sciences), Kong Xianyang, Senior Engineer, Ou Chaowu, Engineer (South China Agricultural University). The manuscript is reviewed by Prof. Li Cuiying of Entomology Research Institute of Zhongshan University. Prof. Zhao Shanjuan (Member

of Academia Sinica) writes the foreword.

The electron microscopic photographers are Zhang Qiancai, Lun Xuan (South China Agricultural University), Ma Jinxin (Shanghai Entomology Research Institute). Microphotographs are taken by Huang Zhenbang. Han Hui takes charge of English translation of the manuscript. I hereby wish to thank all the above colleagues for their efficient work and cooperation.

*Chief Editor: Prof. Wu Weiguang*  
Regional Sericulture Training Center for Asia/Pacific  
South China Agricultural University

June 26, 1993

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## 1 外部形态

桑蚕是完全变态的昆虫,在一生中,要经过卵→幼虫→蛹→成虫 4 个形态和机能上完全不同的发育阶段。

### 1.1 卵

椭圆形,略扁平,一端稍尖,上有卵孔。卵色因品种不同而异。卵的最外层为卵壳,表面遍布多角形的卵纹,并有无数微细的气孔。卵壳内依次有卵黄膜、浆膜、卵黄等。卵是胚胎发育的阶段。

### 1.2 幼虫

长圆筒形,分头、胸、腹 3 部分。头部较小,上有口器、触角、单眼、吐丝管等。胸部分前、中、后胸,各有 1 对胸足。腹部有 10 个腹节,共有 5 对腹足。前胸和腹部两侧共有 9 对气门。幼虫是摄取营养的生长阶段。

### 1.3 蛹

纺锤形,黄褐色,分头、胸、腹 3 部分。前胸和腹部两侧共有 8 对气门。雌蛹腹部大,末端较钝,在第 8 腹节腹面正中有 X 形线缝。雄蛹小而腹部末端较尖,第 9 腹节腹面中央有 1 个褐色圆点。蛹是从幼虫过渡到成虫的变态阶段。

### 1.4 成虫

分头、胸、腹 3 部分。全身被有白色鳞片。头部有大形的触角和复眼。口器显著退化。胸部分 3 个胸节,各节有 1 对胸足,中、后胸各生 1 对翅。腹部末端有外生殖器,前胸和腹部共有 8 对气门。成虫是交配产卵、繁殖后代的生殖阶段。

## 1. External Morphology

Silkworm (*Bombyx mori*) is an insect of complete metamorphosis. In its life cycle, it passes through egg, larva, pupa, and moth, the four developmental stages totally different in morphological characters and functions.

### 1.1. Egg

Silkworm eggs are oval, flat, slightly pointed at the anterior pole with a micropyle on it. The color of the egg varies from race to race. The outermost of it is the shell bearing polygonal markings on the surface. Inside, it contains vitelline membrane, serosa, and yolk. Egg is the stage when embryo develops.

### 1.2. Larva

The larva has a long, cylindrical body which is divided into: head, thorax, and abdomen. The head is small, having mouth parts, antennae, stemmata, and spinneret on it. The thorax



consists of three segments called the pro-meso-and meta-thorax ,each carrying a pair of thoracic legs. The abdomen is composed of ten segments ,carrying 5 pairs of abdominal legs. There are nine pairs of spiracles on both sides of the thorax and abdomen. Larva is the stage when silkworm takes food.

### **1. 3. Pupa**

The pupa is spindle in shape ,and brown in color. The body is also divided into ;head ,thorax ,and abdomen. There are eight pairs of spiracles on both sides of the thorax and abdomen. The female pupa is bigger ,and comparatively blunt at the distal end ,with an 'X' marking on the ventral side of the 8th abdominal segment. The male is smaller ,the distal end is slightly pointed ,there is a dark spot on the ventral side of the 9th abdominal segment. The pupal stage is the transitional stage when metamorphosis takes place.

### **1. 4. Adult (moth)**

The body of the moth is divided into; head ,thorax ,and abdomen ,and is covered with white scales. There are a pair of large antennae and compound eyes on either side of the head. The mouth parts are apparently degenerated. The thorax consists of three segments ,each carrying a pair of thoracic legs. The meso-and meta-thorax each bears a pair of wings. The caudal end carries genitalia. There are eight pairs of spiracles on both sides of the thorax and abdomen. Moth is the stage when silkworm mates and lays its eggs so as to multiply its offspring.

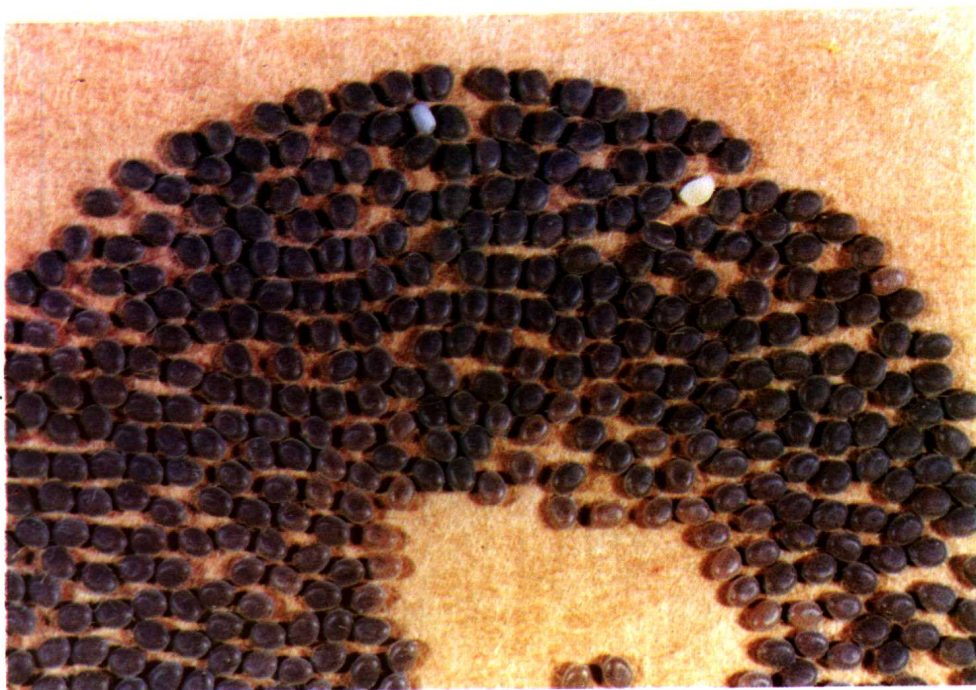


图 1.1(上) 卵的彩色图片。  $\times 4$

图 1.2(下) 幼虫的彩色图片。  $\times 1.5$

1.1(above) A colored photo of the eggs.  $\times 4$

1.2(below) A colored photo of the larvae.  $\times 1.5$



图 1.3(上) 蛹的腹面形态。左:雌、右:雄  $\times 3$

图 1.4(下) 成虫的彩色图片。  $\times 5$

1. 3(above) A ventral side view of the pupae. Left: female, right: male.  $\times 3$

1. 4(below) A colored photo of a moth.  $\times 5$



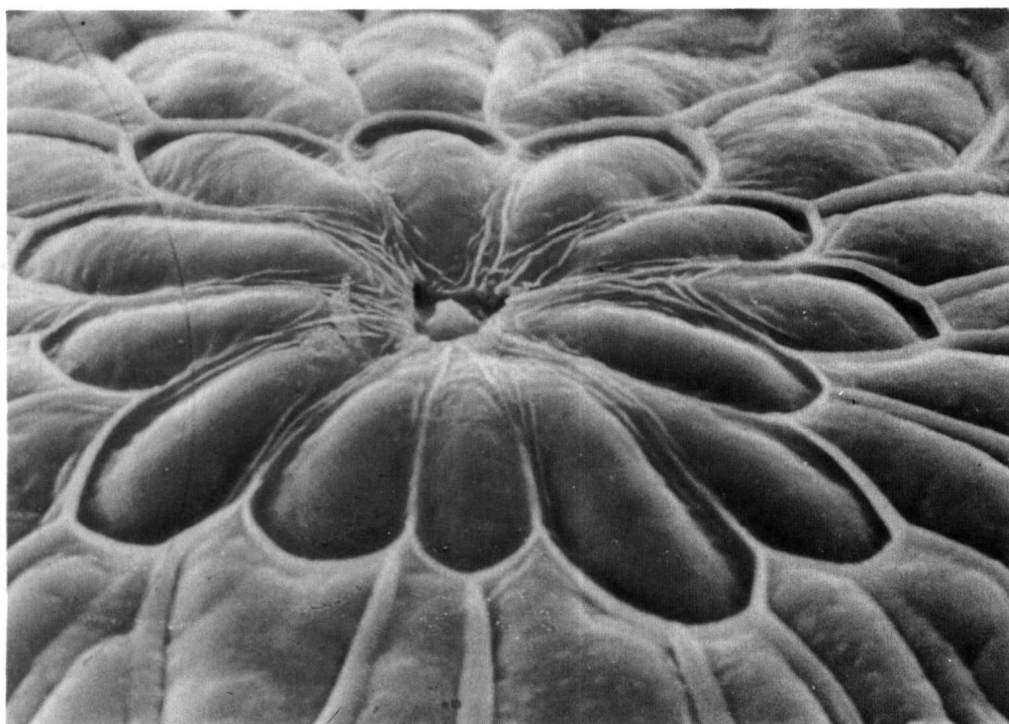
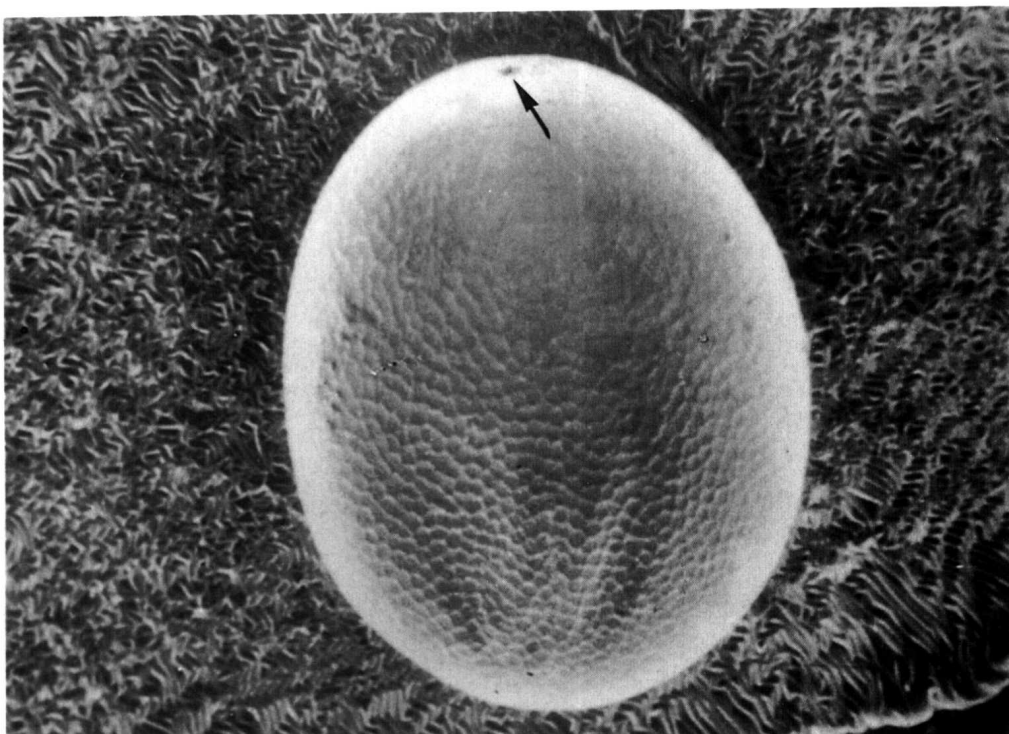


图 1.1.1(上) 卵的外形,箭头处为卵孔。  $\times 60$

图 1.1.2(下) 卵孔周围有花瓣形的卵纹。  $\times 3000$

1.1.1(above) This shows the morphology of an egg. Arrow points the micropyle.  $\times 60$

1.1.2(below) This shows the rose marking around the micropyle.  $\times 3000$