

PRACTICAL BIOLOGY

FOR

ADVANCED LEVEL
MEDICAL AND INTERMEDIATE
STUDENTS

VOLUME I
PRACTICAL ZOOLOGY

BY

G. J. WALLIS, M.A. (Cantab.)

FOURTH EDITION

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A

LABORATORY MANUAL

Covering the Syllabuses in *Zoology* of the General Certificate in Education (Advanced Level), Intermediate Examinations in Science, the Syllabuses in *Zoology* of the First Examinations for Medical Degrees, the Pre-Medical Examination of the Conjoint Board of the Royal College of Physicians and the Royal College of Surgeons, and other Examinations.

FOURTH EDITION



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FOREWORD TO THE FOURTH EDITION

WHEN revising my *Practical Biology* for its Fourth Edition, it was decided to publish it in two separate volumes under the titles *Practical Zoology* and *Practical Botany* to provide for the needs of students taking only one of these subjects at Advanced Level in the General Certificate of Education.

In the revision, advantage has been taken of helpful suggestions made in the reviews of the previous edition.

Some extra types required by Examination Syllabuses and a considerable amount of additional descriptive detail and many extra practical directions have been added to the Sections dealing with Animal Morphology and Anatomy, and Vertebrate Embryology in Volume I, *Practical Zoology*. At the same time the original object of avoiding long and tedious reading has been borne in mind. Several of the illustrations have been re-drawn and a number of additional ones inserted.

Little change appeared necessary in the parts concerned with Microscopical Technique and Biochemistry or in the Animal Physiology Sections and the Appendices, but a few amendments have been made. The notes on Vitamins and Hormones have been amplified and brought up to date and the prevalent use of millilitres instead of cubic centimetres has been adopted throughout.

I am very grateful to those teachers and students who have kindly made constructive criticisms and offered useful suggestions for improvement.

It is hoped that the alterations and additions in this Edition and the separation into two volumes will be to the advantage of those using the book and that it will continue to enjoy the favourable reception accorded to the earlier Editions.

Once again I must record my grateful thanks to my publishers and to Dr. Johnston Abraham and Mr. Owen R. Evans in particular for the very considerable help given in the production of this Edition.

C. J. W.

September 1957.

PREFACE

BIOLOGICAL knowledge, like all scientific knowledge, can be properly acquired only when it is the result of practical investigation. The following scheme of practical work has been drawn up in accordance with the requirements of the syllabuses in *Biology* of the First Examinations for Medical Degrees of the Universities, the Pre-Medical Examination of the Conjoint Board of the Royal College of Physicians and the Royal College of Surgeons, Intermediate Examinations in Science and the General Certificate in Education (Advanced Level), and of the syllabuses in the separate subjects *Botany* and *Zoology* of the Intermediate Science and the General Certificate Examinations. Teachers and students can easily discover what should be omitted by reference to the various examination syllabuses.

Unfortunately, Practical Classes are often unavoidably large and it is impossible for a great deal of individual attention to be given to the students. It is in any case desirable that they should learn by discovering things for themselves, provided they are guided along the right paths, for by this method they not only absorb facts more easily but learn to think and work on scientific lines. This is evident even in the small groups one takes in a tutor's practice in which students work individually and not as a class, and in which there is adequate time to devote to each student.

An attempt has therefore been made to make the book more than a mere list of morphological characters, and to give sufficient directions to enable the student to proceed with his practical work with a minimum of assistance from the demonstrator. At the same time, the inclusion of elaborate and unnecessary details which make the reading long and tedious has been avoided. Simple experiments have been included in plant and animal physiology to emphasise the correlation between structure and function. Drawings and diagrams have been freely inserted when it was considered necessary for the guidance of the student *solely* to assist him in his identifications. It is *essential* that the student should draw *exactly* what he sees in his preparations and that he should *not* copy diagrams from a book. *

For the sake of practical convenience, this manual is divided into four parts—Microscopical Technique, Elementary Biochemistry,

* Many of the illustrations in this manual are intentionally diagrammatic or semi-diagrammatic, though several are drawings from specimens.

Plant Biology and Animal Biology *; but the unity of life should be realised throughout. Introductory notes have been written to each part of the book, giving instructions peculiar to that part, and appendices have been added which contain information which it is hoped will be useful to those in charge of biological laboratories as well as to students. It is realised that teachers have their own individual methods in practical work, but there is much that is common to all. The book is *essentially a laboratory manual*, and is, of course, intended for use in conjunction with the usual text-books.

I have much pleasure in expressing my gratitude to Sir Frederick Gowland Hopkins, O.M., M.B., F.R.S., Professor of Biochemistry in the University of Cambridge, to Professor A. G. Tansley, M.A., F.R.S., Sherardian Professor of Botany in the University of Oxford and to Dr. L. A. Borradaile, M.A., Sc.D., Lecturer in Zoology in the University of Cambridge, for kindly reading through the First Edition manuscripts of the Biochemistry, Plant Biology and Animal Biology sections respectively, and for many helpful suggestions; also to Professor Tansley for allowing me to adapt some of the experiments on crystalloids and colloids from his "Elements Plant of Biology" and my own records of his practical course at Cambridge.

I am deeply indebted to Dr. J. H. Woodger, D.Sc., Reader in Biology in the University of London and Lecturer in the Middlesex Hospital Medical School, for reading through the proofs of the entire First Edition and of the vertebrate types of the Second; and to Dr. C. L. Foster, M.Sc., Ph.D., also of the Middlesex Hospital Medical School, for reading through the proofs of the complete Second Edition. In the course of these readings they made several invaluable suggestions, the majority of which I was glad to adopt. My thanks are also due to the late Mr. E. F. Steer, formerly Demonstrator at University College School, for devising, constructing and drawing the diagram of the aquarium aerating apparatus described in Appendix II.

I gratefully appreciate the courtesy of the authors and publishers of certain text-books for permission to use or adapt illustrations (acknowledged in each instance) from those books.

Lastly, I should like to acknowledge my indebtedness to my publishers, and particularly to the late Mrs. G. Fielding, the late Mr. L. B. Cavender and Mr. Owen R. Evans for the assistance they gave me in the production of the first three editions of the book.

LONDON, W.

December, 1949.

C. J. WALLIS.

*The Plant and Animal Biology have now been published in separate volumes, each containing appropriate sections on Microscopical Technique and Elementary Biochemistry.

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FLATTERS & GARNETT LTD., Manchester, for the illustration of the microscope.

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Volume II: Botany

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INTRODUCTION

I. GENERAL DIRECTIONS FOR PRACTICAL WORK

(1) Cleanliness, tidiness and accuracy are of the utmost importance. See that all your dissecting instruments are sharp and that all apparatus is clean before beginning your work.

(2) Read the directions carefully.

(3) If an experiment has to be left for some time, carefully label it with the object (or number) of the experiment and keep a record of any other relevant information such as the name of the animal, stage of growth, date, time, temperature, barometer reading, etc.

(4) Always set up a "control" experiment under opposite (or normal) conditions when practicable.

(5) Wash, clean, dry and put away all your instruments, apparatus, etc., when you have finished with them.

(6) In the case of microscopical preparations, it is advisable to compare your own slides with permanent slides. Always put the permanent slides back *in their proper places* in the trays or boxes; otherwise you (and others) will have difficulty in finding them on a future occasion.

(7) In the case of dissections, etc., examination of museum specimens is often very helpful.

(8) Throughout the study of biology, try to realise the correlation between the structure (anatomy) and functions (physiology) of the various organs and systems.

II. GENERAL DIRECTIONS FOR THE KEEP- ING OF PRACTICAL NOTEBOOKS IN PLANT AND ANIMAL BIOLOGY

(1) Experiments

Write the **object** of the experiment on the top of the page, then write a concise **method** or account of how the experiment was set up. Keep a record of any necessary readings and draw a *sectional diagram* of the apparatus, if any (*e.g.*, Fig. 147, p. 245). Lastly, when the experiment is finished, enter up the **result** together with any observations you have made and write a **conclusion**.

(2) Dissections and Microscopical Preparations

(i.) Print the name of the animal and the system, structure or organs on top ; state whether it is a dorsal or ventral dissection or an entire specimen, and in the latter case which view.

If it is a microscopical preparation, state whether it is a longitudinal or transverse section or entire specimen, and whether it is as seen under the low or high power.

(ii.) Write notes of any special directions, *e.g.*, removal or deflection of organs method of staining.

(iii.) Then make a **drawing or diagram**, roughly to scale. Examine the object carefully before you begin to draw it. *Draw only what you see* and draw on a *large* scale, showing all the necessary details.

(iv.) PRINT the names in BLOCK CAPITALS *horizontally* and join them to the corresponding parts by straight lines. Avoid crossing these lines over one another. (The use of letters and a key at the bottom is not desirable.)

(v.) When you have a complicated microscopical structure to draw, make a **diagram** (or plan) of the whole structure under the *low power* and detailed **drawings** of small samples of each tissue under the *high power*, all suitably named (*e.g.*, Figs. 19, p. 52 ; 135, p. 331).

(vi.) All drawings and diagrams should be drawn in pencil and should be *large*. The use of shading and colours should be kept down to a minimum, *e.g.*, red for arteries, and blue for veins.

(vii.) Never copy drawings or diagrams from textbooks. By doing so, you learn very little and are therefore wasting valuable time. Draw only what you see in nature. *The illustrations in this book are intended solely to help the student to find and identify the various structures and tissues. Many of the figures are diagrammatic or semi-diagrammatic, though this is not so in all cases. This is intentional.*

III. INSTRUMENTS AND APPARATUS REQUIRED

By each Student

(1) A set of *dissecting instruments* in a case or cloth roll as follows :—

1 large all-steel *scalpel* ($1\frac{1}{2}$ in. blade).

1 medium all-steel *scalpel* ($1\frac{1}{2}$ in. blade).

1 small all-steel *scalpel* (1 in. blade, or less).

Alternatively, scalpel handles with detachable blades of various shapes and sizes can be purchased.

- 1 pair of large *scissors* (5 or $5\frac{1}{2}$ in. overall length).
- 1 pair of small *scissors* with fine points (4 or $4\frac{1}{2}$ in. overall length).
- 1 pair of large *forceps*, blunt (5 in.).
- 1 pair of small *forceps* with fine points ($4\frac{1}{2}$ in.).
- 3 or 4 mounted *needles*.
- 1 *seeker*, 1 *camel-hair brush*, 1 *section-lifter*.
- 1 flat and hollow ground *razor* for section-cutting.
- Other instruments, e.g., *bone forceps*, may be added as desired.

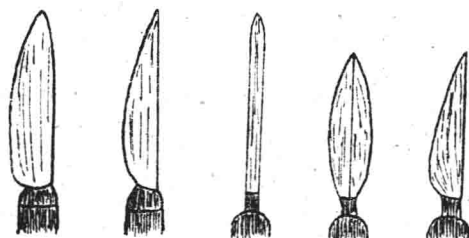


FIG. 1. Scalpel Shapes.

(2) Large-page practical *note-books* or *files*, with plain pages. A separate book or file should be kept for Animal Morphology. The Elementary Biochemistry and the Animal Physiology can be conveniently kept together in separate parts of the file or in another book, preferably with alternate ruled and unruled pages.

(3) A *hand-lens* (unless supplied by the laboratory).

(4) A *microscope* (unless supplied by the laboratory). See (3) below.

(5) The necessary *drawing materials* and *red and blue coloured pencils*.

(6) At least one *white coat* is advisable unless an old jacket is kept for laboratory work.

By the Laboratory

In addition to the usual laboratory apparatus, the following will be needed :—

(1) *Dissecting Dishes*. Rectangular enamel trays (about 8 × 6 in.) with black wax composition in the bottom are better than those which contain weighted cork.

(2) *Dissecting boards* with a rim round the edge (about 24 × 18 in.) (which may be fitted with hooks at the corners) for larger animals.

(3) *Microscopes* (unless provided by the students) with $\frac{2}{3}$ and $\frac{1}{8}$ in.

objectives, on a double or triple nose-piece, and No. 1 ($\times 5$) and No. 3 ($\times 8$) or No. 4 ($\times 10$) eyepieces. A few better instruments fitted with sub-stage condensers, Nos. 2 ($\times 6$) and 4 ($\times 10$) eyepieces, and a $\frac{1}{12}$ in. O.I. objective are also desirable. A blue glass disc to fit below the condenser giving a daylight effect is an advantage when using artificial light. *All must be kept covered when not in use.*

(4) *Microscope lamps*, preferably fitted with daylight bulbs.

(5) *Lenses*. Watchmaker's lenses clamped in small retort stands serve well as dissecting lenses. Better hand lenses should also be provided.

(6) A *dissecting microscope*.

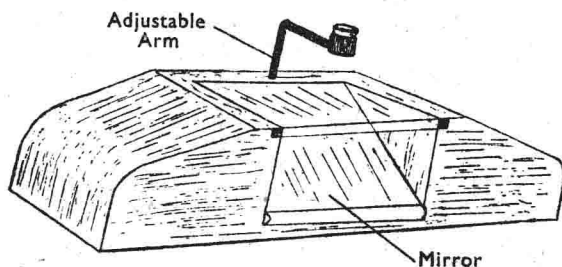


FIG. 2. A Simple Dissecting Microscope.

(7) A *turntable* for ringing slides.

(8) *Soft cloths* (e.g., chamois leather) for lenses and objectives.

(9) *Pins*, large and small; and *awls* for large animals.

(10) *Thread* for ligatures.

(11) *Stains and Reagents*. See Appendix I.

(12) *Preserving tank* for animal material containing 4 per cent. formaldehyde.

(13) The *Apparatus* and *accessories* mentioned in the text. Much of this can be made or adapted from other pieces of apparatus at small cost.

PART I

MICROSCOPICAL TECHNIQUE

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I. THE MICROSCOPE

(a) Description

The microscope is a delicately adjusted scientific instrument and *must be handled with care.*

It consists of the following parts (see Fig. 3) :—

- (i.) **The Stand.** This is made up of a heavy **foot** which carries an inclinable **limb** or **arm**, bearing the **body-tube**. The body-tube can be raised or lowered by the **coarse adjustment** which

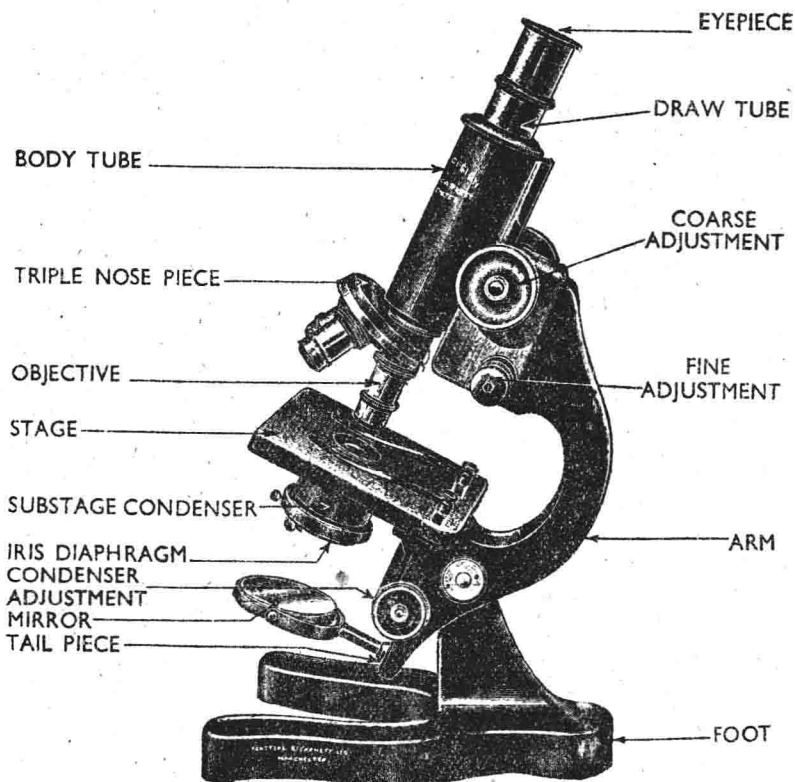


FIG. 3. The Microscope.

works by a rack and pinion arrangement and by the **fine adjustment** for more accurate focussing. Both are controlled by milled heads. Most modern microscopes are made with a tube length of 160 mm. This may be increased by raising the **draw-tube**, thus giving greater magnification. The draw-tube is usually graduated. A **nose-piece** (which may be *single*, *double* or *triple*) at the bottom of the tube carries the magnifying lenses or **objectives**. The arm also carries the **stage** on which the slides to be examined are placed and kept in position by springs. An attachable **mechanical stage** for moving the slides can be fitted. It is a luxury for ordinary use but a necessity for advanced work. In the more expensive instruments, it is built in. The **tail-piece**, into which the mirror is fitted, is on the lower part of the arm.

- (ii.) **The Optical Parts.** These consist of the objectives, the eye-pieces, the mirror and the sub-stage condenser. The **objectives** are small tubes containing a combination of lenses. Those in common use have a focal length of $\frac{2}{3}$ in. (16 mm.) (low power) and $\frac{1}{6}$ in. (4 mm.) (high power). A $\frac{1}{12}$ in. (2 mm.) oil immersion lens is used in bacteriological, cytological, and other work requiring the highest magnification attainable. The $\frac{2}{3}$ -in. and $\frac{1}{6}$ -in. objectives are used dry, but when using the $\frac{1}{12}$ -in. O.I. objective, a drop of cedar wood oil (of practically the same refractive index as the glass) is put on the coverslip and the objective focussed into it. This increases the illumination. The high power objectives are focussed slightly nearer the object than the $\frac{2}{3}$ -in. objective, and the distance between the objective and the slide is called the **working distance**. In most modern microscopes, once the object has been focussed with the low power, it is almost in focus when the high power objective has been swung into position, about one turn of the fine adjustment being all that is necessary to get it sharply into focus. The **resolving power** of a lens or its power to define detail depends on what is known as its **numerical aperture**. This is constant for any one lens and the higher it is, the greater the resolving power though the working distance is decreased. Good resolution is obtained with a $\frac{2}{3}$ in. objective of N.A. of about 0.28, with a $\frac{1}{6}$ in. objective of N.A. of about 0.7 and with a $\frac{1}{12}$ in. O.I. objective of N.A. of 1.25 to 1.28. Makers always state the N.A. of their objectives. It should be noted that lenses have a curved field and consequently when, under the