

TISSUE RESPIRATION IN INVERTEBRATES

DOROTHY E. BLISS
AND
DOROTHY M. SKINNER

THE AMERICAN MUSEUM OF NATURAL HISTORY
NEW YORK: 1963

QH
521
B 61

4

TISSUE RESPIRATION IN INVERTEBRATES



577.014
B61

TISSUE RESPIRATION IN INVERTEBRATES

DOROTHY E. BLISS

*Associate Curator
Department of Living Invertebrates
The American Museum of Natural History
and
Research Assistant Professor
Department of Anatomy
The Albert Einstein College of Medicine*

DOROTHY M. SKINNER

*Assistant Professor
Department of Physiology and Biophysics
New York University School of Medicine*



**THE AMERICAN MUSEUM OF NATURAL HISTORY
NEW YORK: 1963**

PREFACE

May we introduce this work with an explanation of its general organization and its contents? In Section 1, Introduction, we have traced the historical development of the study of invertebrate tissue respiration from its beginnings late in the nineteenth century up to the present time. In doing so, we have placed particular emphasis on the influence exerted by new apparatus and techniques. We have presented graphically the distribution of studies among various phyla and classes of invertebrate animals. From this initial survey it should be apparent to the reader how rapidly the field of invertebrate tissue respiration is developing and how broad and active it remains today.

While scanning the literature, we found a wealth of usable data. Section 2, the principal portion of this volume, contains these data, arranged to indicate the variation in respiratory rate with animal and type of tissue, with amount of tissue, with concentration and type of substrate, with sex of the animal, with season of the year in which the assay was made, and with many other factors.

Owing to such an abundance of material, we found it necessary to limit our coverage as regards specific enzymes and enzyme systems. Thus, while Section 2 includes many examples of endogenous respiration, for the most part it omits reference to enzymes other than those of the citric acid cycle and the electron transport system. Furthermore, whereas data from an original paper containing few entries usually appear in their entirety, those from a more extensive study have been selected (1) to afford representative sampling and (2) to illustrate principles and hypotheses. Footnote superscript "t" appears after any bibliographical reference in Section 2 if there are more data in an original paper than appear in Section 2.

Although the data contained in Section 2 refer

to tissues derived from invertebrates of many species, the section includes no information regarding the respiration of protozoans, nor does it deal with respiratory rates of sperms and of fertilized or unfertilized eggs.

Many types of tissue preparations are mentioned in Section 2. These include whole organs, slices, teased tissues, minces, cell suspensions, homogenates, and fractions (nuclear fraction, mitochondria, microsomes, or soluble fraction).

The arrangement of data in Section 2 is phylogenetic, according to the classification advocated by Hyman (1940-1959, vol. 1). Since phylum and class are the categories most frequently selected for mention by biochemists and experimental biologists, we have not included references to other higher categories. The valid scientific name of each animal and at least one of its common names appear in this section. In a Systematic Index (see Section 9) a scientific name, if no longer valid, can be traced to the presently correct one.

In order to tabulate the data on invertebrate tissue respiration, we found it necessary to convert figures on oxygen uptake from the units employed by a given investigator into one of several selected expressions of metabolic rate. Thus in Section 2, data appear as the mean number of microliters of oxygen per hour per milligram of nitrogen, protein, wet weight, or dry weight, or alternatively as "enzymatic activity," with footnotes indicating the units in which enzymatic activity is given. The complete list of footnotes, which are arranged in an arbitrary, not sequential, order, is repeated on each page of Section 2, although a reference to every footnote may not appear on every page within the body of the table.

Wherever we have converted our units, we have indicated this fact by the footnote superscript "a" after the data. When possible, we have changed all expressions for concentration of reactants into molarity and have noted this

also by the superscript "a." We have omitted all reference to standard deviation and standard error.

Within the table comprising Section 2 is a column bearing the title "Remarks." It contains miscellaneous information about the salt solutions and inhibitors used, the methods employed for determining nitrogen content, the composition of various gas phases, and so on. In this column we have noted, for example, that during an assay cytochrome *c* was present in the complete system, that P/O ratios appear in an original paper, or that specimens used in a particular study were collected during winter and spring. In other words, items that we consider vital for proper evaluation of the data appear in this column.

There are many unfilled spaces in Section 2. The reader should clearly understand their significance. The scientific name and common name of an animal appear only once for each work. Such usage is also true for temperature, providing there is no change in this factor during a given study, and also for apparatus, when only one type is used throughout the study. The author or authors and the date of publication are given once for each work. Thus, an unfilled space in the first, second, third, and last columns signifies that the same animal was used by the same author at the same temperature and with the same apparatus as previously noted.

Quite a different meaning should be read into an unfilled space in columns 4 through 15. In these columns such a blank space usually indicates that no information regarding the point in question appears in the original paper. In a few instances, however, an unfilled space in columns 4 through 15 relates to data or descriptive material which, in our opinion, is either unsuitable for inclusion or of questionable interpretation.

In Section 3 we have analyzed the data on invertebrate tissue respiration, giving emphasis to principles and relationships that the data illustrate. We have noted particularly the effects of metabolic inhibitors and the influence of sex, age, composition of the suspending medium, surgery, injury, and stage in the molt cycle or life cycle on tissue respiration in various invertebrates. In some instances we have based our analysis in part upon in-

formation contained within an original paper but not included in Section 2.

A discussion (Section 4) follows the analysis of data. It is concerned not only with the material presented in tabular form in Section 2 and analyzed in the subsequent section but also with broad principles and hypotheses suggested in the various original papers. This discussion seeks to examine selected data in terms of the light that they may shed upon these principles and hypotheses.

A list of abbreviations and symbols used in Section 2 appears in Section 5. Wherever possible, abbreviations are identical with those given in Webster's New International Dictionary, second edition, unabridged, 1958.

Section 6 consists of the Glossary, which is intended to give in a cursory way some understanding of the many technical terms used in this work. For the most part, this glossary does not include terms that appear in Webster's New International Dictionary, second edition, unabridged, 1958.

In Section 7 (Guide to Literature), we have made suggestions for supplementary reading on tissue metabolism and other pertinent fields. Here we have listed books and articles that deal with such topics as cell structure, electron microscopy, intermediary metabolism, and manometric methods, to name a few. Popular, semi-popular, and semi-technical references bear an asterisk. The complete citation for each book and article appears in the Bibliography (Section 8).

Section 9 consists of three indexes. In the first, designated the Systematic Index, there is a page reference for every mention of a given animal in this volume. Insofar as we are aware, the generic and specific names appearing in this work are valid. Occasionally an author has used an invalid name in an original paper. By use of the Systematic Index, the reader can trace the invalid name to the presently correct one. Also indexed here are common names of animals cited in the present work.

In the Author Index, there is a reference for every citation in this volume (exclusive of the Bibliography).

The third and last index deals with the various subjects of which there is mention in this work.

No paper on invertebrate tissue respiration

that has come to our attention since February 1, 1960, have we analyzed for inclusion in this work. On the other hand, we have cited without analysis some papers that have appeared since that time. The closing date does not apply to entries in Sections 7 and 8, which we have continually revised to include pertinent recent publications.

May we request that any reader who finds errors or omissions in this volume bring them to our attention? Should usage justify such action, we may eventually assemble and publish any data appearing in new studies or in those inadvertently omitted from the present work.

Persons to whom we owe a debt of gratitude are many. In the first place, we thank Dr. William R. Harvey, Dr. Melvin V. Simpson, and Dr. Heinrich Waelsch, all of whom offered valuable advice regarding the content and format of certain entries.

For verifying scientific names and making suggestions regarding generally accepted common names, we thank Dr. Elisabeth Deichmann, Dr. William K. Emerson, Dr. G. E. Gates, Dr. Willard D. Hartman, Dr. Libbie H. Hyman, Mr. Morris K. Jacobson, and Mr. John C. Pallister. Valid names of Crustacea came from the systematic index included in Waterman (1960). According to the preface, Dr. Fenner A. Chace, Jr., acted as referee on all taxonomic citations pertaining to the Crustacea. Hence, for their indirect assistance, we are grateful to Dr. Chace and Dr. Waterman.

For suggesting or verifying definitions of terms included within the glossary we thank Dr. H. E. Coomans, Dr. Emerson, Dr. Henry Harbury, Dr. Hyman, Dr. Mary Ellen Jones, Dr. Sam Katz, Dr. Sasha Malamed, Dr. Berta Scharrer, and Dr. Simpson.

For permitting inclusion of unpublished material, we thank Dr. Rose Robyns Coelho and Dr. Harvey. The unpublished data submitted by Dr. Harvey appear in his thesis for the Ph.D. degree, Harvard University.

For permission to quote a passage from *Cancer Research*, we thank the University of Chicago.

For her patient, experienced editorial advice and guidance, we express appreciation to Miss Ruth Tyler, Editor of Scientific Publications of the American Museum of Natural History. With-

out her, this volume would never have reached its final stages.

For giving freely of their time and still retaining their patience despite the trying nature of their tasks, we thank Miss Ana Usocovich, Mrs. Phyllis Fish, and Miss Joan Ruff, typists. For considerable assistance in the initial stages of the work, when references had to be tracked down and unwanted ones eliminated, we acknowledged particularly the help of Mrs. Patricia Cannon Sprague. For other assistance of various sorts during the course of compilation, we are grateful to Mrs. Jane Rouillion Boyer, Mr. William F. Mussig, Mr. Frederick V. Weir, and Mrs. Mary Weitzman. For their competent help in the tedious task of preparing the indexes, we thank Mr. Arnold Ross and Miss Susan E. Bliss.

We have a special word of thanks for members of the staff of the Library of the American Museum of Natural History, who furthered in no small way the progress of our work.

We also express our gratitude to Dr. Charles M. Breder, Jr., and to members of the Publications Committee of the Council of the Scientific Staff of the American Museum of Natural History for making possible the preparation and printing of this volume.

Lastly, we gratefully acknowledge the support of the National Science Foundation through grants (NSF G-4006 and NSF G-11254) to one of us (D.E.B.), and also the support of both the National Institute of Neurological Diseases and Blindness and the National Cancer Institute of the United States Public Health Service through predoctoral and postdoctoral fellowships to the other (D.M.S.) while she was at Radcliffe College, Brandeis University, and Yale University.

We have tried to produce an accurate reference on tissue respiration in invertebrates. For all errors that remain, we accept full responsibility.

DOROTHY E. BLISS
DOROTHY M. SKINNER

December 15, 1961

CONTENTS



Preface	v
Section 1: Introduction	1
Section 2: Presentation of Data: A Table of Respiratory Rates of Invertebrate Tissues	7
Porifera	9
Demospongiae	9
Coelenterata	11
Hydrozoa	11
Scyphozoa	11
Anthozoa	11
Aschelminthes	11
Nematoda	11
Mollusca	15
Gastropoda	15
Pelecypoda	21
Cephalopoda	33
Annelida	39
Polychaeta	39
Clitellata	41
Arthropoda	43
Merostomata	43
Crustacea	45
Insecta	55
Echinodermata	73
Holothuroidea	73
Section 3: Analysis of Data	75
Effects of Certain Inhibitors on Respiratory Rate	75
2, 4-Dinitrophenol (DNP)	75
Carbon Monoxide (CO)	75
Cyanide	75
Antimycin A	76
Comparison of Respiratory Rates of Various Tissues	76
Sex Differences in Respiratory Rate	77
Variation in Respiratory Rate with Age	78
Variation in Respiratory Rate During Crustacean Molt Cycle	78
Variation in Respiratory Rate During Insect Life Cycle	78
Variation in Respiratory Rate with Season	79
Variation in Respiratory Rate with Salinity	79
Effects of Various Ions on Respiratory Rate	79
Gradient of Respiratory Rate Along Long Axis of Body	79
Gradient of Respiratory Rate Along a Nerve	79
Respiratory Rate After Removal of Endocrine Organs	80
Respiratory Rate Following Injury	80

Section 4: Discussion	81
Enzymes of Citric Acid Cycle	81
Cytochrome System	81
Comparison of Respiratory Rates of Various Tissues	83
Sex Differences in Respiratory Rate	83
Variation in Respiratory Rate with Age	84
Variation in Respiratory Rate During Crustacean Molt Cycle	84
Variation in Respiratory Rate During Insect Life Cycle	86
Respiratory Rate Following Injury	86
Effect of Environment on Respiratory Rate	86
Effect of Various Ions on Respiratory Rate	86
Gradients in Respiratory Rate	86
Section 5: Abbreviations and Symbols	89
Section 6: Glossary	91
Section 7: Guide to Literature	95
Section 8: Bibliography	101
Section 9: Indexes	119
Systematic Index	119
Author Index	123
Subject Index	127

Section 1: INTRODUCTION

This introductory chapter traces the historical development of the study of invertebrate tissue respiration as a branch of experimental biology. Interest in its study has appeared relatively recently. It is only slightly more than 30 years since the first work to come to the attention of the authors appeared in print. Today tissue respiration of the invertebrates is an established domain of the experimental biologist.

During the period 1929 through 1959, there occurred at least 114 studies on the respiration of invertebrate tissues as reported in 98 different papers. Other published accounts, not known

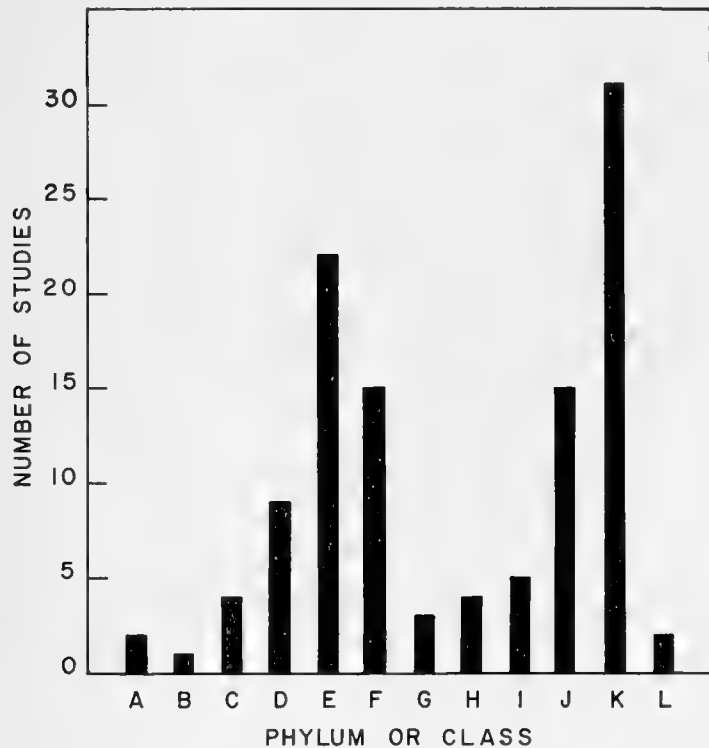


Fig. 1. Frequency distribution of studies on invertebrate tissue respiration from 1929 through 1959 arranged according to phyla and classes studied. A. Porifera: Demospongiae. B. Coelenterata: Hydrozoa, Scyphozoa, Anthozoa. C. Aschelminthes: Nematoda. D. Mollusca: Gastropoda. E. Mollusca: Pelecypoda. F. Mollusca: Cephalopoda. G. Annelida: Polychaeta. H. Annelida: Clitellata. I. Arthropoda: Merostomata. J. Arthropoda: Crustacea. K. Arthropoda: Insecta. L. Echinodermata: Holothuroidea.

to us, may exist. Figure 1 shows the phylogenetic distribution of the animals used in these studies. Note that, with the exception of the Platyhelminthes, all the major invertebrate phyla are represented. Investigators have used insects and pelecypod mollusks most often, cephalopod mollusks and crustaceans quite frequently. The preponderance of insects as experimental animals seems particularly significant when one examines figure 2. Here (fig. 2M) the distribution of all studies on invertebrate tissue respiration appears according to year. Clearly apparent is a marked increase in the total number of studies during the last decade. It is also clear that one may attribute much of this increase to work with insect tissues (fig. 2K).

There are several other points worthy of note. In the first place, the respiratory activity of crustacean tissues (fig. 2J) has been a regular subject of investigation throughout the period of 1929 through 1959, with no single year or period of years notable for any particularly large number of studies. Secondly, studies on Merostomata (entirely confined to the American species or horseshoe crab, *Limulus polyphemus*) appeared for the most part during the 1930's (fig. 2I). On the other hand, work with tissues of cephalopod mollusks has taken place largely during the late 1940's and 1950's (fig. 2F). Some of this work concerns the metabolism of squid giant axons, now so important as a research tool to the neurophysiologist (see Keynes, 1958).

The historical development of the types of tissue preparations used in the study of tissue respiration is the historical development of tissue respiration itself. Earliest studies generally concerned the respiration of whole organs or pieces of organs. Warburg (1931) was the first investigator to slice tissues into thin sections in order to provide an adequate supply of oxygen for cells of the interior. Because freehand slicing produced non-uniform results, Deutsch (1936) and later Stadie and Riggs (1944) devised mechan-

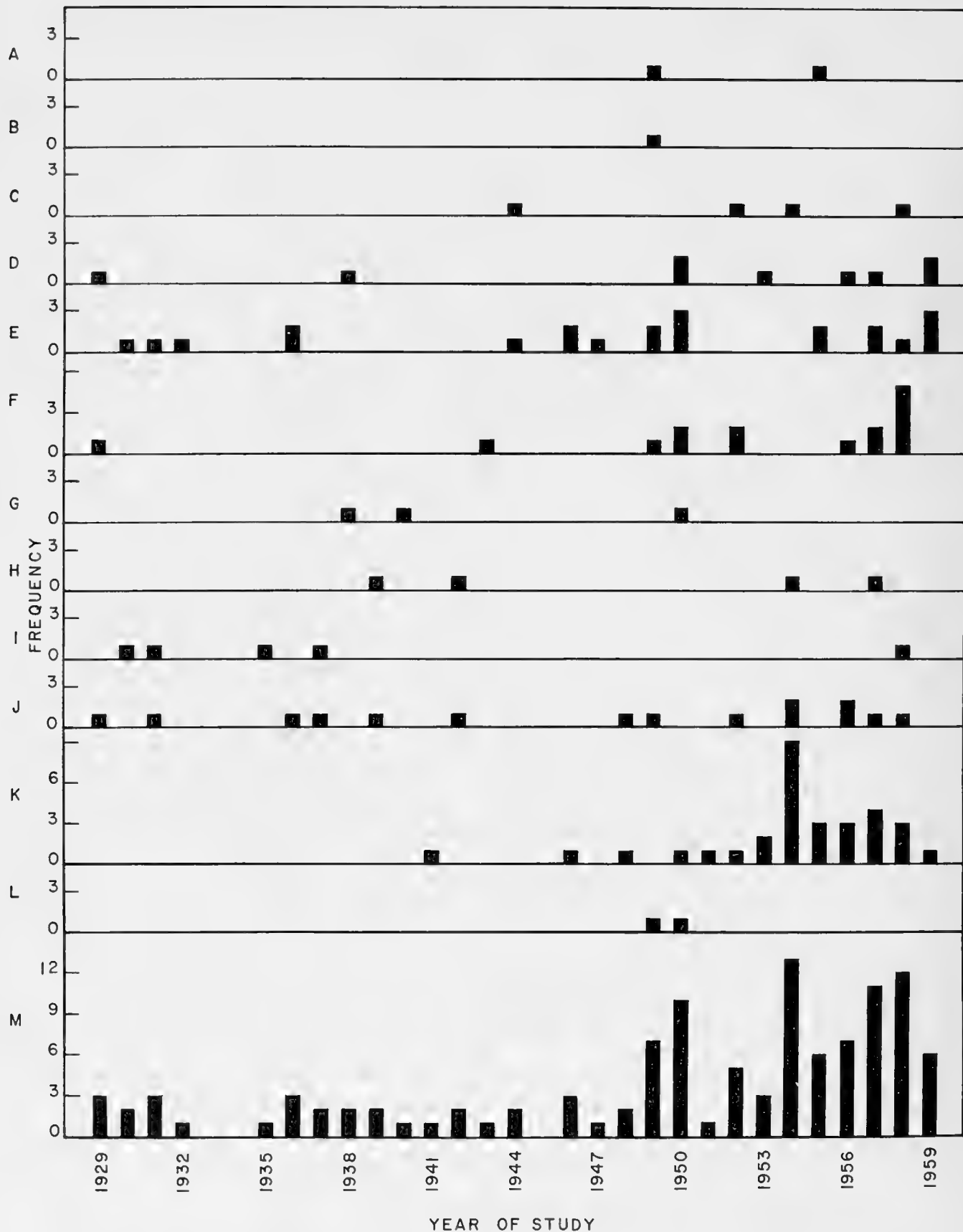


Fig. 2. Frequency distribution of studies on invertebrate tissue respiration from 1929 through 1959 arranged according to year in which the studies were published. A. Porifera: Demospongiae. B. Coelenterata: Hydrozoa, Scyphozoa, Anthozoa. C. Aschelminthes: Nematoda. D. Mollusca: Gastropoda. E. Mollusca: Pelecypoda. F. Mollusca: Cephalopoda. G. Annelida: Polychaeta. H. Annelida: Clitellata. I. Arthropoda: Merostomata. J. Arthropoda: Crustacea. K. Arthropoda: Insecta. L. Echinodermata: Holothuroidea. M. Frequency distribution of all studies.

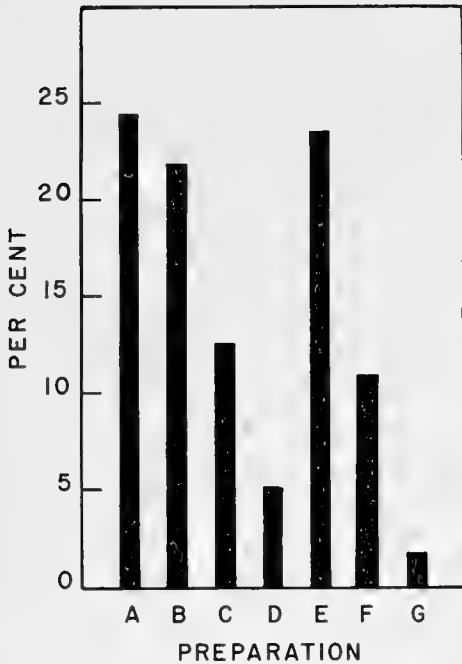


Fig. 3. Percentage distribution of various types of tissue preparations employed in studies on invertebrate tissue respiration from 1929 through 1959. Types of preparations indicated as follows: A. Whole organ. B. Pieces (including fragments, strips, teased tissue, zones, parts). C. Slices (including sheets, thin sections). D. Suspension (including cell suspension, ground tissue, mince). E. Homogenate. F. Particulate fraction (including mitochondria and microsomes). G. Other fractions (nuclear, supernatant).

ical aids. For a more complete treatment of work with tissue slices, see Field (1948) and Robbie (1948).

Soon a method was devised for fractionating finely ground or homogenized tissues into their cellular components by centrifugation at different speeds for different lengths of time (see Claude, 1946a, 1946b; Schneider, 1946). Thenceforth, workers directed much of their attention to characterizing these cell fractions. They studied the effects of various metabolites, ions, suspending media, and poisons on the respiratory rates of the various fractions and also on the ability of these fractions to form the high-energy phosphate compounds found to be coupled to their respiration.

In figure 3 there appears the per cent of the total number of studies on invertebrate respiration for which each type of procedure was used. Selection of the whole organ (A), pieces of organ (B), and homogenate (E) took place with approximately equal frequency. A more revealing graph is that of figure 4. The diagonal line from the lower left to the upper right corner of the

graph emphasizes the trend through the years towards the use of more and more finely divided tissue preparations. The vertical arrow indicates the approximate time when methods for the preparation of suspensions and homogenates first appeared. The use of homogenates and particulate fractions derived from homogenates in studies on invertebrate tissue respiration followed quickly upon this development.

At no time during the 30-year period have whole organs or tissue slices fallen into disfavor as subjects for respiratory studies. Indeed, in 1950 Krebs questioned the trend towards the disruption of cell structure in attempts to explore certain aspects of cell physiology. He pointed out that one can attribute much of the conflicting data on the respiratory rates of homologous tissues from different animals to the type of tissue preparation and the type of medium used. From his studies he concluded that tissue slices suspended in particular synthetic media comprise the type of preparation most likely to yield meaningful results.

For the future, therefore, a reverse trend has something to recommend it. According to Greenstein (1956, p. 651): "It is possible that studies of cellular metabolism, which began with observation on the whole animal and then progressed successively through studies of isolated organs, tissue slices, homogenates, cell fractions, and finally highly purified individual metabolic factors can with profit turn back to the whole animal. Studies of the effect of constitutional factors on metabolic reactions . . . *in vitro* provide a certain interest but, like all *in vitro* approaches, are at the mercy of the experimental conditions which the investigator chooses to select."

Just as methods of preparing tissues for study of their respiratory rates have undergone marked changes over a period of years, so also have the ways in which respiratory measurements are made. First, let us examine the percentage distribution of the various methods. More than one-half of the investigations cited in Section 2 have involved the use of the Warburg manometric method (see fig. 5A), while 16 per cent have involved various forms of differential manometer, including Fenn, Barcroft, and Thunberg (fig. 5B). Another 11 per cent of these studies were concerned with the spectrophotometer (fig. 5E), 5 per cent with chemical methods (Winkler and micro-Winkler, fig. 5D), 4 per cent with microvolumetric techniques (fig. 5C),

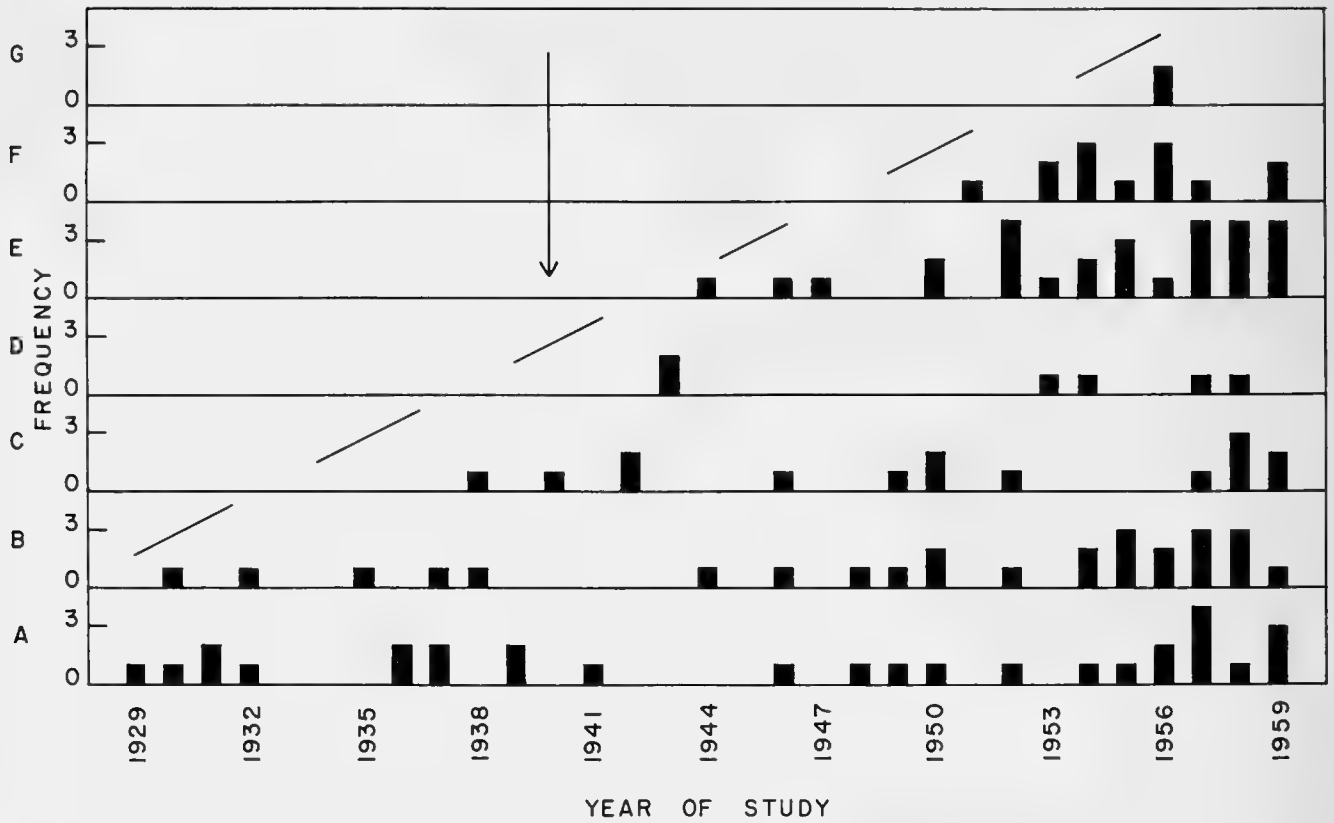


Fig. 4. Frequency distribution of types of tissue preparations used in studies on invertebrate tissue respiration from 1929 through 1959 arranged according to year in which studies were published. Vertical arrow: approximate date when methods for preparation of suspensions and homogenates were first developed. A. Whole organ. B. Pieces (including fragments, strips, teased tissue, zones, parts). C. Slices (including sheets, thin sections). D. Suspension (including cell suspension, ground tissue, mince). E. Homogenate. F. Particulate fraction (including mitochondria and microsomes). G. Other fractions (nuclear, supernatant).

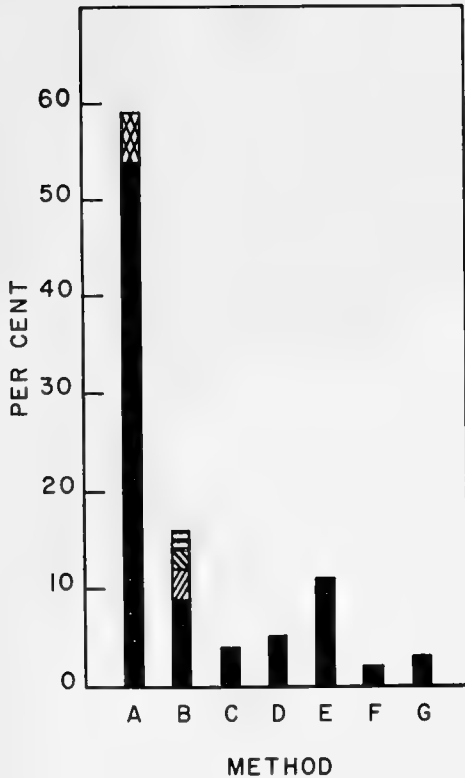


Fig. 5. Percentage distribution of methods employed in studies of invertebrate tissue respiration from 1929 through 1959. Methods indicated are: A. Manometric (Warburg, ■; unspecified, ▣). B. Differential (Barcroft, ▨; Fenn, ▩; Thunberg, ▤; unspecified, ■). C. Microvolumetric. D. Chemical (Winkler and micro-Winkler). E. Spectrophotometric. F. Polarographic. G. Miscellaneous.

2 per cent with the polarograph (fig. 5F), and 3 per cent with a variety of miscellaneous procedures (fig. 5G).

The selection of method as a function of year is illustrated in figure 6. That the Warburg method has been a perennial favorite is clear from figure 6A. In only eight out of the 30 years has there been no use of the Warburg method for studies of invertebrate tissue respiration; furthermore, in every year since 1945 this method has been used at least once. During the 1950's the Warburg method was selected for use on the average of four times a year.

With the advent of spectrophotometric methods for the investigation of tissue metabolism, various investigators applied these procedures to invertebrate tissues, most frequently those of insects. Particular mention may be made of a study by Shappirio and Williams (1957a, 1957b). Through spectroscopy at low temperatures (see Keilin and Hartree, 1949), Shappirio and Williams (1957a) were able to detect enzymes of the terminal electron transport system in diapausing pupae of the *Cecropia* moth, even though these enzymes are present during this stage of the life cycle in extremely low concentrations. Subsequently (1958b), by the spectrophotometric method, they traced changes in the activity of these enzymes during diapause and adult development (see Discussion, p. 82).

Studies involving the use of differential respirometers, including the Barcroft, Fenn, and Thunberg, have appeared quite regularly throughout the 30-year period (fig. 6B), without, apparently, marked fluctuations in the frequency of their use. A scarcity of studies employing microvolumetric techniques (fig. 6C) seems somewhat surprising in view of the convenience of this type of procedure.

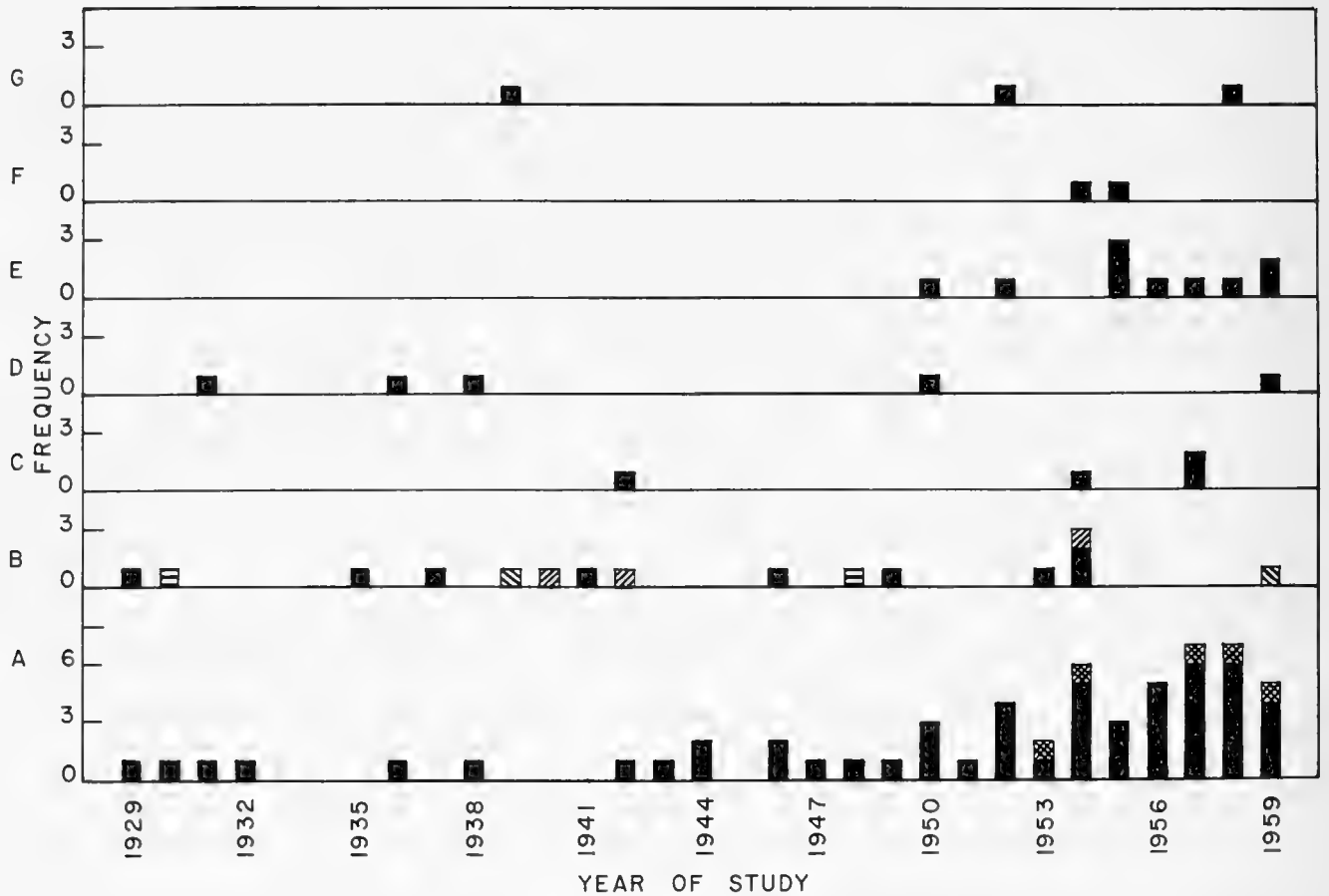








Fig. 6. Frequency distribution of methods used in studies on invertebrate tissue respiration from 1929 through 1959 arranged according to year in which the studies were published. Methods indicated are: A. Manometric (Warburg, ; unspecified, ). B. Differential (Barcroft, ; Fenn, ; Thunberg, ; unspecified, ). C. Microvolumetric. D. Chemical (Winkler and micro-Winkler). E. Spectrophotometric. F. Polarographic. G. Miscellaneous.

Section 2: PRESENTATION OF DATA:

A TABLE OF RESPIRATORY RATES OF INVERTEBRATE TISSUES

TABLE OF RESPIRATORY RATES OF INVERTEBRATE TISSUES

ANIMAL	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE		
	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity	
									Nitrogen	Protein	Wet Weight	Dry Weight				
PORIFERA																
Demospongiae																
<i>Cinachya cavernosa</i> Sponge	25	Warburg	Slices	Endogenous		3						0.6		Dry weight given for tissue minus skeletal material	Robbie (1949) [†]	
<i>Dysidea crawshayi</i> Sponge	25	Warburg	Slices	Endogenous		2						0.6		(Same as above)	Robbie (1949) [†]	
<i>Geodia gibberosa</i> Sponge	25	Warburg	Slices	Endogenous		1						0.6		(Same as above)	Robbie (1949) [†]	
<i>Ircinia fasciculata</i> Stinker sponge	25	Warburg	Slices	Endogenous		5						1.6		(Same as above)	Robbie (1949) [†]	
<i>Lissodendoryx</i> <i>isodictyalis</i> Sponge	25	Warburg	Slices	Endogenous		4						1.4		(Same as above)	Robbie (1949) [†]	
<i>Microciona prolifera</i> Red oyster sponge	37	Warburg	Finger-like projections (apical portions): Slices (Same as above) (Same as above)	Endogenous	ca. 200 mg.	1						0.115		Without phenol	Gordon, Spiegel, and Villet (1955)	
				Endogenous	ca. 200 mg.	1							0.157			With phenol (0.2%) With insulin (4 units) containing phenol (0.2%)
				Endogenous	ca. 200 mg.	2							0.169 ^a			
				Pyruvate (1×10^{-3} M ^a)		1								0.126		
Finger-like projections (apical portions): Slices (Same as above) (Same as above)	Pyruvate (1×10^{-3} M ^b)		3								0.146 ^a		With phenol (0.2%) With insulin (4 units) containing phenol (0.2%)			
	Pyruvate (1×10^{-3} M ^b)		4								0.164 ^a					
Finger-like projections (apical portions): Slices (Same as above) (Same as above)	Glucose (5.6×10^{-3} M ^b)		4									0.110 ^a		Without phenol		
	Glucose (5.6×10^{-3} M ^b)		6									0.123 ^a		With phenol (0.2%) With insulin (4 units) containing phenol (0.2%)		
	Glucose (5.6×10^{-3} M ^b)		7								0.146 ^a					
<i>Pseudaxinella</i> <i>rosacea</i> (formerly <i>Axinella rosacea</i>) Sponge	25	Warburg	Slices	Endogenous		2						0.7		Dry weight given for tissue minus skeletal material	Robbie (1949) [†]	
<i>Sphaciospongia</i> sp. Sponge	25	Warburg	Slices	Endogenous		1						0.4		(Same as above)	Robbie (1949) [†]	
<i>Tedania ignis</i> Fire sponge	25	Warburg	Slices	Endogenous		6						2.9		(Same as above)	Robbie (1949) [†]	

^aEstimated or calculated from available data.^bInitial concentration.^cFinal concentration.^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.^f $\Delta \log$ [cytochrome c]/mg. wet wt./min.^g $-\Delta \log$ [ferricytochrome c]/mg. protein/min.^hMoles substrate converted/kilo protein/hour (For
axoplasm, protein = total protein; for sheath,
protein of non-collagenous component).ⁱ $\Delta \log$ [ferricytochrome c]/mg. protein/min.^j $\Delta \log$ [CyFe⁺⁺]/min.^kActivity/mg. N when standard activity =
 $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \text{final tissue dilution}$ ^lActivity/mg. protein when activity =
 $\frac{\Delta \log (\text{cytochrome c})}{\Delta t (\text{min.})}$ ^m $\mu\text{moles cytochrome c reduced (mg. N)}^{-1} \text{min.}^{-1}$ ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{min.}^{-1}$ ^o $\mu\text{moles cytochrome c oxidized (mg. N)}^{-1} \text{min.}^{-1}$ ^pMoles cytochrome c reduced/mg. tissue/5 min. at
10°C. (extinction coefficient of reduced cyto-
chrome c taken as 2.8×10^{-4} cm.²/mol.).^qO. D. of clear supernatant when measured at 520 m μ .^r Δ O. D./mg. protein/min.^sMoles DPN reduced/g. wet wt./hr.^tAdditional respiratory data on invertebrate tissues
present in original paper and not included in
Section 2.

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE	
	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
<i>Terpios fugax</i> Sponge	25	Warburg	Slices	Endogenous		1						0.6		(Same as above)	Robbie (1949) [†]
<i>Tethya aurantia</i> Sea orange (sponge)	25	Warburg	Slices	Endogenous		1						0.5		(Same as above)	Robbie (1949) [†]
COELENTERATA															
Hydrozoa															
<i>Physalia physalis</i> (formerly <i>Physalia pelagica</i>) Portuguese man-of-war	25	Warburg	Tentacles	Endogenous		3						1.7			Robbie (1949) [†]
Scyphozoa															
<i>Cassiopea frondosa</i> Jellyfish	25	Warburg	Tentacles Umbrella	Endogenous Endogenous		10 18						0.6 0.7			Robbie (1949) [†]
<i>Pelagia noctiluca</i> (formerly <i>Pelagia cyanella</i>) Jellyfish	25	Warburg	Umbrella	Endogenous		2						0.8			Robbie (1949) [†]
Anthozoa															
<i>Condylactis gigantea</i> Sea anemone	25	Warburg	Tentacles	Endogenous		3						0.8			Robbie (1949) [†]
<i>Gorgonia flabellum</i> Purple sea fan	25	Warburg	Branches: Cell suspension	Endogenous		2						2.2		Dry weight given for tissue minus skeletal material	Robbie (1949) [†]
<i>Plexaura flexuosa</i> Purple gorgonian	25	Warburg	Slices	Endogenous		13						3.0		(Same as above)	Robbie (1949) [†]
ASCHELMINTHES															
Nematoda															
<i>Ascaris lumbricoides</i> Pig ascarid	39	Warburg	Muscle: Homogenate "Muscle pulp" "Muscle pulp" "Muscle pulp" "Muscle pulp"	Endogenous Succinate (0.02 M) Succinate (0.02 M) Succinate (0.02 M)								1.3 1.3 11.0 ^a 27.5 ^a		Methylene blue added Methylene blue added; also catalase and ethanol added to remove H ₂ O ₂ formed as a product of the reaction	Lasar (1944) [†]

^aEstimated or calculated from available data.
^bInitial concentration.
^cFinal concentration.
^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.
^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

¹ $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$
² $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
³Moles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).
⁴ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
⁵ $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$
^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t (\text{min.})}$

^m $\mu\text{moles cytochrome } c \text{ reduced (mg. N)}^{-1} \text{ min.}^{-1}$
ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{ min.}^{-1}$
^o $\mu\text{moles cytochrome } c \text{ oxidized (mg. N)}^{-1} \text{ min.}^{-1}$
^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-3} \text{ cm}^2 / \text{mol.}$).

^qO. D. of clear supernatant when measured at 520 $\mu\mu$.
^r $\Delta \text{O. D.} / \text{mg. protein} / \text{min.}$
^sMoles DPN reduced/g. wet wt./hr.
^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE	
	Temp. ° C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
			“Coenzyme-free muscle pulp” “Coenzyme-free muscle pulp”	Succinate (0.02 M) Succinate (0.02 M)							19.5 ^a 57 ^a		Methylene blue added Methylene blue added; also catalase and ethanol added to remove H ₂ O ₂ formed as a product of the reaction		
<i>Ascaris lumbricoides</i> Pig ascarid	38	Warburg	Muscle: Homogenate (“coenzyme-free muscle pulp”)	Succinate (0.025 M)							0.85 ^a		In 100% O ₂ ; catalase and ethanol added to remove H ₂ O ₂ formed as a product of the reaction	Bueding and Charms (1952) [†]	
<i>Ascaris lumbricoides</i> Pig ascarid	25	Warburg	Muscle: Particulate fraction (Same as above) (Same as above) (Same as above) (Same as above) (Same as above)	 Pyruvate (0.02 M) Pyruvate (0.02 M) Pyruvate (0.02 M) + succinate (0.02 M) Pyruvate (0.02 M) Pyruvate (0.02 M) Pyruvate (0.02 M)							 0.0718 ^a 0.0406 ^a 0.0304 ^a 0.0607 ^a 0.0443 ^a 0.0749 ^a 0.0457 ^a		All assays: P/O ratios in original paper Gas phase: O ₂ ; undialysed supernatant of perienteric fluid added Gas phase: O ₂ ; dialysed supernatant of perienteric fluid added Gas phase: air; dialysed supernatant of perienteric fluid added (Same as above) (Same as above) Gas phase: air; dialysed supernatant of perienteric fluid added; with DNP (3 × 10 ⁻⁵ M) Gas phase: air; dialysed supernatant of perienteric fluid added; with DNP (8 × 10 ⁻⁵ M)	Chin and Bueding (1954) [†]	
<i>Parascaris equorum</i> (formerly <i>Ascaris megalcephala</i>) Horse ascarid	39	Warburg	Muscle of body wall: Cell suspension (Same as above) (Same as above) (Same as above)	Endogenous Endogenous Glucose (0.22 M ^a) Succinate (0.05 M ^b)							6.0 2.3 3.1 7.2		In physiological saline; gas phase: air In distilled water; gas phase: air	Durrani (1958)	

^aEstimated or calculated from available data.
^bInitial concentration.
^cFinal concentration.
^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.
^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

^f $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$
^g $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).
ⁱ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
^j $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$
^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t (\text{min.})}$

^mmμ moles cytochrome c reduced (mg. N)⁻¹ min.⁻¹
ⁿmμ moles DPNH oxidized (mg. N)⁻¹ min.⁻¹
^omμ moles cytochrome c oxidized (mg. N)⁻¹ min.⁻¹
^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as 2.8 × 10⁻⁴ cm.²/mol.).

^qO. D. of clear supernatant when measured at 520 mμ.
^rΔ O. D./mg. protein/min.
^sMoles DPN reduced/g. wet wt./hr.
^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE		
	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity	
									Nitrogen	Protein	Wet Weight	Dry Weight				
MOLLUSCA																
Gastropoda																
<i>Aplysia</i> sp. Sea hare	16	Warburg; also differential manometer	Nerve	Endogenous	22.9 mg. dry wt.							0.52		Nerve unstimulated; in artificial sea water with urea and bicar- bonate	Meyerhof and Schulz (1929)	
<i>Aplysia</i> sp. Sea hare	25	Warburg	Gizzard: Slices (from frozen tissue)	Endogenous								0.33		With KCN (1×10^{-3} M)	Ghiretti, Ghiretti- Magaldi, and Tosi (1959)	
			Gizzard: Slices (from frozen tissue)	Endogenous									0.06			
			Gizzard: Slices (from frozen tissue)	Succinate ($0.01 M^c$)									1.80			
			Gizzard: Slices (from frozen tissue)	Succinate ($0.01 M^c$) + malonate ($0.01 M^c$)									0.96			
			Gizzard: Slices (from frozen tissue)	Succinate ($0.01 M^c$) + malonate ($0.01 M^c$) + fumarate ($0.003 M^c$)									0.90			
			Gizzard: Slices (from frozen tissue)	Fumarate ($0.003 M^c$)									0.30			
			Gizzard: Slices (from frozen tissue)	Citrate ($0.01 M^c$)									0.64			
			Gizzard: Slices (from frozen tissue)	Malate ($0.01 M^c$)									0.56			
	Not specified	Spectropho- tometer	Buccal mass muscle: Particle preparation (from frozen tissue) (Same as above) Gizzard muscle: Particle preparation (from frozen tissue) (Same as above)	Succinate ($1.7 \times 10^{-3} M$) + cytochrome <i>c</i> ($1.8 \times 10^{-3} M$)									0.077	With KCN (1×10^{-3} M)	All assays: For units of enzymatic activ- ity, see footnote r	
				Reduced cytochrome <i>c</i> ($2.5 \times 10^{-5} M$) Succinate ($1.7 \times 10^{-3} M$) + cytochrome <i>c</i> ($1.8 \times 10^{-3} M$) Reduced cytochrome <i>c</i> ($2.5 \times 10^{-5} M$)										0.019		With KCN (1×10^{-3} M)
			Buccal mass muscle: Particle preparation (from frozen tissue): 30,000 x g. 107,000 x g. Gizzard muscle: Particle preparation (from frozen tissue): 30,000 x g. 107,000 x g.	DPNH ($2 \times 10^{-4} M$) + cytochrome <i>c</i> ($1.8 \times 10^{-5} M$)									0.301	With KCN (1×10^{-3} M)	All assays: Protein de- termination by meth- ods of Lowry <i>et al.</i> (1951) and Kalckar (1947)	
				DPNH ($2 \times 10^{-4} M$) + cytochrome <i>c</i> ($1.8 \times 10^{-5} M$)										0.113		With KCN (1×10^{-3} M)
				DPNH ($2 \times 10^{-4} M$) + cytochrome <i>c</i> ($1.8 \times 10^{-5} M$)										0.262		With KCN (1×10^{-3} M)
				DPNH ($2 \times 10^{-4} M$) + cytochrome <i>c</i> ($1.8 \times 10^{-5} M$)										0.076		With KCN (1×10^{-3} M)

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome ϵ per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome ϵ per minute for 1:100 tissue dilution.

^f $\Delta \log$ [cytochrome ϵ]/mg. wet wt./min.

^g $-\Delta \log$ [ferricytochrome ϵ]/mg. protein/min.

^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).

ⁱ $\Delta \log$ [ferricytochrome ϵ]/mg. protein/min.

^j $\Delta \log$ [CyFe³⁺]/min.

^kActivity/mg. N when standard activity = $\frac{\Delta \log (CyFe^{3+})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$.

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } \epsilon]}{\Delta t (\text{min.})}$.

^m $\mu\mu$ moles cytochrome ϵ reduced (mg. N)⁻¹ min.⁻¹

ⁿ $\mu\mu$ moles DPNH oxidized (mg. N)⁻¹ min.⁻¹

^o $\mu\mu$ moles cytochrome ϵ oxidized (mg. N)⁻¹ min.⁻¹

^pMoles cytochrome ϵ reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome ϵ taken as 2.8×10^{-4} cm.²/mol.).

^qO. D. of clear supernatant when measured at 520 $\mu\mu$.

^r Δ O. D./mg. protein/min.

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

⁹O. D. of clear supernatant when measured at 520 $\mu\mu$.

^r Δ O. D./mg. protein/min.

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

TABLE OF RESPIRATORY RATES OF INVERTEBRATE TISSUES

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE	
PHYLUM Class Scientific name Common name	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
			Midgut gland: Crude homogenate (from frozen tissue) Midgut gland: Particle preparation (from frozen tissue) 30,000 x g. 107,000 x g.	DPNH (2×10^{-4} M) + cytochrome c (1.8×10^{-5} M) DPNH (2×10^{-4} M) + cytochrome c (1.8×10^{-5} M) DPNH (2×10^{-4} M) + cytochrome c (1.8×10^{-5} M)								0.106 0.106 0.039	With KCN (1×10^{-3} M) With KCN (1×10^{-3} M) With KCN (1×10^{-3} M)		
<i>Aplysia limacina</i> Sea hare	25	Manometer	Buccal mass muscle: Particle suspension (from frozen tissue) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above)	Endogenous Succinate (0.01 M ^{a,c}) Succinate (0.01 M ^{a,c}) + cytochrome c (6×10^{-7} M ^c) Ascorbate (0.01 M ^{a,c}) Ascorbate (0.01 M ^{a,c}) + cytochrome c (6×10^{-7} M ^c) Hydroquinone (0.01 M ^{a,c}) Hydroquinone (0.01 M ^{a,c}) + cytochrome c (6×10^{-7} M ^c) p-phenylenediamine (0.01 M ^{a,c}) p-phenylenediamine (0.01 M ^{a,c}) + cytochrome c (6×10^{-7} M ^c)	4.5 mg. dry wt. 4.5 mg. dry wt. 4.5 mg. dry wt. 4.5 mg. dry wt. 4.5 mg. dry wt. 4.5 mg. dry wt. 4.5 mg. dry wt.						0 4.7 ^a 8.9 ^a 0 46.1 ^a 3.6 ^a 35.8 ^a 10.2 ^a 30.4 ^a		Ghiretti, Ghiretti- Magaldi, and Tosi (1959)		
<i>Busycon</i> sp. Conch	25	Warburg	Muscle, white: Thin sheets or slices	Glucose (0.011 M ^a)		10						0.052 ^a		Villee, Lichtenstein, Nathanson, and Ro- lander (1950)	
<i>Helix aspersa</i> Dented garden snail or petit-gris	23	Warburg	Heart Heart Heart	Endogenous Endogenous Endogenous	1.50 mg. dry wt. 1.50 mg. dry wt. 1.50 mg. dry wt.							1.00 2.27 1.65	In isotonic chloride solution In salt solution: Na ⁺ /K ⁺ =5 Na ⁺ /K ⁺ =20	Cardot, Faure, and Arvanitaki (1950) ^t	
<i>Helix pisana</i> Little edible land snail	23	Warburg	Heart	Endogenous	0.50 mg. dry wt.							1.75	In isotonic chloride solution	Cardot, Faure, and Arvanitaki (1950) ^t	
<i>Helix pomatia</i> Vineyard snail or Burgundy snail	28	Warburg	Midgut gland: Slices	Endogenous		92						2.93	In Baldwin's (1938) phosphate solution	Baldwin (1938) ^t	
<i>Helix pomatia</i> Vineyard snail or Burgundy snail	23	Warburg	Heart	Endogenous	3.50 mg. dry wt.							0.85	In isotonic chloride solution	Cardot, Faure, and Arvanitaki (1950) ^t	

^aEstimated or calculated from available data.^bInitial concentration.^cFinal concentration.^dDecrease in log of molar concentration of oxidized cytochrome ϵ per minute for 1:150 tissue dilution.^eDecrease in log of molar concentration of reduced cytochrome ϵ per minute for 1:100 tissue dilution.^f $\Delta \log [\text{cytochrome } \epsilon] / \text{mg. wet wt.} / \text{min.}$ ^g $-\Delta \log [\text{ferricytochrome } \epsilon] / \text{mg. protein} / \text{min.}$ ^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).ⁱ $\Delta \log [\text{ferricytochrome } \epsilon] / \text{mg. protein} / \text{min.}$ ^j $\Delta \log [\text{CyFe}^{++}] / \text{min.}$ ^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$ ^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } \epsilon]}{\Delta t (\text{min.})}$ ^m $\mu\text{moles cytochrome } \epsilon \text{ reduced (mg. N)}^{-1} \text{min.}^{-1}$ ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{min.}^{-1}$ ^o $\mu\text{moles cytochrome } \epsilon \text{ oxidized (mg. N)}^{-1} \text{min.}^{-1}$ ^pMoles cytochrome ϵ reduced/mg. tissue/5 min. at10°C. (extinction coefficient of reduced cytochrome ϵ taken as $2.8 \times 10^{-3} \text{ cm.}^2 / \text{mol.}$).^qO. D. of clear supernatant when measured at 520 $\mu\text{m.}$ ^r $\Delta \text{O. D.} / \text{mg. protein} / \text{min.}$ ^sMoles DPN reduced/g. wet wt./hr.^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

TABLE OF RESPIRATORY RATES OF INVERTEBRATE TISSUES

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE		
	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity	
									Nitrogen	Protein	Wet Weight	Dry Weight				
<i>Helix pomatia</i> Vineyard snail or Burgundy snail	38	Manometer	Midgut gland: Suspension	Endogenous		5		Active	11					All assays: Cytochrome c (1×10^{-5} M ^c) present All assays: Method of nitrogen determination not specified	Rees (1953) ^t	
			(Same as above)	Endogenous		7		Hibernating	12							
			(Same as above)	Succinate (0.033 M ^{a,c})		8		Active	36							
			(Same as above)	Succinate (0.033 M ^{a,c})		6		Hibernating	39							
			(Same as above)	α -Ketoglutarate (0.01 M ^{a,c})		5		Active	16							
			(Same as above)	α -Ketoglutarate (0.01 M ^{a,c})		5		Hibernating	17							
			Midgut gland: Mitochondria	Endogenous						0						
			(Same as above)	Succinate (0.033 M ^{a,c})						110						
			(Same as above)	Malate (0.01 M ^{a,c})						18 ^a						
			(Same as above)	Malate (0.01 M ^{a,c} + DPN (3.3×10^{-4} M ^{a,c}))						31 ^a						
(Same as above)	α -Ketoglutarate (0.01 M ^{a,c})						19 ^a									
(Same as above)	α -Ketoglutarate (0.01 M ^{a,c}) + DPN (3.3×10^{-4} M ^{a,c})						25 ^a									
<i>Helix pomatia</i> Vineyard snail or Burgundy snail	28	Warburg	Slices of: Cerebral ganglion	Endogenous		20						4.00		In Baldwin's (1938) phosphate solution (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above)	Kerkut and Laver- ack (1957) ^t	
			Pedal ganglion	Endogenous		18						2.89				
			Midgut gland	Endogenous		23						2.78				
			Gut buccal mass	Endogenous		24						1.37				
			Esophagus	Endogenous		24						2.68				
			Midgut	Endogenous		24						2.56				
			Mantle	Endogenous		24						1.76				
			Kidney	Endogenous		27						2.24				
			Columella muscle	Endogenous		24						1.80				
			Female duct	Endogenous		24						1.03				
			Albuminous gland	Endogenous		22						1.20				
			Body wall	Endogenous		24						0.78				
			Dart sac	Endogenous		22						0.66				
			Foot: fore	Endogenous		17						0.81				
			Foot: middle	Endogenous		12						0.67				
Foot: rear	Endogenous		13						0.79							
<i>Helix vermiculata</i> White-lipped edible land snail	23	Warburg	Heart	Endogenous	0.92 mg. dry wt.							1.36		In isotonic chloride solution	Cardot, Faure, and Arvanitaki (1950) ^t	
<i>Levantina hierosolyma</i> (formerly <i>Helix hierosolyma</i>) Jerusalem land snail	37	Spectrophotometer; also tetrazolium method (see Kun and Abood, 1949)	Midgut gland: Homogenate (20%)	Endogenous		8		During estivation					0.025	For units of enzy- matic activity, see footnote q	Eckstein and Abra- ham (1959)	
			(Same as above)	Endogenous		5		After estivation: 10-15 hr.					0.075			
			(Same as above)	Endogenous		3		24 hr.					0.187			
			(Same as above)	Endogenous		4		48 hr.					0.115			
			(Same as above)	Endogenous		7		5-6 da.					0.101			
			Midgut gland: Homogenate (20%)	Succinate (0.014 M ^{a,c})		8		During estivation								0.114
			(Same as above)	Succinate (0.013 M ^{a,c})		5		After estivation: 10-15 hr.								0.130
			(Same as above)	Succinate (0.013 M ^{a,c})		3		24 hr.								0.222
			(Same as above)	Succinate (0.013 M ^{a,c})		4		48 hr.								0.321
			(Same as above)	Succinate (0.013 M ^{a,c})		7		5-6 da.								0.496

^aEstimated or calculated from available data.^bInitial concentration.^cFinal concentration.^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.¹ $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$ ² $-\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$ ^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).ⁱ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$ ^j $\Delta \log [\text{CyFe}^{++}] / \text{min.}$ ^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$ ^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t (\text{min.})}$ ^m $\mu\text{moles cytochrome } c \text{ reduced (mg. N)}^{-1} \text{min.}^{-1}$ ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{min.}^{-1}$ ^o $\mu\text{moles cytochrome } c \text{ oxidized (mg. N)}^{-1} \text{min.}^{-1}$ ^pMoles cytochrome c reduced/mg. tissue/5 min. at10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-7} \text{ cm.}^2 / \text{mol.}$).^qO. D. of clear supernatant when measured at 520 m μ ^rO. D./mg. protein/min.^sMoles DPN reduced/g. wet wt./hr.^tAdditional respiratory data on invertebrate tissues

present in original paper and not included in

Section 2.

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE	
	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
<i>Lymnaea stagnalis</i> Pond snail	25	Warburg	Albumen gland; Particulate fraction, largely mitochondria	Endogenous					218 ^a					P/O ratios in original paper Cytochrome c (5 × 10 ⁻⁵ M ^c) present Nitrogen determination by micro-Kjeldahl procedure	Weinbach (1956) ^t
Pelecypoda															
<i>Anodonta cellensis</i> (cited as <i>Anodonta celensis</i>) Fresh-water mussel	Not specified	Polarograph	Posterior adductor muscle: Strips Yellow portion White portion Yellow portion White portion	Endogenous Endogenous Endogenous Endogenous								0.070 ^a 0.073 ^a 0.067 ^a 0.080 ^a		Winter Winter Spring Spring	Brecht, Utz, and Lutz (1955) ^t
<i>Crassostrea gigas</i> (formerly <i>Ostrea gigas</i>) Oyster	25	Warburg	Mantle: Slices Gill: Pieces Mantle: Slices Gill: Pieces Mantle: Slices Gill: Pieces	Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous	50-100 mg. wet wt. 50-100 mg. wet wt. 50-100 mg. wet wt. 50-100 mg. wet wt. 50-100 mg. wet wt. 50-100 mg. wet wt.							0.43 ^a 0.78 ^a 0.19 ^a 0.42 ^a 0.39 ^a 0.77 ^a		Gas phase: 90% N ₂ and 10% O ₂ (Same as above) Gas phase: 90% CO and 10% O ₂ ; in darkness (Same as above) Gas phase: 90% CO and 10% O ₂ ; in light (Same as above)	Kawai (1958)
<i>Crassostrea gigas</i> (formerly <i>Ostrea gigas</i>) Oyster	25	Warburg	Heart Heart Gill Gill Mantle Mantle	Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous	50-100 mg. wet wt. 50-100 mg. wet wt. 50-100 mg. wet wt. 50-100 mg. wet wt. 50-100 mg. wet wt. 50-100 mg. wet wt.			2 yrs. (11 cm.) 2 yrs. (11 cm.) 2 yrs. (11 cm.) 2 yrs. (11 cm.) 2 yrs. (11 cm.) 2 yrs. (11 cm.)				0.39 ^a 0.20 ^a 0.53 ^a 0.26 ^a 0.29 ^a 0.14 ^a		Gas phase: air Gas phase: 90% CO and 10% O ₂ ; in darkness Gas phase: air Gas phase: 90% CO and 10% O ₂ ; in darkness Gas phase: air Gas phase: 90% CO and 10% O ₂ ; in darkness	Kawai (1959)
<i>Crassostrea gigas</i> (formerly <i>Ostrea gigas</i>) Oyster	25	Micro-Winkler	Gill	Endogenous	500 ^a mg. wet wt.							0.86-1.44		In sea water	Okamura (1959) ^t

^aEstimated or calculated from available data.
^bInitial concentration.
^cFinal concentration.
^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.
^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

^f $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$
^g $-\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).
ⁱ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
^j $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$.
^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t (\text{min.})}$.

^m $\mu\text{moles cytochrome } c \text{ reduced (mg. N)}^{-1} \text{ min.}^{-1}$
ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{ min.}^{-1}$
^o $\mu\text{moles cytochrome } c \text{ oxidized (mg. N)}^{-1} \text{ min.}^{-1}$
^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as 2.8 × 10⁻⁷ cm.²/mol.).

^qO. D. of clear supernatant when measured at 520 $\mu\mu$.
^r $\Delta \text{O. D.} / \text{mg. protein} / \text{min.}$
^sMoles DPN reduced/g. wet wt./hr.
^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

TABLE OF RESPIRATORY RATES OF INVERTEBRATE TISSUES

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE			
PHYLUM Class Scientific name Common name	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity		
									Nitrogen	Protein	Wet Weight	Dry Weight					
<i>Crassostrea virginica</i> (formerly <i>Ostrea virginica</i>) Virginia oyster	28	Thunberg micro-respi- rometer (see Thunberg, 1905)	Adductor muscle: Pieces	Endogenous	269 ^a mg. wet wt.	5		6.8-13.5 cm. long			0.0480 ^a				Hopkins (1930) [†]		
			Gray portion	Endogenous	228 ^a mg. wet wt.	5		6.8-13.5 cm. long			0.0372 ^a						
<i>Crassostrea virginica</i> (formerly <i>Ostrea virginica</i>) Virginia oyster	18-21	Warburg	Mantle:	Endogenous							0.13			Florida oysters Florida oysters Florida oysters	Jodrey and Wilbur (1955) [‡]		
			Marginal zone	Endogenous							0.15						
	Pallial zone	Endogenous								0.12							
	Central zone																
	25	Warburg	Mantle	Succinate (0.05 M)		9					25			Mantles isolated for 2-7 days Mantles freshly dissected			
			Mantle	Succinate (0.05 M)		7						23					
	25	Warburg	Mantle: Pieces	Succinate (0.01 M)							15						
			Mantle: Pieces	iso Citrate (0.01 M)								26					
			Mantle: Pieces	Citrate (0.01 M)								2					
Not specified	Spectropho- tometer		Mantle: Homogenate	Succinate (0.1 M)		9 or more		8.0-11.5 cm. long					0.03	For units of enzy- matic activity, see footnote d For units of enzy- matic activity, see footnote e			
			Mantle: Homogenate	Cytochrome c (4.5 × 10 ⁻⁵ M ^a)		9 or more		8.0-11.5 cm. long					0.61				
<i>Crassostrea virginica</i> (formerly <i>Ostrea virginica</i>) Virginia oyster	26	Warburg	Mantle: Strips	Endogenous	180-220 mg. wet wt.						0.156 ^a			With DNP (1 × 10 ⁻⁶ M) With DNP (1 × 10 ⁻³ M) With DNP (1 × 10 ⁻² M)	Maroney, Barber, and Wilbur (1957)		
			Mantle: Strips	Endogenous	180-220 mg. wet wt.							0.181 ^a					
			Mantle: Strips	Endogenous	180-220 mg. wet wt.								0.287 ^a				
			Mantle: Strips	Endogenous	180-220 mg. wet wt.								0.135 ^a				
<i>Cristaria plicata</i> Fresh-water mussel	25	Warburg	Gill	Endogenous		10		4-6 yrs.					1.8		Higashi and Kawai (1959) [‡]		
			Mantle:	Endogenous		6		4-6 yrs.				0.7					
			Edge	Endogenous		6		4-6 yrs.				0.5					
			Lobe	Endogenous		5		4-6 yrs.				0.8					
			Heart	Endogenous		4		4-6 yrs.				0.14					
			Adductor muscle:	Endogenous		4		4-6 yrs.				0.14					
Striated	Endogenous																
Smooth	Endogenous																
<i>Dreissena</i> sp. (cited as <i>Dreissensia</i>) Mussel	20	Warburg	Gill: Epithelium	Endogenous						18.7			R. Q. 0.87 Method of nitrogen de- termination not spec- ified	Wernstedt (1944)			

^a Estimated or calculated from available data.
^b Initial concentration.
^c Final concentration.
^d Decrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.
^e Decrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

^f $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$
^g $-\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
^h Moles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).
ⁱ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
^j $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^k Activity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$.
^l Activity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t (\text{min.})}$

^m $\mu\text{moles cytochrome } c \text{ reduced (mg. N)}^{-1} \text{ min.}^{-1}$
ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{ min.}^{-1}$
^o $\mu\text{moles cytochrome } c \text{ oxidized (mg. N)}^{-1} \text{ min.}^{-1}$
^p Moles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-3} \text{ cm.}^2 / \text{mol.}$).

^q O. D. of clear supernatant when measured at 520 $\mu\mu$.
^r $\Delta \text{O. D.} / \text{mg. protein} / \text{min.}$
^s Moles DPN reduced/g. wet wt./hr.
^t Additional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE			
	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity		
									Nitrogen	Protein	Wet Weight	Dry Weight					
<i>Gryphaea angulata</i> Portuguese oyster	28	Warburg	Mantle: Whole	Endogenous	100 mg. wet wt.	7							0.89 ^a		Chapheau (1932) ^t		
			Pieces	Endogenous	100 mg. wet wt.	8										0.98 ^a	
			Gill: Whole	Endogenous	80 mg. wet wt.	7										1.76 ^a	
			Pieces	Endogenous	80 mg. wet wt.	8										1.86 ^a	
			Muscle: Whole	Endogenous	120 mg. wet wt.	7										0.15 ^a	
			Pieces	Endogenous	120 mg. wet wt.	8										0.26 ^a	
			Midgut gland: Pieces	Endogenous	60 mg. wet wt.	8										1.96 ^a	
			Mantle	Endogenous	100 mg. wet wt.	2			10-15 mos.								1.24 ^a
			Mantle	Endogenous	100 mg. wet wt.	6			30 mos.								0.96 ^a
			Mantle	Endogenous	100 mg. wet wt.	1			6 yrs.								0.68
			Gill	Endogenous	80 mg. wet wt.	2			10-15 mos.								2.3 ^a
			Gill	Endogenous	80 mg. wet wt.	6			30 mos.								1.76 ^a
			Gill	Endogenous	80 mg. wet wt.	1			6 yrs.								1.23
			Muscle	Endogenous	120 mg. wet wt.	2			10-15 mos.								0.46 ^a
			Muscle	Endogenous	120 mg. wet wt.	6			30 mos.								0.26 ^a
			Muscle	Endogenous	120 mg. wet wt.	1			6 yrs.								0.17
Midgut gland	Endogenous	60 mg. wet wt.	2			10-15 mos.						2.14 ^a					
Midgut gland	Endogenous	60 mg. wet wt.	6			30 mos.						1.78 ^a					
Midgut gland	Endogenous	60 mg. wet wt.	1			6 yrs.						0.92					
<i>Hyriopsis schlegelii</i> Fresh-water mussel	25	Warburg	Gill	Endogenous		24		4-6 yrs.					1.3		Higashi and Kawai (1959) ^t		
			Mantle: Edge	Endogenous		8		4-6 yrs.					0.6				
			Lobe	Endogenous		8		4-6 yrs.					0.5				
			Heart	Endogenous		10		4-6 yrs.					0.8				
			Adductor muscle: Striated	Endogenous		6		4-6 yrs.					0.19				
			Smooth	Endogenous		6		4-6 yrs.					0.19				
<i>Isognomon alata</i> (formerly <i>Pedalion alata</i>) Tree oyster	25	Warburg	Gill	Endogenous		6							1.3		Robbie (1949) ^t		

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

¹ $\Delta \log [\text{cytochrome c}]/\text{mg. wet wt./min.}$

² $-\Delta \log [\text{ferricytochrome c}]/\text{mg. protein/min.}$

³Moles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).

⁴ $\Delta \log [\text{ferricytochrome c}]/\text{mg. protein/min.}$

⁵ $\Delta \log [\text{CyFe}^{++}]/\text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$.

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome c}]}{\Delta t (\text{min.})}$.

^m $\mu\text{moles cytochrome c reduced (mg. N)}^{-1} \text{ min.}^{-1}$

ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{ min.}^{-1}$

^o $\mu\text{moles cytochrome c oxidized (mg. N)}^{-1} \text{ min.}^{-1}$

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-7} \text{ cm}^2/\text{mol.}$).

^qO. D. of clear supernatant when measured at 520 m μ .

^rO. D./mg. protein/min.

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

TABLE OF RESPIRATORY RATES OF INVERTEBRATE TISSUES

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE					
PHYLUM Class Scientific name Common name	Temp. ° C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity				
									Nitrogen	Protein	Wet Weight	Dry Weight							
<i>Macra</i> sp. Clam	25	Warburg	Muscle: Thin sheets or slices Gill: Thin sheets	Glucose (0.011 M ^a) Glucose (0.011 M ^b)		5						0.0784 ^a			Villee, Lichten- stein, Nathanson, and Rolander (1950)				
						15						0.253 ^a							
<i>Mercenaria mercenaria</i> (formerly <i>Venus mercenaria</i>) Quahog	28	Thunberg micro- respirometer (see Thunberg, 1905)	Posterior adductor muscle: Pieces	Endogenous	292 ^a mg. wet wt.	32		5.3-13.5 cm. long				0.0419 ^a			Hopkins (1930) ^t				
			Red portion			31		5.3-13.5 cm. long			0.0353 ^a								
			White portion			16		<6.5 cm. long			0.0485 ^a								
			Red portion			16		>9 cm. long			0.0354 ^a								
			White portion			15		<6.5 cm. long			0.0427 ^a								
			White portion			16		>9 cm. long			0.0285 ^a								
<i>Mercenaria mercenaria</i> (formerly <i>Venus mercenaria</i>) Quahog	20	Differential volumeter (modified Thunberg; see Hopkins and Handford, 1943)	Adductor muscle (red): Thin sections	Endogenous		21		2-6 yrs.				0.157 ^a		Winter and spring	Hopkins (1946) ^t				
			(Same as above)	Endogenous		21		7-20+ yrs.				0.108 ^a							
			(Same as above)	Endogenous		12		2-6 yrs.				0.139 ^a				Winter and spring			
			(Same as above)	Endogenous		12		7-20+ yrs.				0.103 ^a				Summer and autumn			
			Mantle: Pieces	Endogenous		23		2-6 yrs.				1.325 ^a				Summer and autumn			
			Mantle: Pieces	Endogenous		23		7-20+ yrs.				1.040 ^a				Winter and spring			
			Mantle: Pieces	Endogenous		7		2-6 yrs.				0.912 ^a				Winter and spring			
			Mantle: Pieces	Endogenous		7		7-20+ yrs.				0.815 ^a				Summer and autumn			
			Gill: Pieces	Endogenous		46		2-6 yrs.				1.597 ^a				Summer and autumn			
			Gill: Pieces	Endogenous		46		7-20+ yrs.				1.590 ^a				Winter and spring			
			Gill: Pieces	Endogenous		43		2-6 yrs.				1.603 ^a				Winter and spring			
			Gill: Pieces	Endogenous		43		7-20+ yrs.				1.316 ^a				Summer and autumn			
				25	(Same as above)	Gill: Pieces	Endogenous		16		2-6 yrs.						1.546 ^a		From water 25°-28° C.
			Gill: Pieces			Endogenous		16		7-20+ yrs.						1.189 ^a		From water 25°-28° C.	
Gill: Pieces	Endogenous		15				4 yrs.				1.770 ^a		From water <20° C.						
Gill: Pieces	Endogenous		15				22-27 yrs.				1.747 ^a		From water <20° C.						
<i>Mercenaria mercenaria</i> (formerly <i>Venus mercenaria</i>) Quahog	20	Differential volumeter (modified Thunberg; see Hopkins and Handford, 1943)	Gill: Pieces	Endogenous	25 mg. dry wt.	21						1.225 ^a		Sea water (s.g. 1.025). R. Q. 0.90 ^a	Hopkins (1946) ^t				
			Gill: Pieces	Endogenous	25 mg. dry wt.	21							1.144 ^a	Sea water (s.g. 1.025). With HCN (1 × 10 ⁻³ M)					
			Gill: Pieces	Endogenous	25 mg. dry wt.	5							1.819 ^a	Sea water (s.g. 1.015). R. Q. 0.94 ^a					
			Gill: Pieces	Endogenous	25 mg. dry wt.	10							1.417 ^a	Sea water (s.g. 1.015). With HCN (1 × 10 ⁻³ M)					

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome ϵ per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome ϵ per minute for 1:100 tissue dilution.

^f $\Delta \log$ [cytochrome ϵ]/mg. wet wt./min.

^g $\Delta \log$ [ferricytochrome ϵ]/mg. protein/min.

^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).

ⁱ $\Delta \log$ [ferricytochrome ϵ]/mg. protein/min.

^j $\Delta \log$ [CyFe⁺⁺]/min.

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$.

^lActivity/mg. protein when activity = $\frac{\Delta \log (\text{cytochrome } \epsilon)}{\Delta t (\text{min.})}$.

^m μ moles cytochrome ϵ reduced (mg. N)⁻¹ min.⁻¹

ⁿ μ moles DPNH oxidized (mg. N)⁻¹ min.⁻¹

^o μ moles cytochrome ϵ oxidized (mg. N)⁻¹ min.⁻¹

^pMoles cytochrome ϵ reduced/mg. tissue/5 min. at 10° C. (extinction coefficient of reduced cytochrome ϵ taken as 2.8 × 10⁻⁷ cm.²/mol.).

^qO. D. of clear supernatant when measured at 520 μ .

^rO. D./mg. protein/min.

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE	
	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
			Mantle (central portion): Pieces (Same as above)	Endogenous	20 mg. dry wt.	8						0.771 ^a		Sea water (s.g. 1.025)	
			(Same as above)	Endogenous	20 mg. dry wt.	8						0.303 ^a		Sea water (s.g. 1.025). With HCN (1×10 ⁻³ M)	
			(Same as above)	Endogenous	20 mg. dry wt.	7						0.851 ^a		Sea water (s.g. 1.015)	
			(Same as above)	Endogenous	20 mg. dry wt.	3						0.274 ^a		Sea water (s.g. 1.015). With HCN (1×10 ⁻³ M)	
			Adductor muscle (red): Pieces (Same as above)	Endogenous	100 mg. dry wt.	3						0.0712 ^a		Sea water (s.g. 1.025)	
			(Same as above)	Endogenous	100 mg. dry wt.	3						0.0278 ^a		Sea water (s.g. 1.025). With HCN (1×10 ⁻³ M)	
			(Same as above)	Endogenous	100 mg. dry wt.	3						0.0603 ^a		Sea water (s.g. 1.015)	
<i>Mya</i> sp. Soft-shelled clam	25	Warburg	Gill: Thin sheets	Glucose (0.011 M ^b)		10						0.280 ^a			Villee, Lichtenstein, Nathanson, and Rolander (1950)
<i>Mytilus</i> sp. Mussel	17	Winkler	Gill	Endogenous	67 ^a mg. dry wt.	5						1.56 ^a		In sea water (S=15‰)	Schlieper (1931) ^t
			Gill	Endogenous	50 ^a mg. dry wt.	4						2.49 ^a		In isotonic NaCl solution	
			Gill	Endogenous	67 ^a mg. dry wt.	5						1.73 ^a		In sea water (S=15‰)	
			Gill	Endogenous	55 ^a mg. dry wt.	5						2.37 ^a		In isotonic KCl solution	
			Gill	Endogenous	90 ^a mg. dry wt.	6						1.26 ^a		In sea water (S=15‰)	
			Gill	Endogenous	74 ^a mg. dry wt.	6						2.16 ^a		In isotonic CaCl ₂ solution	
<i>Mytilus crassitesta</i> Mussel	25	Warburg	Gill	Endogenous	50-100 mg. wet wt.			8 cm. long				0.26 ^a		Gas phase: air	Kawai (1959)
			Gill	Endogenous	50-100 mg. wet wt.			8 cm. long				0.13 ^a		Gas phase: 90% CO and 10% O ₂ ; in darkness	
<i>Mytilus edulis</i> Edible mussel	7.5	Warburg	Retractor muscle of foot	Endogenous		9						0.018 ^a	0.11	In buffered artificial sea water	Glaister and Kerly (1936) ^t
	15	Warburg	(Same as above)	Endogenous		13						0.037 ^a	0.22	(Same as above)	
	25	Warburg	(Same as above)	Endogenous		13						0.040 ^a	0.24	(Same as above)	
<i>Mytilus edulis</i> Edible mussel	19	Winkler	Gill	Endogenous		11		5.7-7.0 cm. long				1.92 ^a		In artificial sea water (S=15‰)	Pieh (1936) ^t
			Gill	Endogenous		11		5.7-7.0 cm. long				3.10 ^a		In isotonic NaCl solution	
<i>Mytilus galloprovincialis</i> Mussel	23	Warburg	Heart: Ventricle only	Endogenous								1.18		In sea water	Cardot, Faure, and Arvanitaki (1950) ^t
			(Same as above)	Endogenous								0.90		In isotonic MgCl ₂	
			(Same as above)	Endogenous								0.70		In isotonic CaCl ₂	
			(Same as above)	Endogenous								1.42		In salt solution: Na ⁺ +Ca ⁺⁺ +Mg ⁺⁺	
			(Same as above)	Endogenous								1.18		$\frac{K^+}{Na^++Ca^{++}+Mg^{++}} = 10$	
														$\frac{K^+}{Na^++Ca^{++}+Mg^{++}} = 50$	

^aEstimated or calculated from available data.
^bInitial concentration.
^cFinal concentration.
^dIncrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.
^eIncrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

$\Delta \log [\text{cytochrome c}]/\text{mg. wet wt./min.}$
 $\Delta \log [\text{ferricytochrome c}]/\text{mg. protein/min.}$
^bMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).
 $\Delta \log [\text{ferricytochrome c}]/\text{mg. protein/min.}$
 $\Delta \log [\text{CyFe}^{++}]/\text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \text{final tissue dilution}$.
^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome c}]}{\Delta t (\text{min.})}$.

mμ moles cytochrome c reduced (mg. N)⁻¹ min.⁻¹
 nμ moles DPNH oxidized (mg. N)⁻¹ min.⁻¹
 oμ moles cytochrome c oxidized (mg. N)⁻¹ min.⁻¹
^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as 2.8×10³ cm²/mol.)

^qO. D. of clear supernatant when measured at 520 mμ.
^rΔ O. D./mg. protein/min.
^sMoles DPN reduced/g. wet wt./hr.
^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE		
	Temp. ° C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity	
									Nitrogen	Protein	Wet Weight	Dry Weight				
<i>Noetia ponderosa</i> (formerly <i>Arca ponderosa</i>) Ark shell	28	Thunberg micro-respirometer (see Thunberg, 1905)	Posterior adductor muscle: Pieces	Endogenous	278 ^a mg. wet wt.	7		5.0-6.9 cm. long			0.0312 ^a				Hopkins (1930) ^t	
			Red portion	Endogenous	285 ^a mg. wet wt.	7		5.0-6.9 cm. long			0.0179 ^a					
<i>Ostrea circumpecta</i> Oyster	24	Micro-Winkler	Heart: Ventricle only	Endogenous	92 ^a mg. wet wt.			15 cm. long			0.061 ^a			Resting heart	Nomura (1950) ^t	
			(Same as above)	Endogenous	92 ^a mg. wet wt.			15 cm. long			0.088 ^a			Weighted heart		
<i>Pecten</i> sp. Scallop	25	Warburg	Gill: Thin sheets	Glucose (0.011 M ^b)		10					0.222 ^a				Villee, Lichtenstein, Nethanson, and Rolander (1950)	
			Muscle of mantle: Thin sheets or slices	Glucose (0.011 M ^b)		5					0.130 ^a					
<i>Pecten irradians</i> Scallop	28	Thunberg micro-respirometer (see Thunberg, 1905)	Adductor muscle: Pieces	Endogenous	282 ^a mg. dry wt.	12		5.0-8.2 cm. long			0.0767 ^a				Hopkins (1930) ^t	
			Gray portion	Endogenous	269 ^a mg. dry wt.	12		5.0-8.2 cm. long			0.0424 ^a					
<i>Pinctada martensii</i> Pearl oyster	25	Warburg	Gill	Endogenous		10		2 yrs.			2.1			Latter half of June (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above)	Kawai (1957) ^t	
			Pallial margin	Endogenous		7		2 yrs.			0.9					
			Midgut gland	Endogenous		6		2 yrs.			0.8					
			Gonad	Endogenous		6		2 yrs.			0.6					
			Foot muscle	Endogenous		4		2 yrs.			0.6					
			Epithelium of middle part of mantle edge	Endogenous		5		2 yrs.			0.4					
			Epithelium adhering to inner surface of shell	Endogenous		5		2 yrs.			0.17					
			Adductor muscle	Endogenous		5		2 yrs.			0.15					
			Gill	Endogenous		10					0.36					Latter half of June Middle of July to end of August Middle of October End of December to middle of January
			Gill	Endogenous		5					0.43					
<i>Pinctada martensii</i> Pearl oyster	25	Warburg	Gill	Endogenous	50-100 mg. wet wt.			2 yrs. (6 cm.)			0.48 ^a			Gas phase: air	Kawai (1959)	
			Gill	Endogenous	50-100 mg. wet wt.			(Same as above)			0.25 ^a			Gas phase: 90% CO and 10% O ₂ ; in darkness		
			Mantle	Endogenous	50-100 mg. wet wt.			2 yrs. (6 cm.)			0.15 ^a			Gas phase: air		
			Mantle	Endogenous	50-100 mg. wet wt.			(Same as above)			0.07 ^a			Gas phase: 90% CO and 10% O ₂ ; in darkness		
			Midgut gland	Endogenous	50-100 mg. wet wt.			2 yrs. (6 cm.)			0.27 ^a			Gas phase: air		
			Midgut gland	Endogenous	50-100 mg. wet wt.			(Same as above)			0.15 ^a			Gas phase: 90% CO and 10% O ₂ ; in darkness		

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

^f $\Delta \log$ [cytochrome c]/mg. wet wt./min.

^g $-\Delta \log$ [ferricytochrome c]/mg. protein/min.

^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).

ⁱ $\Delta \log$ [ferricytochrome c]/mg. protein/min.

^j $\Delta \log$ [CyFe⁺⁺]/min.

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$.

^lActivity/mg. protein when activity = $\frac{\Delta \log (\text{cytochrome c})}{\Delta t (\text{min.})}$.

^m μ moles cytochrome c reduced (mg. N)⁻¹ min.⁻¹

ⁿ μ moles DPNH oxidized (mg. N)⁻¹ min.⁻¹

^o μ moles cytochrome c oxidized (mg. N)⁻¹ min.⁻¹

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as 2.8 × 10⁻⁷ cm.²/mol.).

^qO. D. of clear supernatant when measured at 520 m μ .

^r Δ O. D./mg. protein/min.

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE	
PHYLUM Class Scientific name Common name	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
<i>Pinna muricata</i> (probably refers to <i>Atrina serrata</i>) Pen shell	28	Thunberg micro- respirometer (see Thunberg, 1905)	Posterior adductor muscle: Pieces	Endogenous	273 ^a mg. wet wt.	6		14.2-28.8 cm. long				0.0507 ^a			Hopkins (1930) ^t
			Gray portion	Endogenous	276 ^a mg. wet wt.	6		14.2-28.8 cm. long				0.0413 ^a			
			White portion	Endogenous	258 ^a mg. wet wt.	4		16.5-28.2 cm. long				0.0371 ^a			
<i>Saxostrea commercialis</i> Australian rock oyster	37	Warburg	Adductor muscle: Homogenate	Endogenous	600 mg. (200 mg./ml.)			2-3 yrs.				0.00525 ^a		Duration of homogenization: 1.5 min. } Temp. of homogeni- zation: 37° C.	Humphrey (1946) ^t
			(Same as above)	Endogenous	300 mg. (100 mg./ml.)			2-3 yrs.				0.0148 ^a			
			(Same as above)	Endogenous	150 mg. (50 mg./ml.)			2-3 yrs.				0.0260 ^a			
			Adductor muscle: Homogenate	Endogenous	600 mg.			2-3 yrs.				0.0283 ^a		1 min. } Temp. of homogeni- zation: 20° C.	
			(Same as above)	Endogenous	600 mg.			2-3 yrs.				0.0242 ^a			
			(Same as above)	Endogenous	600 mg.			2-3 yrs.				0.0267 ^a			
(Same as above)	Endogenous	600 mg.			2-3 yrs.				0.0265 ^a		3 min. } 37° C.				
(Same as above)	Endogenous	600 mg.			2-3 yrs.				0.0213 ^a						
(Same as above)	Endogenous	600 mg.			2-3 yrs.				0.0205 ^a						
(Same as above)	Endogenous	600 mg.			2-3 yrs.				0.21 (max.)		1.5 min. } 37° C.				
<i>Saxostrea commercialis</i> Australian rock oyster	"Room temp."	Warburg	Muscle: Homogenate	Succinate (0.02 M ^c)	600 mg.			2-3 yrs.				0.055 ^a		Humphrey (1947) ^t	
			Muscle: Homogenate	Succinate (0.02 M ^c) + cytochrome c (1 × 10 ⁻⁵ M)	600 mg.			2-3 yrs.				0.138 ^a			
			Muscle: Homogenate	Cytochrome c (1 × 10 ⁻⁵ M ^c) + ascorbic acid (0.01 M ^c)	400 mg.			2-3 yrs.				0.120 ^a			
Cephalopoda															
<i>Eledone sp.</i> Octopus	16	Warburg; also differential manometer	Mantle nerve and stel- late ganglion	Endogenous	9.8 mg. dry wt.	3						0.63 ^a		Nerve and ganglion unstimulated; in artificial sea water with urea and bicarbonate	Meyerhof and Schulz (1929)
			(Same as above)	Endogenous	16.0 mg. dry wt.	1						0.30			
<i>Loligo pealeii</i> Squid	25	Warburg	Gill	Endogenous		5						1.8		Robbie (1949) ^t	
			Eye:												
			Retina	Endogenous		3							1.1		
			"Cornea"	Endogenous		4							0.4		
Lens	Endogenous		2								0.002				

^aEstimated or calculated from available data.
^bInitial concentration.
^cFinal concentration.
^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.
^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.
^f $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$
^g $-\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).
ⁱ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
^j $\Delta \log [\text{CyFe}^{++}] / \text{min.}$
^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$
^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t} (\text{min.})$
^m $\mu\text{moles cytochrome } c \text{ reduced (mg. N)}^{-1} \text{min.}^{-1}$
ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{min.}^{-1}$
^o $\mu\text{moles cytochrome } c \text{ oxidized (mg. N)}^{-1} \text{min.}^{-1}$
^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-7} \text{ cm.}^2 / \text{mol.}$)
^qO. D. of clear supernatant when measured at 520 $\mu\mu$.
^rO. D./mg. protein/min.
^sMoles DPN reduced/g. wet wt./hr.
^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE		
PHYLUM Class <i>Scientific name</i> Common name	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity	
									Nitrogen	Protein	Wet Weight	Dry Weight				
<i>Loligo pealeii</i> Squid	Not specified	Spectropho- meter	Giant nerve fiber: Homogenate	Succinate (0.017 M ^c) + cytochrome <i>c</i> (1.7 × 10 ⁻⁵ M ^c)									0.120	All assays: For units of enzymatic activ- ity, see footnote f	Cooperstein and Lazarow (1950)	
			Axoplasm Homogenate	(Same as above) Cytochrome <i>c</i>									0.108			
			Axoplasm	Cytochrome <i>c</i>									0.375			
				Cytochrome <i>c</i>									0.395			
			Fibrous sheath and small nerves surrounding giant axon: Homogenate	Succinate (0.017 M ^c) + cytochrome <i>c</i> (1.7 × 10 ⁻⁵ M ^c)												0.112
			(Same as above)	Cytochrome <i>c</i>												0.410
Fin nerve: Homogenate	Succinate (0.017 M ^c) + cytochrome <i>c</i> (1.7 × 10 ⁻⁵ M ^c)										0.113					
Fin nerve: Homogenate	Cytochrome <i>c</i>										0.360					
Stellate ganglion: Homogenate	Succinate (0.017 M ^c) + cytochrome <i>c</i> (1.7 × 10 ⁻⁵ M ^c)										0.227					
Stellate ganglion: Homogenate	Cytochrome <i>c</i>										2.12					
Muscle: Homogenate	Succinate (0.017 M ^c) + cytochrome <i>c</i> (1.7 × 10 ⁻⁵ M ^c)										0.155					
Muscle: Homogenate	Cytochrome <i>c</i>										1.53					
<i>Loligo pealeii</i> Squid	16	Continous flow respirometer (oxygen cathode)	Stellar nerve: Giant axons alone	Endogenous									0.068	Mean value from 8 nerves Mean value from 5 nerves	Connelly (1952)	
			Giant axons plus accom- panying small nerve fibers	Endogenous									0.074			
<i>Loligo pealeii</i> Squid	Not specified	Spectropho- meter	Giant nerve fiber: Homogenate of:											All assays: For units of enzymatic activ- ity, see footnote g All assays: Protein de- termination by method of Lowry <i>et al.</i> (1951)	Foster (1956) ^t	
			Whole nerve	Cytochrome <i>c</i>									14.7			
			Isolated sheath	Cytochrome <i>c</i>									2.3			
			Mitochondria of:										83.4			
			Axoplasm	Cytochrome <i>c</i>									18.0			
Isolated sheath	Cytochrome <i>c</i>									10.2						
<i>Loligo pealeii</i> Squid	15	Micro-volumeter (see Scholander Claff, Andrews, and Wallach, 1952)	Giant nerve fiber: Entire fiber	Endogenous		3-4							2.7	Based on total protein	Coelho <i>et al.</i> , cited by Schmitt and Geschwind (1957) ^t Also Coelho (per- sonal communica- tion)	
			Entire fiber	Endogenous									0.106 ^a			
			Isolated sheath	Endogenous		6							4.4			0.200 ^a
			Isolated sheath	Endogenous												0.125 ^a
<i>Loligo pealeii</i> Squid	38	Fluometric measurement of TPNH	Giant nerve fiber: Isolated sheath:	<i>iso</i> Citrate									4.8	All assays: For units of enzymatic activ- ity, see footnote h	Roberts, Coelho, Lowry, and Craw- ford (1958) ^t	
			Homogenate Axoplasm	<i>iso</i> Citrate									0.36			
<i>Loligo pealeii</i> Squid	38	Fluometric measurement of DPN ⁺	Giant nerve fiber: Isolated sheath:	Malate									147	All assays: Protein de- termination by method of Lowry <i>et al.</i> (1951)		
			Homogenate Axoplasm	Malate									103			

^aEstimated or calculated from available data.
^bInitial concentration.
^cFinal concentration.
^dDecrease in log of molar concentration of oxidized
cytochrome ϵ per minute for 1:150 tissue dilution.
^eDecrease in log of molar concentration of reduced
cytochrome ϵ per minute for 1:100 tissue dilution.

$\Delta \log [\text{cytochrome } \epsilon] / \text{mg. wet wt.} / \text{min.}$
 $\epsilon = \Delta \log [\text{ferricytochrome } \epsilon] / \text{mg. protein} / \text{min.}$
^bMoles substrate converted/kilo protein/hour (For
axoplasm, protein = total protein; for sheath,
protein of non-collagenous component).
 $\Delta \log [\text{ferricytochrome } \epsilon] / \text{mg. protein} / \text{min.}$
 $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity =
 $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$
^lActivity/mg. protein when activity =
 $\frac{\Delta \log [\text{cytochrome } \epsilon]}{\Delta t (\text{min.})}$

^m $\mu\text{moles cytochrome } \epsilon \text{ reduced (mg. N)}^{-1} \text{ min.}^{-1}$
ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{ min.}^{-1}$
^o $\mu\text{moles cytochrome } \epsilon \text{ oxidized (mg. N)}^{-1} \text{ min.}^{-1}$
^pMoles cytochrome ϵ reduced/mg. tissue/5 min. at
10°C. (extinction coefficient of reduced cyto-
chrome ϵ taken as $2.8 \times 10^{-7} \text{ cm}^2 / \text{mol.}$).

^qO. D. of clear supernatant when measured at 520 μm
^r $\Delta \text{O. D.} / \text{mg. protein} / \text{min.}$
^sMoles DPN reduced/g. wet wt./hr.
^tAdditional respiratory data on invertebrate tissues
present in original paper and not included in
Section 2.

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE	
PHYLUM Class Scientific name Common name	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
Squid (Sci. name not given)	23	Warburg	Head ganglion (minced)	Glucose (0.01 M)	38.0 ^a mg. wet wt.	5						7.5 ^a			Nachmansohn, Steinbach, Machado, and Spiegelman (1943) [†]
			(Same as above)	Pyruvate (0.05 M ^c)	41.7 ^a mg. wet wt.	3						8.0 ^a			
			(Same as above)	Pyruvate (0.05 M ^c) + cytochrome c (8 × 10 ⁻⁵ M ^{a,c})	89.0 mg. wet wt.	1						9.7			
			Trunk containing giant axon (minced)	Pyruvate (0.05 M ^c)	45.0 ^a mg. wet wt.	2						1.11 ^a			
			(Same as above)	Pyruvate (0.05 M ^c) + cytochrome c (8 × 10 ⁻⁵ M ^{a,c})	131.0 ^a mg. wet wt.	2						1.34 ^a			
			Axoplasm (extruded)	Pyruvate (0.05 M ^c) + cytochrome c (8 × 10 ⁻⁵ M ^{a,c})	44.0 ^a mg. wet wt.	3						3.23			
			Remaining tissue (minced)	Pyruvate (0.05 M ^c) + cytochrome c (8 × 10 ⁻⁵ M ^{a,c})	98.0 ^a mg. wet wt.	2						0.63 ^a			
			Head ganglion (ground)	Cytochrome c (8 × 10 ⁻⁵ M ^{a,c})	55.0 ^a mg. wet wt.	3						10.6 ^a			
			Trunk containing giant axon (ground)	Cytochrome c (8 × 10 ⁻⁵ M ^{a,c})	110.0 ^a mg. wet wt.	2						0.94 ^a			
			Axoplasm (extruded)	Cytochrome c (8 × 10 ⁻⁵ M ^{a,c})	44.0 ^a mg. wet wt.	3						3.23 ^a			
Remaining tissue (ground)	Cytochrome c (8 × 10 ⁻⁵ M ^{a,c})	58.0 ^a mg. wet wt.	2						0.50 ^a						
Squid (Sci. name not given)	28	Not specified	Heart: Slices	Endogenous							9.0		Gas phase: O ₂	Harron (1958)	
<i>Octopus</i> sp. Octopus	16	Warburg; also differential manometer	Mantle nerve	Endogenous	18.7 mg. dry wt.	1					0.48		Nerve unstimulated; in <i>Maja</i> serum (pre- sumably <i>Maja</i> blood)	Meyerhof and Schulz (1929)	
			Mantle nerve	Endogenous	24.5 mg. dry wt.	1					0.28		Nerve unstimulated; in artificial sea water lacking urea or bicarbonate		
<i>Octopus macropus</i> Octopus	24	Warburg	Salivary gland: Slices (from frozen tissue)	Endogenous							0.88		Gas phase: 95% N ₂ and 5% O ₂	Ghiretti-Magaldi, Giuditta, and Ghiretti (1958) [†]	
			(Same as above)	Endogenous							0.54		Gas phase: 95% CO and 5% O ₂ ; in dark- ness		
			(Same as above)	Endogenous							0.83		Gas phase: 95% CO and 5% O ₂ ; in light		
<i>Octopus vulgaris</i> Octopus	20	Warburg	Retina	Glucose (0.011 M ^a)		4					0.88			Vincentiis (1952)	
			Optic ganglion: Slices	Glucose (0.011 M ^a)		7					1.42				
			Midgut gland: Slices	Glucose (0.011 M ^a)		3					0.86				

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

¹ $\Delta \log [\text{cytochrome c}] / \text{mg. wet wt.} / \text{min.}$

² $-\Delta \log [\text{ferricytochrome c}] / \text{mg. protein} / \text{min.}$

³Moles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).

⁴ $\Delta \log [\text{ferricytochrome c}] / \text{mg. protein} / \text{min.}$

⁵ $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$.

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome c}]}{\Delta t} (\text{min.})$.

^mmμ moles cytochrome c reduced (mg. N)⁻¹ min.⁻¹

ⁿmμ moles DPNH oxidized (mg. N)⁻¹ min.⁻¹

^omμ moles cytochrome c oxidized (mg. N)⁻¹ min.⁻¹

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as 2.8 × 10⁻³ cm²/mol.).

^qO. D. of clear supernatant when measured at 520 mμ.

^rO. D./mg. protein/min.

^sMoles DPN reduced/g. wet wt./hr.

[†]Additional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE		
	PHYLUM Class Scientific name Common name	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram					Enzymatic Activity	
										Nitrogen	Protein	Wet Weight				Dry Weight
<i>Octopus vulgaris</i> Octopus	24	Manometer	Mantle and tentacles (skinned muscle); Particle suspension (from frozen tissue) (Same as above)	Succinate (0.05 M ^c)								1.8 ^a		Ghiretti-Magaldi, Giuditta, and Ghiretti (1957) ¹		
			(Same as above)	Succinate (0.05 M ^c) + cytochrome c (2.5 × 10 ⁻⁵ M ^c)								3.3 ^a				
			(Same as above)	Ascorbic acid								0.33 ^a				
			(Same as above)	Ascorbic acid + cytochrome c (2.5 × 10 ⁻⁵ M ^c)								4.56 ^a				
			(Same as above)	Quinol								0.14 ^a				
			(Same as above)	Quinol + cytochrome c (2.5 × 10 ⁻⁵ M ^c)								4.28 ^a				
			(Same as above)	p-phenylenediamine								0.19 ^a				
			(Same as above)	p-phenylenediamine + cytochrome c (2.5 × 10 ⁻⁵ M ^c)								2.00 ^a				
<i>Octopus vulgaris</i> Octopus	24	Warburg	Optic ganglion Optic ganglion Kidney Kidney Salivary gland Salivary gland Gill Gill Branchial heart Branchial heart Branchial gland Branchial gland Midgut gland Midgut gland Mantle muscle Mantle muscle Central heart	Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous								1.86 4.76 2.07 3.05 0.83 2.81 1.64 2.43 1.78 1.74 1.13 1.42 0.67 1.02 0.42 0.88 1.57		Gas phase: Air O ₂ Air O ₂ Air O ₂ Air O ₂ Air O ₂ Air O ₂ Air O ₂ Air O ₂ Air	Ghiretti-Magaldi, Giuditta, and Ghiretti (1958) ¹	
<i>Sepia officinalis</i> Cuttlefish	20-22	Warburg	Nerve Nerve Nerve Nerve	Endogenous Endogenous Endogenous Endogenous	50-100 mg. wet wt. 50-100 mg. wet wt.	4 1						0.63 ^a 0.18 0.73 0.61		In sea water In isotonic MgCl ₂ In salt solution: Na ⁺ + Ca ⁺⁺ + Mg ⁺⁺ = 40 K ⁺ Na ⁺ + Ca ⁺⁺ + Mg ⁺⁺ = 53 K ⁺	Cardot, Faure, and Arvanitaki (1950) ¹	
ANNELIDA																
Polychaeta																
<i>Chaetopterus</i> sp. Parchment worm	25	Warburg	Muscle: Thin sheets or slices	Glucose (0.011 M ^a)		10						0.116 ^a		Villee, Lichten- stein, Nathanson, and Rolander (1950)		
<i>Sabella pavonina</i> Feather-duster worm or peacock-worm	17	Micro-Winkler	Isolated crown	Endogenous		21						0.167 ^a	1.152 ^a		Fox (1938)	

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

¹ $\Delta \log [\text{cytochrome c}] / \text{mg. wet wt.} / \text{min.}$

² $-\Delta \log [\text{ferricytochrome c}] / \text{mg. protein} / \text{min.}$

³Moles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).

⁴ $\Delta \log [\text{ferricytochrome c}] / \text{mg. protein} / \text{min.}$

⁵ $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome c}]}{\Delta t (\text{min.})}$

^m $\mu\text{moles cytochrome c reduced (mg. N)}^{-1} \text{min.}^{-1}$

ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{min.}^{-1}$

^o $\mu\text{moles cytochrome c oxidized (mg. N)}^{-1} \text{min.}^{-1}$

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-7} \text{ cm.}^2 / \text{mol.}$.)

^qO. D. of clear supernatant when measured at 520 $\mu\mu$.

^rO. D./mg. protein/min.

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

TABLE OF RESPIRATORY RATES OF INVERTEBRATE TISSUES

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE	
	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
<i>Sabella pavonina</i> Feather-duster worm or peacock-worm	17	Barcroft	Body wall: Slices Body wall: Slices Body wall: Slices Body wall: Slices	Succinic acid (0.001 M) Succinic acid (0.001 M) Succinic acid (0.001 M) Succinic acid (0.001 M)		11 11 11 11						0.504 ^a 0.430 ^a 0.539 ^a 0.444 ^a	First hour: in air Second hour: in CO First hour: in air Second hour: in air	Ewer and Fox (1940)	
Clitellata															
<i>Eisenia foetida</i> Manure worm or brandling	Not specified	Warburg	Viscera: Mince Segments 1-9 Segments 30-34 (clitellum) Segments 40-49 Segments 60-69 Segments 90-100	Endogenous Endogenous Endogenous Endogenous	Wet wt. 100 mg. 100 mg. 100 mg. 100 mg.			Clitellate worms Clitellate worms Clitellate worms Clitellate worms				0.12 ^a 0.01 ^a 0.04 ^a 0.05 ^a 0.08 ^a	All assays: Segmenta- tion approximate	O'Brien (1957) ^t	
	Not specified	Warburg	Body wall: Mince Segments 1-9 Segments 10-19 Segments 20-29 Segments 40-49 Segments 60-69 Segments 90-100	Endogenous Endogenous Endogenous Endogenous Endogenous	Wet wt. 100 mg. 100 mg. 100 mg. 100 mg. 100 mg. 100 mg.			Clitellate worms Clitellate worms Clitellate worms Clitellate worms Clitellate worms Clitellate worms				0.48 ^a 0.30 ^a 0.27 ^a 0.23 ^a 0.31 ^a 0.44 ^a	All assays: Segmenta- tion approximate		
	27	Warburg	Body wall: Mince Segments 1-9 Segments 10-19 Segments 30-34 (clitellum) Segments 35-40 Segments 55-60 Segments 100-110	Succinate + cytochrome c Succinate + cytochrome c Succinate + cytochrome c Succinate + cytochrome c Succinate + cytochrome c				Clitellate worms Clitellate worms Clitellate worms Clitellate worms Clitellate worms				0.78 ^a 0.69 ^a 0.63 ^a 0.62 ^a 0.55 ^a 0.76 ^a	All assays: Segmenta- tion approximate		
	Not specified	Warburg	Viscera: Homogenate Segments 1-9 Segments 30-34 (clitellum) Segments 40-49 Segments 60-69 Segments 90-100	Endogenous Endogenous Endogenous Endogenous	Wet wt. 200 mg. 200 mg. 200 mg. 200 mg.			Clitellate worms Clitellate worms Clitellate worms Clitellate worms				0.046 ^a 0.025 ^a 0.028 ^a 0.029 ^a 0.031 ^a	All assays: Segmenta- tion approximate		
	Not specified	Warburg	Body wall: Homogenate Segments 1-9 Segments 40-49 Segments 60-69 Segments 90-100	Endogenous Endogenous Endogenous Endogenous	Wet wt. 200 mg. 200 mg. 200 mg. 200 mg.			Clitellate worms Clitellate worms Clitellate worms Clitellate worms				0.053 ^a 0.026 ^a 0.041 ^a 0.076 ^a	All assays: Segmenta- tion approximate		
	27	Warburg	Body wall: Homogenate Segments 1-9 Segments 10-19 Segments 30-34 (clitellum) Segments 35-40 Segments 55-60 Segments 100-110	Succinate + cytochrome c Succinate + cytochrome c Succinate + cytochrome c Succinate + cytochrome c Succinate + cytochrome c				Clitellate worms Clitellate worms Clitellate worms Clitellate worms Clitellate worms				1.020 ^a 0.870 ^a 0.700 ^a 0.660 ^a 0.550 ^a 0.860 ^a	All assays: Segmenta- tion approximate		

^aEstimated or calculated from available data.^bInitial concentration.^cFinal concentration.^dIncrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.¹ $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$ ² $-\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$ ³Moles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).⁴ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$ ⁵ $\Delta \log [\text{CyFe}^{++}] / \text{min.}$ ⁶Activity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$ ⁷Activity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t (\text{min.})}$ ⁸ $\mu\text{moles cytochrome } c \text{ reduced (mg. N)}^{-1} \text{ min.}^{-1}$ ⁹ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{ min.}^{-1}$ ¹⁰ $\mu\text{moles cytochrome } c \text{ oxidized (mg. N)}^{-1} \text{ min.}^{-1}$ ¹¹Moles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-7} \text{ cm.}^2 / \text{mol.}$.)¹²O. D. of clear supernatant when measured at 520 m μ .¹³ $\Delta \text{O. D.} / \text{mg. protein} / \text{min.}$ ¹⁴Moles DPN reduced/g. wet wt./hr.¹⁵Additional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE		
	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram			Enzymatic Activity				
									Nitrogen	Protein	Wet Weight				Dry Weight	
<i>Lumbricus terrestris</i> Earthworm or night crawler	15-18	Barcroft	Body wall: Slices	Endogenous	83 mg. dry wt.	32 (2 per exp.)		Large worms (2.5-5 g.)				0.632 ^a		In gas mixture of 20% O ₂ and 80% N ₂	Johnson (1942)	
			Body wall: Slices	Endogenous	83 mg. dry wt.	32 (2 per exp.)		Large worms (2.5-5 g.)					0.685 ^a			In gas mixture of 20% O ₂ , 20% CO ₂ , and 60% N ₂
<i>Octolasion cyaneum</i> Blue worm	27	Warburg	Body wall: Mince Segments 1-9 Segments 35-40 Segments 55-60 Segments 100-110	Succinate + cytochrome c Succinate + cytochrome c Succinate + cytochrome c Succinate + cytochrome c				Clitellate worms Clitellate worms Clitellate worms Clitellate worms				0.55 ^a 0.34 ^a 0.41 ^a 0.52 ^a		All assays: Segmenta- tion approximate	O'Brien (1957) ^t	
			Body wall: Homogenate Segments 1-9 Segments 35-40 Segments 55-60 Segments 100-110	Succinate + cytochrome c Succinate + cytochrome c Succinate + cytochrome c Succinate + cytochrome c				Clitellate worms Clitellate worms Clitellate worms Clitellate worms					0.680 ^a 0.410 ^a 0.420 ^a 0.590 ^a			All assays: Segmenta- tion approximate
Earthworm (Sci. name not given)	Not specified	Microrespi- rometer	Ventral nerve cord	Endogenous								0.372 ^a		R.Q. 0.8-0.9	Winterstein and Basoglu (1939)	
Leech (Sci. name not given)	20-22	Polarograph	Smooth muscle of back: Fragments	Endogenous								0.096 ^a		Muscle at rest	Brecht, Behrens, and Bartels (1954) ^t	
ARTHROPODA																
Merostomata																
<i>Limulus polyphemus</i> Horseshoe crab	25	Warburg	Cardiac ganglion	Endogenous	100 mg. wet wt. (5 + gan- glia pooled)							0.104		Mean resting value from 3 experiments	Dann and Gardner (1930)	
			Cardiac ganglion	Endogenous	100 mg. wet wt. (5 + gan- pooled)								0.114			Mean resting value from 3 experiments
<i>Limulus polyphemus</i> Horseshoe crab	24	Warburg	Claw nerve	Endogenous								0.082 ^a			Chang (1931)	
<i>Limulus polyphemus</i> Horseshoe crab	31	Differential volumeter (see Gerard and Hartline (1934))	Optic nerve: Pieces Proximal 1/5	Endogenous		2	♂					0.101 ^a			Guttman (1935) ^t	
			Medial 1/5	Endogenous		2	♂						0.118 ^a			
			Distal 1/5	Endogenous		2	♂						0.082 ^a			
	28	(Same as above)	Optic nerve: Pieces Proximal 1/5	Endogenous		2	♂						0.067 ^a			
			Medial 1/5	Endogenous		2	♂						0.076 ^a			
			Distal 1/5	Endogenous		2	♂						0.050 ^a			
16	(Same as above)	Optic nerve: Pieces Proximal 1/5	Endogenous		2	♂						0.032 ^a				
		Medial 1/5	Endogenous		5	♂						0.022 ^a				
		Distal 1/5	Endogenous		5	♂						0.018 ^a				

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

^f $\Delta \log [\text{cytochrome c}] / \text{mg. wet wt.} / \text{min.}$

^g $-\Delta \log [\text{ferricytochrome c}] / \text{mg. protein} / \text{min.}$

^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).

ⁱ $\Delta \log [\text{ferricytochrome c}] / \text{mg. protein} / \text{min.}$

^j $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$.

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome c}]}{\Delta t (\text{min.})}$.

^m $\mu\text{moles cytochrome c reduced (mg. N)}^{-1} \text{min.}^{-1}$

ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{min.}^{-1}$

^o $\mu\text{moles cytochrome c oxidized (mg. N)}^{-1} \text{min.}^{-1}$

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-3} \text{ cm.}^2 / \text{mol.}$).

^qO. D. of clear supernatant when measured at 520 $\mu\text{m.}$

^r $\Delta \text{O. D.} / \text{mg. protein} / \text{min.}$

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

TABLE OF RESPIRATORY RATES OF INVERTEBRATE TISSUES

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE		
	Temp. ° C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity	
									Nitrogen	Protein	Wet Weight	Dry Weight				
<i>Limulus polyphemus</i> Horseshoe crab	24	Differential volumeter (see Gerard and Hartline, 1934)	Optic nerve: Pieces Axon: Proximal 1/5 Medial 1/5 Distal 1/5	Endogenous		8	♂♂♂	Adult			0.107 ^a				Shapiro (1937) ^t	
				Endogenous		8		Adult		0.110 ^a						
				Endogenous		8		Adult		0.086 ^a						
			Sheath: Proximal 1/5 Medial 1/5 Distal 1/5	Endogenous	8	♂♂♂	Adult		0.035 ^a							
				Endogenous	8		Adult		0.036 ^a							
				Endogenous	8		Adult		0.031 ^a							
	20		(Same as above)	Retina	Endogenous							0.129 ^a				
	24		(Same as above)	Forebrain	Endogenous							0.134 ^a				
24	(Same as above)	Foregut	Endogenous							0.123 ^a						
24	(Same as above)	Muscle	Endogenous							0.036 ^a						
<i>Limulus polyphemus</i> Horseshoe crab	28	Not specified	Heart: Slices	Endogenous								2.1	Gas phase: O ₂	Barron (1958)		
Crustacea																
<i>Astacus</i> sp. Crayfish	16	Warburg; also differential manometer	Nerve	Endogenous	2.72 mg. dry wt.	1							0.77	Nerve unstimulated; in Ringer's solution Δ f.p. = -0.8° C.	Meyerhof and Schulz (1929)	
<i>Callinectes sapidus</i> Blue crab	26	Fenn (modified)	Claw nerve	Endogenous	36 ^a mg. wet wt.	11							0.136 ^a	Mean value for 19 claw nerves Mean value for 20 claw nerves Mean value for 11 claw nerves Mean value for 11 leg nerves	Lindeman (1939)	
	20	(Same as above)	Claw nerve	Endogenous	34 ^a mg. wet wt.	11							0.105 ^a			
	20	(Same as above)	Claw nerve	Endogenous		11							0.099 ^a			
	20	(Same as above)	Leg nerve (1st walking leg)	Endogenous		11							0.156 ^a			
<i>Callinectes sapidus</i> Blue crab	27	Warburg	Gill	Endogenous		40	♂ + ♀						0.351 ^a		Vernberg (1956)	
			Gill	Endogenous		15		0.345 ^a								
			Gill	Endogenous		25		0.357 ^a								
			Midgut gland	Endogenous		48		0.734 ^a								
			Midgut gland	Endogenous		15		0.626 ^a								
			Midgut gland	Endogenous		33		0.782 ^a								
<i>Carcinus maenas</i> (formerly <i>Carcinides maenas</i>) Green crab	24	Warburg	Gill	Endogenous		19							2.61 ^a	In artificial sea water (S=32‰) In brackish water (S=15‰) In NaCl solution	Pieh (1936) ^t	
			Gill	Endogenous		8	3.91 ^a									
			Gill	Endogenous		6	4.55 ^a									
<i>Carcinus maenas</i> (formerly <i>Carcinides maenas</i>) Green crab	20-25	Warburg	Muscle: Homogenate	Endogenous									0.010 ^a	All assays: Arbitrary selected pairs (bracketed) of simultaneous determinations on tissues prepared at same time Eyestalk extract added to homoge- nate	Scheer, Schwabe, and Scheer, (1952) ^t	
			Muscle: Homogenate	Succinate + cytochrome c				0.019 ^a								
			Muscle: Homogenate	Succinate + cytochrome c				0.015 ^a								
			Muscle: Homogenate	Succinate + cytochrome c				0.011 ^a								
			Muscle: Homogenate	Succinate + cytochrome c				0.010 ^a								
			Muscle: Homogenate	Succinate + cytochrome c				0.014 ^b								

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

¹Δ log [cytochrome c]/mg. wet wt./min.

²ε-Δ log [ferricytochrome c]/mg. protein/min.

^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).

ⁱΔ log [ferricytochrome c]/mg. protein/min.

^jΔ log [CyFe⁺⁺]/min.

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$.

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome c}]}{\Delta t (\text{min.})}$.

^mμ moles cytochrome c reduced (mg. N)⁻¹ min.⁻¹

ⁿμ moles DPNH oxidized (mg. N)⁻¹ min.⁻¹

^oμ moles cytochrome c oxidized (mg. N)⁻¹ min.⁻¹

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10° C. (extinction coefficient of reduced cytochrome c taken as 2.8 × 10⁻³ cm.²/mol.).

^qO. D. of clear supernatant when measured at 520 mμ.

^rΔ O. D./mg. protein/min.

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE
PHYLUM Class Scientific name Common name	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram					
									Nitrogen	Protein	Wet Weight	Dry Weight		
	20	Spectrophotometer	Leg and claw nerves: Mitochondria Mitochondria Mitochondria Mitochondria Mitochondria	Succinate ($8.3 \times 10^{-3} M^{a,c}$) Fumarate ($8.3 \times 10^{-3} M^{a,c}$) Malate ($8.3 \times 10^{-3} M^{a,c}$) Citrate ($8.3 \times 10^{-3} M^{a,c}$) α -Ketoglutarate ($8.3 \times 10^{-3} M^{a,c}$)						3.54 ^a 0.93 ^a 6.06 ^a 1.34 ^a 0.90 ^a 2.59 ^a 0.57 ^a 4.46 ^a 0.76 ^a 0.49 ^a 0.61 ^a			All assays: Cytochrome c ($8.3 \times 10^{-6} M^{a,c}$) present All assays: P/O ratios in original paper All assays: Protein determina- tion by method of Lowry <i>et al.</i> (1951)	
<i>Homarus gammarus</i> (formerly <i>Homarus vulgaris</i>) Lobster	20-25	Warburg	Muscle: Homogenate Muscle: Homogenate	Succinate + cytochrome c Succinate + cytochrome c			With eyestalks Without eyestalks				0.040 ^a 0.036 ^a		Arbitrarily selected pair of simultaneous determinations on tissues prepared at same time	Scheer, Schwabe, and Scheer (1952) [†]
Lobster (Sci. name not given)	Not specified 25 and 37 Not specified Not specified	Warburg Warburg Warburg	Muscle Midgut gland Midgut gland Midgut gland	Endogenous Endogenous Cytochrome c Cytochrome c + p-phenylenediamine							<0.01 0.08 0.14 ^a 0.54			Kermack, Lees, and Wood (1954) [†]
<i>Libinia dubia</i> Spider crab	27	Warburg	Gill Gill Gill Midgut gland Midgut gland Midgut gland	Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous		21 14 7 20 13 7	σ^a σ^a σ^a σ^a σ^a σ^a				0.214 ^a 0.208 ^a 0.266 ^a 0.346 ^a 0.354 ^a 0.391 ^a			Vernberg (1956)
<i>Libinia emarginata</i> Spider crab	23	Thunberg, modified (see Hopkins and Handford, 1943)	Claw nerve Claw nerve Claw nerve Claw nerve Claw nerve Claw nerve	Endogenous Endogenous Endogenous Endogenous Endogenous Endogenous	70 mg. wet wt. (nerves of 4 speci- mens pooled) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above)	8 ^a 36 ^a 8 ^a 24 ^a 8 ^a 4 ^a 12 ^a				0.116 ^a 0.0906 ^a 0.131 ^a 0.162 ^a 0.144 ^a 0.0697 ^a 0.0479 ^a		In sea water con- taining ca. 12 mM K ⁺ In artificial sea water with the following mM/liter of K ⁺ : 0 15 30 40 70 100	Shanes and Hop- kins (1948) [†]	

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

$\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$

$e - \Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$

^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).

$\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$

$\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t (\text{min.})}$

^m μ moles cytochrome c reduced (mg. N)⁻¹ min.⁻¹

ⁿ μ moles DPNH oxidized (mg. N)⁻¹ min.⁻¹

^o μ moles cytochrome c oxidized (mg. N)⁻¹ min.⁻¹

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-4} \text{ cm}^2 / \text{mol.}$).

^qO. D. of clear supernatant when measured at 520 μ .

^r Δ O. D./mg. protein/min.

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

TABLE OF RESPIRATORY RATES OF INVERTEBRATE TISSUES

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE	
PHYLUM Class Scientific name Common name	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
<i>Maja</i> sp. Spider crab	16	Warburg; also differential manometer	Leg nerve	Endogenous	12.93 ^a mg. dry wt.	4						0.87 ^a		Nerve unstimulated; in artificial sea water with urea and bicarbonate	Meyerhof and Schulz (1929)
			Leg nerve	Endogenous	22.93 ^a mg. dry wt.	5						1.12 ^a			
<i>Menippe mercenaria</i> Stone crab	27	Warburg	Gill	Endogenous		32						0.329 ^a			Vernberg (1956)
			Gill	Endogenous		16						0.310 ^a			
			Gill	Endogenous		16						0.348 ^a			
			Midgut gland	Endogenous		33						0.623 ^a			
			Midgut gland	Endogenous		20						0.618 ^a			
<i>Ocypode quadrata</i> (formerly <i>Ocypode albicans</i>) Ghost crab	27	Warburg	Gill	Endogenous		25						0.914 ^a			Vernberg (1956)
			Gill	Endogenous		11						9.945 ^a			
			Gill	Endogenous		14						0.885 ^a			
			Midgut gland	Endogenous		32						0.772 ^a			
			Midgut gland	Endogenous		17						0.782 ^a			
<i>Pachygrapsus crassipes</i> Striped shore crab	20	Scholander- Wennesland microrespiro- meter (see Wennesland, 1951)	Brain	Endogenous	13.4 mg. wet wt. (3 brains pooled)	6	♂	Adult				0.268 ^a		8.5 } 16.0 } 23.5 } Acclimat- ization temp. (°C.)	Roberts (1957)
			Brain	Endogenous	13.5 mg. wet wt. (3 brains pooled)	6	♂	Adult				0.258 ^a			
			Brain	Endogenous	12.5 mg. wet wt. (3 brains pooled)	7	♂	Adult				0.242 ^a			
			Leg muscle (teased)	Endogenous	293 mg. wet wt.	14	♂	Adult				0.0475 ^a		8.5 } 16.0 } 23.5 } Acclimat- ization temp. (°C.)	
			(Same as above)	Endogenous	291 mg. wet wt.	19	♂	Adult				0.0500 ^a			
			(Same as above)	Endogenous	297 mg. wet wt.	17	♂	Adult				0.0270 ^a			
			<i>Palaeomon squilla</i> (formerly <i>Leander adspersus</i>) Shrimp	20-25	Warburg	Muscle: Homogenate	Endogenous				With eyestalks				
(Same as above)	Succinate + cytochrome c							With eyestalks				0.013 ^a			
(Same as above)	Succinate + cytochrome c							With eyestalks				0.010 ^a			
(Same as above)	Succinate + cytochrome c							Without eyestalks				0.007 ^a			
(Same as above)	Succinate + cytochrome c							With eyestalks				0.004 ^a			
(Same as above)	Succinate + cytochrome c				With eyestalks				0.006 ^a						

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

^f $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$

^g $-\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$

^hMoles substrate converted/kilo protein/hour (For oxoplasm, protein = total protein; for sheath, protein of non-collagenous component).

ⁱ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$

^j $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t (\text{min.})}$

^m $\mu\text{ moles cytochrome } c \text{ reduced (mg. N)}^{-1} \text{ min.}^{-1}$

ⁿ $\mu\text{ moles DPNH oxidized (mg. N)}^{-1} \text{ min.}^{-1}$

^o $\mu\text{ moles cytochrome } c \text{ oxidized (mg. N)}^{-1} \text{ min.}^{-1}$

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-7} \text{ cm.}^2 / \text{mol.}$)

^qO. D. of clear supernatant when measured at 520 $\mu\mu$

^r $\Delta \text{ O. D.} / \text{mg. protein} / \text{min.}$

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE		
	Temp. ° C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity	
									Nitrogen	Protein	Wet Weight	Dry Weight				
<i>Pandalus borealis</i> Prawn	6	Not specified	Dorsal extensor abdominal muscle	Endogenous							0.038 ^a			Specimens from Kristineberg, Sweden Specimens from Kristineberg, Sweden	Fox and Wingfield (1937)	
	10	Not specified	(Same as above)	Endogenous							0.065 ^a					
<i>Pandalus montagui</i> Pink shrimp	6	Not specified	Dorsal extensor abdominal muscle	Endogenous							0.040 ^a			Specimens from Kristineberg, Sweden Specimens from Kristineberg, Sweden Specimens from Plymouth, England Specimens from Plymouth, England	Fox and Wingfield (1937)	
	10	Not specified	(Same as above)	Endogenous							0.070 ^a					
	10	Not specified	(Same as above)	Endogenous							0.077 ^a					
	16	Not specified	(Same as above)	Endogenous							0.094 ^a					
<i>Panopeus herbstii</i> Mud crab	27	Warburg	Gill	Endogenous		32	+O ₂					0.319 ^a				Vernberg (1956)
			Gill	Endogenous		17						0.314 ^a				
			Gill	Endogenous		15						0.325 ^a				
			Midgut gland	Endogenous		32						0.536 ^a				
			Midgut gland	Endogenous		18						0.565 ^a				
			Midgut gland	Endogenous		12						0.552 ^a				
<i>Panulirus argus</i> Spiny lobster	25	Warburg	Midgut gland	Endogenous		4						3.0			Robbie (1949) ^t	
			Leg nerve	Endogenous		5						1.1				
			Leg muscle	Endogenous		2						1.0				
<i>Pugettia producta</i> Kelp crab	15	Warburg	Midgut gland; Slices (Same as above) (Same as above)	Endogenous Endogenous Endogenous		61 28 33	+O ₂					1.73			Belding, Field, Weymouth, and Allen (1942) ^t	
												1.92				
												1.57				
<i>Sesarma cinereum</i> (formerly <i>Sesarma cinerea</i>) Marsh crab	27	Warburg	Gill	Endogenous		10					0.911 ^a			Vernberg (1956)		
			Midgut gland	Endogenous		14					0.357 ^a					
<i>Uca minax</i> Red-jointed fiddler crab	27	Warburg	Gill	Endogenous		33	+O ₂					0.373 ^a			Vernberg (1956)	
			Gill	Endogenous		26						0.359 ^a				
			Gill	Endogenous		7						0.422 ^a				
			Midgut gland	Endogenous		41						0.383 ^a				
			Midgut gland	Endogenous		32						0.419 ^a				
			Midgut gland	Endogenous		9						0.255 ^a				
<i>Uca pugilator</i> Fiddler crab	27	Warburg	Gill	Endogenous		27	+O ₂					0.550 ^a			Vernberg (1956)	
			Gill	Endogenous		15						0.613 ^a				
			Gill	Endogenous		12						0.471 ^a				
			Midgut gland	Endogenous		34						0.360 ^a				
			Midgut gland	Endogenous		24						0.401 ^a				
			Midgut gland	Endogenous		10						0.263 ^a				

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

¹ $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$

² $-\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$

³Moles substrate converted/kilo protein/hour (For oxoplasm, protein = total protein; for sheath, protein of non-collagenous component).

⁴ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$

⁵ $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t (\text{min.})}$

^m $\mu\text{moles cytochrome } c \text{ reduced (mg. N)}^{-1} \text{ min.}^{-1}$

ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{ min.}^{-1}$

^o $\mu\text{moles cytochrome } c \text{ oxidized (mg. N)}^{-1} \text{ min.}^{-1}$

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-7} \text{ cm}^2 / \text{mol.}$).

^qO. D. of clear supernatant when measured at 520 μm

^r $\Delta \text{O. D.} / \text{mg. protein} / \text{min.}$

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE		
	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity	
									Nitrogen	Protein	Wet Weight	Dry Weight				
Insecta																
<i>Acheta domesticus</i> (formerly <i>Gryllus domesticus</i>) House cricket	30	Fenn	Fat body: Residues (mitochondria)	α -Ketoglutarate			Nymph							30.6	Protein determination by method of Lowry <i>et al.</i> , (1951)	Young (1959) [†]
<i>Apis mellifera</i> Honeybee	37	Warburg	Flight muscle: Mitochondria (Same as above) (Same as above) (Same as above) (Same as above) (Same as above)	Citrate (1×10^{-3} M ^{a,c}) Iso Citrate (1.3×10^{-3} M ^{a,c}) α -Ketoglutarate (1×10^{-3} M ^{a,c}) Succinate (1×10^{-3} M ^{a,c}) Malate (1×10^{-3} M ^{a,c}) Fumarate (1×10^{-3} M ^{a,c})										3.7 ^a 3.6 ^a 1.8 ^a 3.0 ^a 2.6 ^a 2.9 ^a	All assays: Cytochrome <i>c</i> (2.7×10^{-5} M ^{a,c}) present All assays: Protein determina- tion by method of Weichselbaum (1946)	Hoskins, Chel- delin, and New- burgh (1959) [†]
<i>Belostoma</i> spp. Giant water bug	25	Volumetric micro- respirometer (see Scholander, 1942)	Flight muscle (teased) Leg muscle (coxal le- vator, teased)	Endogenous Endogenous	10-20 mg. wet wt. 10-20 mg. wet wt.	3 3	Adult Adult							1.16 0.308 1.43	In Wilder and Smith saline In Wilder and Smith saline	Pérez-González and Edwards (1954) [†]
<i>Blattella germanica</i> German cockroach	30	Fenn	Fat body: Residues (mitochondria)	α -Ketoglutarate			Nymph							10.0	Protein determination by method of Lowry <i>et al.</i> , (1951)	Young (1959) [†]
<i>Bombyx mori</i> Silkworm	30	Manometer	Midgut: Homogenate (Same as above) (Same as above) (Same as above) (Same as above) (Same as above)	Endogenous Endogenous Endogenous Succinate (0.045 M ^{a,c}) Cytochrome <i>c</i> (5.5×10^{-5} M ^{a,c}) + <i>p</i> -phenylenediamine (4.5×10^{-3} M ^{a,c})			5th instar larva 5th instar larva 5th instar larva 5th instar larva 5th instar larva 5th instar larva							27 ^a 68 ^a 46 ^a 32 ^a 12.3 ^a 29.4 ^a	In distilled water In sucrose (0.25 M) In NaCl (0.125 M) In KCl (0.125 M) All assays: Nitrogen determina- tion by micro- Kjeldahl procedure	Ito, Horie, and Ishikawa (1958) [†]
			Midgut: Mitochondria (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above)	Succinate (0.045 M ^{a,c}) Succinate (0.045 M ^{a,c}) Succinate (0.045 M ^{a,c}) Cytochrome <i>c</i> (5.5×10^{-5} M ^{a,c}) + <i>p</i> -phenylenediamine (4.5×10^{-3} M ^{a,c}) Cytochrome <i>c</i> (5.5×10^{-5} M ^{a,c}) + <i>p</i> -phenylenediamine (4.5×10^{-3} M ^{a,c}) Cytochrome <i>c</i> (5.5×10^{-5} M ^{a,c}) + <i>p</i> -phenylenediamine (4.5×10^{-3} M ^{a,c}) Cytochrome <i>c</i> (2.5×10^{-3} M ^{a,c}) Cytochrome <i>c</i> (2.5×10^{-5} M ^{a,c}) Succinate (0.01 M ^{a,c}) Fumarate (0.01 M ^{a,c}) Malate (0.01 M ^{a,c}) α -Ketoglutarate (0.01 M ^{a,c}) Citrate (0.01 M ^{a,c})			5th instar larva 5th instar larva 5th instar larva 5th instar larva 5th instar larva 5th instar larva 5th instar larva 5th instar larva 5th instar larva 5th instar larva 5th instar larva							15.6 ^a 14.0 ^a 25.8 ^a 139.4 ^a 37.5 ^a 161.3 ^a 31.5 14.4 229 158 122 101 35	Fractionating medium: ⁹ KCl (0.9%) Sucrose (0.25 M) KCl (0.9%) + EDTA (0.01 M) KCl (0.9%) Sucrose (0.25 M) KCl (0.9%) + EDTA (0.01 M) Without cyanide With cyanide (1×10^{-3} M) All assays: Nitrogen determina- tion by micro-Kjel- dahl procedure	

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome *c* per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome *c* per minute for 1:100 tissue dilution.

^f $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$

^g $-\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$

^hMoles substrate converted/kilo protein/hour (For axoplasm; protein = total protein; for sheath, protein of non-collagenous component).

ⁱ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$

^j $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t (\text{min.})}$

^m $\mu\text{moles cytochrome } c \text{ reduced (mg. N)}^{-1} \text{ min.}^{-1}$

ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{ min.}^{-1}$

^o $\mu\text{moles cytochrome } c \text{ oxidized (mg. N)}^{-1} \text{ min.}^{-1}$

^pMoles cytochrome *c* reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome *c* taken as 2.8×10^{-7} cm.²/mol.)

⁹O. D. of clear supernatant when measured at 520 $\mu\mu$.

[†] Δ O. D./mg. protein/min.

[‡]Moles DPN reduced/g. wet wt./hr.

^{††}Additional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE		
	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity	
									Nitrogen	Protein	Wet Weight	Dry Weight				
<i>Calliphora erythrocephala</i> Bluebottle fly	25	Differential manometer	Flight muscle: Sarcosomes	α-Ketoglutarate	Sarcosomal protein content: 1.0-1.5 mg. (Same as above)			Adult: 1-7 da.		18.6				All assays: P/O ratios in original paper All assays: Method of protein determination not specified	Lewis and Slater (1954) [†]	
			Flight muscle: Sarcosomes	α-Ketoglutarate				Adult: 8-10 da.								9.4
			Flight muscle: Sarcosomes	α-Ketoglutarate				Adult: 15-17 da.								12.0
<i>Calliphora erythrocephala</i> Bluebottle fly	25	Differential manometer	Flight muscle: Sarcosomes	α-Ketoglutarate	Sarcosomal protein content: 1.0-1.5 mg (Same as above)	5		Adult: 1-2 da.		17.4 ^a				All assays: P/O ratios in original paper All assays: Method of protein determination not specified	Slater and Lewis (1954) [†]	
			Flight muscle: Sarcosomes	α-Ketoglutarate				Adult: 9 da.								8.8 ^a
<i>Carpocapsa pomonella</i> (cited as <i>Cydia pomonella</i>) Codling moth	20	Warburg	Muscle	Endogenous		7	♀	Larva				0.972 ^a		R.Q. 1.17	Graham (1946) [†]	
			Muscle	Endogenous				Larva								0.785 ^a
			Muscle	Endogenous				Larva								
			Fat body	Endogenous				Larva								0.607 ^a
			Fat body	Endogenous				Larva								1.228 ^a
			Fat body	Endogenous				Larva								0.544 ^a
<i>Galleria mellonella</i> Greater wax moth	30	Fenn	Fat body: Residues (mitochondria)	α-Ketoglutarate				Larva		26.2				Protein determination by method of Lowry <i>et al.</i> (1951)	Young (1959) [†]	
			Fat body	Endogenous				Larva								1.100 ^a
			Fat body	Endogenous				Larva								
			Fat body	Endogenous				Larva								
			Fat body	Endogenous				Larva								
<i>Hyalophora cecropia</i> (formerly <i>Platysamia cecropia</i>) Cecropia moth	25	Warburg	Midgut: Washed homogenate (Same as above)	Succinate (0.013 M ^c) + cytochrome c (4.8 × 10 ⁻⁵ M ^c)				Larva		29				All assays: Method of nitrogen determination not specified Without malonate	Sanborn and Williams (1950) [†]	
			(Same as above)	Succinate (0.013 M ^c) + cytochrome c (4.8 × 10 ⁻⁵ M ^c)				Larva								20
			(Same as above)	Ascorbate (0.014 M ^c) + cytochrome c (1.6 × 10 ⁻⁴ M ^c)				Larva								424
			(Same as above)	Ascorbate (0.01 M ^c) + cytochrome c (1.6 × 10 ⁻⁴ M ^c)				Larva								306
<i>Hyalophora cecropia</i> (formerly <i>Platysamia cecropia</i>) Cecropia moth	25	Warburg	Wing	Endogenous		4	♀	Diapausing pupa				5.1		Harvey (MS b)		

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

^f $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$

^g $-\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$

^hMoles substrate converted/kilo protein/hour (For oxoplasm, protein = total protein; for sheath, protein of non-collagenous component).

ⁱ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$

^j $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t} (\text{min.})$

^mmμ moles cytochrome c reduced (mg. N)⁻¹ min.⁻¹

ⁿmμ moles DPNH oxidized (mg. N)⁻¹ min.⁻¹

^omμ moles cytochrome c oxidized (mg. N)⁻¹ min.⁻¹

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as 2.8 × 10⁻³ cm.²/mol.)

^qO. D. of clear supernatant when measured at 520 mμ.

^rΔ O. D./mg. protein/min.

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

TABLE OF RESPIRATORY RATES OF INVERTEBRATE TISSUES

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE					
PHYLUM Class Scientific name Common name	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity				
									Nitrogen	Protein	Wet Weight	Dry Weight							
<i>Hyalophora cecropia</i> (formerly <i>Platysamia cecropia</i>) Cecropia moth	Not specified	Spectropho- tometer	Wing epithelium: Homogenate (Same as above)	Succinate (0.01 M ^c) + cytochrome c (3 × 10 ⁻⁵ M ^c)		2-4		Unchilled pupae: Time after pupation: 2-3 da.						<4	All assays: For units of enzymatic acti- vity, see footnote m All assays: Nitrogen determination by method of Kabat and Mayer (1948) All assays: With KCN (1 × 10 ⁻³ M ^c)	Shappirio and Williams (1957b) ^f			
						6-12								10 wks.			<2		
			Wing epithelium: Homogenate (Same as above)	Succinate (0.01 M ^c) + cytochrome c (3 × 10 ⁻⁵ M ^c)		6-12		Chilled pupae: Length of chilling: 11 wks.										<6	
						6-12												36 wks.	16
			Wing epithelium: Homogenate (Same as above)	Succinate (0.01 M ^c) + cytochrome c (3 × 10 ⁻⁵ M ^c)		6-12		Pupae chilled for 11 wks. and then re- turned to 25°C.: Time after return: 1 da.										<4	
						6-12												5 da.	19
			Wing epithelium: Homogenate (Same as above)	Succinate (0.01 M ^c) + cytochrome c (3 × 10 ⁻⁵ M ^c)		2-4		Developing adults: Time after initiation of development: 2 da.										35	
						2-4												7 da.	58
						2-4												13-14 da.	74
						2-4												18-19 da.	130
			Wing epithelium: Homogenate (Same as above)	DPNH (7.5 × 10 ⁻⁵ M ^c)		6-12		Unchilled pupae: Time after pupation: 2-3 wks.										<8	
						6-12												10 wks.	<4
						6-12												2-3 wks.	96
			Wing epithelium: Homogenate (Same as above)	DPNH (7.5 × 10 ⁻⁵ M ^c) + cytochrome c (7.5 × 10 ⁻⁵ M ^c)		6-12		Unchilled pupae: Time after pupation: 2-3 wks.										51	
6-12	10 wks.																		
6-12	10 wks.																		
Wing epithelium: Homogenate (Same as above)	DPNH (7.5 × 10 ⁻⁵ M ^c)		6-12		Chilled pupae: Length of chilling: 5 wks.								<5						
			6-12										37 wks.	4					
			6-12										5 wks.	24					
Wing epithelium: Homogenate (Same as above)	DPNH (7.5 × 10 ⁻⁵ M ^c) + cytochrome c (7.5 × 10 ⁻⁵ M ^c)		6-12		Chilled pupae: Length of chilling: 5 wks.								93						
			6-12										37 wks.						
			6-12										37 wks.						
Wing epithelium: Homogenate (Same as above)	DPNH (7.5 × 10 ⁻⁵ M ^c)		2-4		Developing adults: Time after initiation of development: 2 da.								14						
			2-4										9 da.	19					
			2-4										18-19 da.	27					
			2-4										2 da.	180					
			2-4										9 da.	350					
			2-4										18-19 da.	240					

^aEstimated or calculated from available data.
^bInitial concentration.
^cFinal concentration.
^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.
^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

^f $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$
^g $-\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).
ⁱ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
^j $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++}) \times \text{final tissue dilution}}{\Delta t} \times \frac{100}{\text{initial concentration}}$
^lActivity/mg. protein when activity = $\frac{\Delta \log (\text{cytochrome } c)}{\Delta t (\text{min.})}$

^m $\mu\text{moles cytochrome } c \text{ reduced (mg. N)}^{-1} \text{ min.}^{-1}$
ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{ min.}^{-1}$
^o $\mu\text{moles cytochrome } c \text{ oxidized (mg. N)}^{-1} \text{ min.}^{-1}$
^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as 2.8 × 10⁻⁷ cm²/mol.).

^qO. D. of clear supernatant when measured at 520 $\mu\mu$.
^r $\Delta \text{O. D.} / \text{mg. protein} / \text{min.}$
^sMoles DPN reduced/g. wet wt./hr.
^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE		
PHYLUM Class Scientific name Common name	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity	
									Nitrogen	Protein	Wet Weight	Dry Weight				
			Wing epithelium: Homogenate	DPNH (7.5 × 10 ⁻⁵ M ^c) + cytochrome c (3 × 10 ⁻⁵ M ^c)		2-4		Unchilled pupae: Time after pupation: 2-3 da.					100	All assays: For units of enzymatic activity, see footnote m All assays: Nitrogen determination by method of Kabat and Mayer (1948) All assays: With KCN (1 × 10 ⁻³ M) With antimycin A (1.2 μg./ml.) (Same as above)		
			(Same as above)	(Same as above)		6-12		10 wks.					16			
			(Same as above)	(Same as above)		2-4		2-3 da.					63			
			(Same as above)	(Same as above)		6-12		10 wks.					10			
			Wing epithelium: Homogenate	DPNH (7.5 × 10 ⁻⁵ M ^c) + cytochrome c (3 × 10 ⁻⁵ M ^c)		6-12		Chilled pupae: Length of chilling: 5 wks.					56		With antimycin A (1.2 μg./ml.) (Same as above)	
			(Same as above)	(Same as above)		6-12		36 wks.					110			
			(Same as above)	(Same as above)		6-12		5 wks.					39			
			(Same as above)	(Same as above)		6-12		36 wks.					89			
			Wing epithelium: Homogenate	DPNH (7.5 × 10 ⁻⁵ M ^c) + cytochrome c (3 × 10 ⁻⁵ M ^c)		6-12		Pupae chilled for 11 wks. and then returned to 25°C.: Time after return: 1 da.					44		With antimycin A (1.2 μg./ml.) (Same as above)	
			(Same as above)	(Same as above)		6-12		5 da.					89			
			(Same as above)	(Same as above)		6-12		1 da.					35			
			(Same as above)	(Same as above)		6-12		5 da.					48			
			Wing epithelium: Homogenate	DPNH (7.5 × 10 ⁻⁵ M ^c) + cytochrome c (3 × 10 ⁻⁵ M ^c)		2-4		Developing adults: Time after initiation of development: 2 da.					52		With antimycin A (1.2 μg./ml.) (Same as above)	
			(Same as above)	(Same as above)		2-4		7 da.					270			
			(Same as above)	(Same as above)		2-4		13-14 da.					160			
			(Same as above)	(Same as above)		2-4		18-19 da.					440			
			(Same as above)	(Same as above)		2-4		2 da.					38			
			(Same as above)	(Same as above)		2-4		7 da.					220			
			(Same as above)	(Same as above)		2-4		13-14 da.					140			
			(Same as above)	(Same as above)		2-4		18-19 da.					100			

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

^f $\Delta \log [\text{cytochrome c}]/\text{mg. wet wt./min.}$

^g $-\Delta \log [\text{ferricytochrome c}]/\text{mg. protein/min.}$

^hMoles substrate converted/kilo protein/hour (For

oxoplasm, protein = total protein; for sheath, protein of non-collagenous component).

ⁱ $\Delta \log [\text{ferricytochrome c}]/\text{mg. protein/min.}$

^j $\Delta \log [\text{CyFe}^{++}]/\text{min.}$

^kActivity/mg. N when standard activity =

$$\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$$

^lActivity/mg. protein when activity =

$$\frac{\Delta \log [\text{cytochrome c}]}{\Delta t (\text{min.})}$$

^mmμ moles cytochrome c reduced (mg. N)⁻¹ min.⁻¹

ⁿmμ moles DPNH oxidized (mg. N)⁻¹ min.⁻¹

^omμ moles cytochrome c oxidized (mg. N)⁻¹ min.⁻¹

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as 2.8 × 10⁻⁴ cm²/mol.).

^qO. D. of clear supernatant when measured at 520 mμ

^rΔ O. D./mg. protein/min.

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE	
	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
			Wing epithelium: Homogenate (Same as above)	Cytochrome c (2 × 10 ⁻⁶ M ^c) (Same as above)		2-4 6-12		Unchilled pupae: Time after pupation: 2-3 da. 10 wks.					520 270	All assays: For units of enzymatic activity, see footnote o All assays: Nitrogen determination by method of Kabat and Mayer (1948)	
			Wing epithelium: Homogenate (Same as above)	Cytochrome c (2 × 10 ⁻⁵ M ^c) (Same as above)		6-12 6-12		Chilled pupae: Length of chilling: 11 wks. 36 wks.					1200 220		
			Wing epithelium: Homogenate (Same as above)	Cytochrome c (2 × 10 ⁻⁵ M ^c) (Same as above)		6-12 6-12		Pupae chilled for 11 wks. and then returned to 25° C.: Time after return: 1 da. 5 da.					360 890		
			Wing epithelium Homogenate (Same as above)	Cytochrome c (2 × 10 ⁻⁵ M ^c) (Same as above)		2-4 2-4 2-4 2-4		Developing adults: Time after initiation of development: 2 da. 7 da. 13-14 da. 18-19 da.					1000 2000 1200 1400		
<i>Hydrophilus ater</i> Water scavenger beetle	25	Volumetric microrespirometer (see Scholander 1942)	Flight muscle (teased) Leg muscle (coxal levator, teased)	Endogenous Endogenous	10-20 mg. wet wt. 10-20 mg. wet wt.	6 6		Adult Adult			1.91 0.416	5.71 1.91		In Wilder and Smith saline In Wilder and Smith saline	Pérez-González and Edwards (1954) ^t
<i>Leucophaea maderae</i> Madeira cockroach	38	Warburg	Thoracic muscle: Homogenate (Same as above)	Succinate (0.2 M) + cytochrome c (2 × 10 ⁻⁵ M ^c) Cytochrome c (8.7 × 10 ⁻⁵ M ^c) + ascorbic acid (0.0114 M ^c)			♀ ♀	Adult: Various ages Adult: 30 da.					199 1770		McShan, Kramer, and Schlegel (1954) ^t
<i>Leucophaea maderae</i> Madeira cockroach	26	Warburg	Thoracic muscle (teased) (Same as above) (Same as above) (Same as above)	Endogenous Endogenous Endogenous Endogenous	ca. 150 mg. wet wt. ca. 150 mg. wet wt. ca. 150 mg. wet wt. ca. 150 mg. wet wt.	11 10 18 18	♂ ♀ With corpora allata Without corpora allata	Adult Adult Adult Adult					3.25 3.35 3.50 4.26	In Belar's solution (Same as above) (Same as above) (Same as above)	Samuels (1956)
<i>Locusta migratoria</i> Migratory locust	32	Manometer	Muscle: Suspension (Same as above) Sarcosomes	Endogenous Succinate (0.033 M ^c) + cytochrome c (1 × 10 ⁻⁵ M ^c) Succinate (0.033 M ^c) + cytochrome c (1 × 10 ⁻⁵ M ^c)	Tissue equiv. to 1 mg. N Tissue equiv. to 1 mg. N Sarcosomes equiv. to 0.3 mg. N		♂ ♂ ♂	Adult Adult Adult	40 ^a -150 ^a 320 ^a 1093 ^a					All assays: P/O ratios in original paper All assays: Method of nitrogen determination not specified	Rees (1954) ^t

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

¹ $\Delta \log [\text{cytochrome c}] / \text{mg. wet wt.} / \text{min.}$

² $-\Delta \log [\text{ferricytochrome c}] / \text{mg. protein} / \text{min.}$

³Moles substrate converted/kilo protein/hour (For assay, protein = total protein; for sheath, protein of non-collagenous component).

⁴ $\Delta \log [\text{ferricytochrome c}] / \text{mg. protein} / \text{min.}$

⁵ $\Delta \log [\text{CyFe}^{+3}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{+3})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome c}]}{\Delta t (\text{min.})}$

^mmμ moles cytochrome c reduced (mg. N)⁻¹ min.⁻¹

ⁿmμ moles DPNH oxidized (mg. N)⁻¹ min.⁻¹

^omμ moles cytochrome c oxidized (mg. N)⁻¹ min.⁻¹

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10° C. (extinction coefficient of reduced cytochrome c taken as 2.8 × 10⁻⁴ cm.²/mol.).

^qO. D. of clear supernatant when measured at 520 mμ.

^rΔ O. D./mg. protein/min.

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

TABLE OF RESPIRATORY RATES OF INVERTEBRATE TISSUES

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE	
PHYLUM Class Scientific name Common name	Temp. ° C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram		Enzymatic Activity				
									Nitrogen	Protein		Wet Weight	Dry Weight		
<i>Melanoplus differentialis</i> Differential locust	23	Differential volumeter (see Rotta and Stannard, 1939)	Muscle of hind femur	Endogenous		29		Adult			0.197 ^a			R.Q. 0.82	Gilmour (1941)
<i>Melanoplus femur-rubrum</i> Red-legged grass-hopper	23	Differential volumeter (see Rotta and Stannard, 1939)	Muscle of hind femur	Endogenous		26		Adult			0.180 ^a				Gilmour (1941)
<i>Musca domestica</i> House fly	25	Warburg	Muscle: Homogenate	Endogenous	10-15 mg. dry wt./ml.		♂ ♀	Adult			4.0			All assays: Cytochrome c (2.5 × 10 ⁻⁸ M ^{a,c}) present	Sacktor (1955) ^t
			(Same as above)	Hexoses (0.13 M ^{a,c})	(Same as above)			Adult		7.8					
			Muscle: Soluble fraction (sarcoplasm)	Endogenous				Adult		0.6 ^a					
			Muscle: Particulate fraction	Endogenous	Equiv. to 10-15 mg. dry wt./ml.			Adult		0.8 ^a					
			(Same as above)	Succinate (0.13 M ^{a,c})	(Same as above)			Adult		5.3 ^a					
(Same as above)	Fumarate (0.13 M ^{a,c})	(Same as above)	Adult		8.3 ^a										
<i>Periplaneta americana</i> American cockroach	25	Warburg	Leg muscle (teased)	Endogenous	ca. 200 mg. wet wt.	10	♂	Adult			5.04			In Belar-phosphate buffer (Same as above) R.Q. 0.96 ^a . In Belar-phosphate buffer R.Q. 0.99 ^a . In Belar-phosphate buffer In Belar-phosphate buffer (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above)	Barron and Tahmisiyan (1948) ^t
			(Same as above)	Endogenous	ca. 200 mg. wet wt.	16	♀	Adult			2.62				
			(Same as above)	Glucose (0.01 M ^c)	ca. 200 mg. wet wt.	16	♂	Adult			5.14				
			(Same as above)	Glucose (0.01 M ^c)	ca. 200 mg. wet wt.	18	♀	Adult			3.56				
			(Same as above)	Pyruvate (0.01 M ^c)	ca. 200 mg. wet wt.		♂	Adult			8.2				
			(Same as above)	Pyruvate (0.01 M ^c)	ca. 200 mg. wet wt.		♀	Adult			4.2				
			(Same as above)	Citrate (0.01 M ^c)	ca. 200 mg. wet wt.		♂	Adult			5.6				
			(Same as above)	Citrate (0.01 M ^c)	ca. 200 mg. wet wt.		♀	Adult			3.6				
			(Same as above)	α-Ketoglutarate (0.01 M ^c)	ca. 200 mg. wet wt.		♂	Adult			8.9				
			(Same as above)	α-Ketoglutarate (0.01 M ^c)	ca. 200 mg. wet wt.		♀	Adult			5.5				
			(Same as above)	Malate (0.01 M ^c)	ca. 200 mg. wet wt.		♂	Adult			8.3				
			(Same as above)	Malate (0.01 M ^c)	ca. 200 mg. wet wt.		♀	Adult			5.9				
			(Same as above)	Succinate (0.01 M ^c)	ca. 200 mg. wet wt.		♂	Adult			12.8				
(Same as above)	Succinate (0.01 M ^c)	ca. 200 mg. wet wt.		♀	Adult			5.4							

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

^f $\Delta \log [\text{cytochrome c}]/\text{mg. wet wt.}/\text{min.}$

^g $-\Delta \log [\text{ferricytochrome c}]/\text{mg. protein}/\text{min.}$

^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).

ⁱ $\Delta \log [\text{ferricytochrome c}]/\text{mg. protein}/\text{min.}$

^j $\Delta \log [\text{CyFe}^{+2}]/\text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{+2})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$.

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome c}]}{\Delta t (\text{min.})}$.

^m $\mu\text{moles cytochrome c reduced (mg. N)}^{-1} \text{min.}^{-1}$

ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{min.}^{-1}$

^o $\mu\text{moles cytochrome c oxidized (mg. N)}^{-1} \text{min.}^{-1}$

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-4} \text{ cm}^2/\text{mol.}$).

^qO. D. of clear supernatant when measured at 520 $\mu\mu$.

^r $\Delta \text{O. D.}/\text{mg. protein}/\text{min.}$

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

TABLE OF RESPIRATORY RATES OF INVERTEBRATE TISSUES

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE	
PHYLUM Class Scientific name Common name	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
<i>Periplaneta americana</i> American cockroach	Not specified	Spectropho- tometer	Homogenate of:	Cytochrome <i>c</i> (1.3×10^{-5} M ^{a,c})		10	♂	Adult					2.11	All assays: For units of enzymatic acti- vity, see footnote k All assays: Nitrogen determination by modified micro-Kjel- dahl procedure (see Folin and Farmer, 1912)	Sacktor and Boden- stein (1952) ^l
			Nerve cord	(Same as above)		10	♂	Adult					3.38		
			Brain	(Same as above)		10	♂	Adult					6.80		
			Muscle	(Same as above)		10	♂	Adult					2.55		
			Heart	(Same as above)		10	♂	Adult					0.87		
			Fat body	(Same as above)		10	♂	Adult					1.39		
			Testes	(Same as above)		10	♂	Adult					0.36		
			Accessory glands	(Same as above)		10	♂	Adult					2.02		
			Foregut	(Same as above)		10	♂	Adult					2.38		
			Midgut	(Same as above)		10	♂	Adult					4.08		
Hindgut	(Same as above)		10	♂	Adult					1.44					
Malpighian tubules	(Same as above)		10	♂	Adult										
<i>Periplaneta americana</i> American cockroach	38	Warburg	Coxal muscle: Homogenate	Succinate (0.0187 M)	3 mg. wet wt.		♂	Adult: 2-4 mo.				158		Cytochrome <i>c</i> (3.2×10^{-5} M) present (Same as above) (Same as above)	Harvey and Beck (1953) ^l
			(Same as above)	Succinate (0.187 M)	3 mg. wet wt.		♂	Adult: 2-4 mo.				302			
			(Same as above)	Succinate (0.187 M) + malonate (3.3×10^{-4} M)	3 mg. wet wt.		♂	Adult: 2-4 mo.				207			
			Coxal muscle: Homogenate	Cytochrome <i>c</i> (0.8×10^{-5} M)	3 mg. wet wt.		♂	Adult: 2-4 mo.				231			
			(Same as above)	Cytochrome <i>c</i> (9.4×10^{-5} M)	3 mg. wet wt.		♂	Adult: 2-4 mo.				274			
			Coxal muscle: Homogenate	Succinate (0.11 M) + cytochrome <i>c</i> (3.2×10^{-5} M)	3 mg. wet wt.		♂	Adult: 2-4 mo.				261			
			(Same as above)	(Same as above)	3 mg. wet wt.		♂	Adult: 2-4 mo.				249			
			(Same as above)	(Same as above)	3 mg. wet wt.		♂	Adult: 2-4 mo.				162			
(Same as above)	(Same as above)	3 mg. wet wt.		♂	Adult: 2-4 mo.				8						
Coxal muscle: Homogenate	Succinate (0.1 M)	3 mg. wet wt.		♂	Adult: 2-4 mo.				187						
(Same as above)	Cytochrome <i>c</i> (4.78×10^{-5} M) + ascorbate (0.026 M ^b)	0.75 mg. wet wt.		♂	Adult: 2-4 mo.				1520						
<i>Periplaneta americana</i> American cockroach	30	Warburg	Leg muscle: Homogenate	Succinate (0.025 - 0.05 M) + cytochrome <i>c</i> (1×10^{-5} M)		14	♂	Adult: 10-20 da.	648		14.5		All assays: Nitrogen determination by method of Ma and Zuazaga (1942)	Allen and Richards (1954) ^l	
			(Same as above)	(Same as above)		12	♀	Adult: 10-20 da.	167		3.4				
			(Same as above)	(Same as above)		6	♂	Adult: 95-185 da.	638		16.2				
			(Same as above)	(Same as above)		7	♀	Adult: 95-185 da.	172		3.8				
<i>Periplaneta americana</i> American cockroach	27	Warburg	Four coxal muscles: Homogenate	Cytochrome <i>c</i> (8.4×10^{-5} M ^{a,c}) + ascorbate (0.4 M ^{a,c})	30 mg. wet wt. (10 mg. dry wt.)	50	♂				3.6 ^a 6.6 ^a		Morrison and Brown (1954) ^l		
<i>Periplaneta americana</i> American cockroach	25	Volumetric micro- respirometer (see Scholander, 1942)	Flight muscle (teased)	Endogenous	10-20 mg. wet wt.	3	♂	Adult			1.88	7.30	In Wilder and Smith saline (Same as above) (Same as above) (Same as above)	Pérez-González and Edwards (1954) ^l	
			(Same as above)	Endogenous	10-20 mg. wet wt.	3	♀	Adult			1.21	4.54			
			Leg muscle (coxal levator, teased)	Endogenous	10-20 mg. wet wt.	5	♂	Adult			1.55	6.2			
			(Same as above)	Endogenous	10-20 mg. wet wt.	3	♀	Adult			1.04	4.41			

^aEstimated or calculated from available data.^bInitial concentration.^cFinal concentration.^dDecrease in log of molar concentration of oxidizedcytochrome ϵ per minute for 1:150 tissue dilution.^eDecrease in log of molar concentration of reducedcytochrome ϵ per minute for 1:100 tissue dilution.^f $\Delta \log$ [cytochrome ϵ]/mg. wet wt./min.^g $-\Delta \log$ [ferricytochrome ϵ]/mg. protein/min.^hMoles substrate converted/kilo protein/hour (For

axoplasm, protein = total protein; for sheath,

protein of non-collagenous component).

ⁱ $\Delta \log$ [ferricytochrome ϵ]/mg. protein/min.^j $\Delta \log$ [CyFe³⁺]/min.^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{3+})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$ ^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } \epsilon]}{\Delta t (\text{min.})}$ ^m $\mu\text{moles cytochrome } \epsilon \text{ reduced (mg. N)}^{-1} \text{ min.}^{-1}$ ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{ min.}^{-1}$ ^o $\mu\text{moles cytochrome } \epsilon \text{ oxidized (mg. N)}^{-1} \text{ min.}^{-1}$ ^pMoles cytochrome ϵ reduced/mg. tissue/5 min. at

10°C. (extinction coefficient of reduced cyto-

chrome ϵ taken as $2.8 \times 10^{-3} \text{ cm.}^2/\text{mol.}$)^qO. D. of clear supernatant when measured at 520 m μ ^r Δ O. D./mg. protein/min.^sMoles DPN reduced/g. wet wt./hr.^tAdditional respiratory data on invertebrate tissues

present in original paper and not included in

Section 2.

TABLE OF RESPIRATORY RATES OF INVERTEBRATE TISSUES

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE	
PHYLUM Class Scientific name Common name	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
<i>Periplaneta americana</i> American cockroach	"Room temp."	Spectropho- tometer	Leg muscle: Homogenate	Cytochrome c				Adult					0.156	All assays: For units of enzymatic acti- vity, see footnote j Homogenate diluted 1:10,000 Homogenate (1:10,000) in alcohol (10%) Homogenate (1:10,000) in alcohol (10%) + DDT (1 × 10 ⁻³ M)	Ludwig, Barsa, and Cali (1955) ^t
			(Same as above)	Cytochrome c				Adult					0.174		
			(Same as above)	Cytochrome c				Adult					0.087		
<i>Periplaneta americana</i> American cockroach	Not specified	Spectropho- tometer	Homogenate of: Muscle	Cytochrome c (2 × 10 ⁻⁵ M) + succinate (1.5 × 10 ⁻⁴ M)		10	♂	Adult					0.177	All assays: For units of enzymatic acti- vity, see footnote l All assays: With KCN (1 × 10 ⁻³ M) All assays: Protein determination by method of Lowry <i>et al.</i> (1951) as modified by Sacktor, Thomas, Moser, and Block (1953)	Sacktor and Thomas (1955)
			Foregut	(Same as above)		10	♂	Adult					0.034		
			Midgut	(Same as above)		10	♂	Adult					0.045		
			Hindgut	(Same as above)		10	♂	Adult					0.125		
			Malpighian tubules	(Same as above)		20	♂	Adult					0.054		
			Fat body	(Same as above)		10	♂	Adult					0.063		
			Brain	(Same as above)		20	♂	Adult					0.033		
			Nerve cord	(Same as above)		10	♂	Adult					0.033		
			Homogenate of: Muscle	(Same as above)		10	♂	Adult					0.045		
			Foregut	(Same as above)		10	♂	Adult					0.054		
			Midgut	(Same as above)		10	♂	Adult					0.038		
			Hindgut	(Same as above)		10	♂	Adult					0.066		
			Malpighian tubules	(Same as above)		20	♂	Adult					0.029		
Fat body	(Same as above)		10	♂	Adult					0.049					
Brain	(Same as above)		20	♂	Adult					0.026					
Nerve cord	(Same as above)		10	♂	Adult					0.019					
<i>Periplaneta americana</i> American cockroach	25	Warburg	Metathorax	Endogenous		8	♂	Adult					0.63 ^a	} Same 4 animals	Kubišta (1956)
			Metathorax	Endogenous		6	♂	Adult					0.44 ^a		
			Metathorax	Endogenous		6	♂	Nymph					0.46 ^a		
			Prothorax	Endogenous		4	♂	Adult					0.88 ^a		
			Mesothorax	Endogenous		4	♂	Adult					0.80 ^a		
			Metathorax	Endogenous		4	♂	Adult					0.54 ^a		
			Abdomen	Endogenous		4	♂	Adult					0.61 ^a		
<i>Periplaneta americana</i> American cockroach	30	Warburg	Leg and wing muscle destined to be pigmented ("pink"); Homogenate	Succinate (0.05 M) + cytochrome c (1 × 10 ⁻⁵ M)	7.5 mg. wet wt.		♂	Adult: 1-5 da.				29		Brooks (1957) ^t	
			Leg and wing pigmented ("pink") muscle: Homogenate	Succinate (0.05 M) + cytochrome c (1 × 10 ⁻⁵ M)	7.5 mg. wet wt.		♂	Adult: 15-65 da.				68			
			Leg and wing non-pig- mented ("white") muscle: Homogenate	Succinate (0.05 M) + cytochrome c (1 × 10 ⁻⁵ M)	7.5 mg. wet wt.		♂	Adult: 1-60 da.				10.4			

^a Estimated or calculated from available data.

^b Initial concentration.

^c Final concentration.

^d Decrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^e Decrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

¹ $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$

² $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$

³ Moles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).

⁴ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$

⁵ $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^k Activity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \text{final tissue dilution} \times 100$

^l Activity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t} (\text{min.})$

^m $\mu\text{moles cytochrome } c \text{ reduced (mg. N)}^{-1} \text{ min.}^{-1}$
ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{ min.}^{-1}$
^o $\mu\text{moles cytochrome } c \text{ oxidized (mg. N)}^{-1} \text{ min.}^{-1}$
^p Moles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-3} \text{ cm}^2 \cdot \text{mol.}^{-1}$.)

^q O. D. of clear supernatant when measured at 520 $\mu\text{m.}$

^r $\Delta \text{O. D.} / \text{mg. protein} / \text{min.}$

^s Moles DPN reduced/g. wet wt. hr.

^t Additional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL		PROCEDURE				SPECIMEN			RESULTS				REMARKS	REFERENCE	
PHYLUM Class Scientific name Common name	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
			Leg and wing muscle anatomically identical with "pink" muscle of older adult males: Homogenate	Succinate (0.05 M) + cytochrome c (1 × 10 ⁻⁵ M)	7.5 mg. wet wt.		♀	Adult: 1-70 da.				13.0			
			Leg and wing pigmented ("pink"): muscle: Homogenate	Succinate (0.05 M) + cytochrome c (1 × 10 ⁻⁵ M)	7.5 mg. wet wt.		♂	Nymph				9.2			
<i>Periplaneta americana</i> American cockroach	Not specified	Warburg	Fat body: Homogenate (Same as above) Fat body: Mitochondria	Succinate + cytochrome c Ascorbate + cytochrome c Ascorbate + cytochrome c						53 150 ^a 700 ^a				All assays: Nitrogen determination by microdiffusion (see Conway, 1950)	Nelson (1958)
<i>Periplaneta americana</i> American cockroach	29-30	Spectrophotometer	Fat body: Homogenate Fat body: Homogenate	Malate Malate	10 µg. wet wt. 10 µg. wet wt.		♂ ♀	Nymph Nymph					1.63 × 10 ⁻³ 1.21 × 10 ⁻³	For units of enzymatic activity, see footnotes	Young (1958)
<i>Periplaneta americana</i> American cockroach	30	Warburg	Fat body: Homogenate (Same as above) Fat body: Residues (mitochondria) (Same as above)	Endogenous Succinate α-Ketoglutarate iso Citrate				Nymph Nymph Nymph Nymph		1.8 5.5 18.8 8.3				All assays: Protein determination by method of Lowry et al. (1951)	Young (1959) ^t
<i>Phormia regina</i> Black blow fly	25	Warburg	Muscle: Sarcosomes (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above) (Same as above)	Ascorbate + cytochrome c (Same as above) Succinate (0.013 M ^c) + cytochrome c (1 × 10 ⁻⁵ M ^c) (Same as above) Malate (0.04 M) + cytochrome c (4 × 10 ⁻⁵ M) (Same as above) Succinate (0.013 M ^c) + cytochrome c (1 × 10 ⁻⁵ M ^c) (Same as above)				Adult: 1 da. Adult: 3-22 da. Adult: 21 da. Adult: 26 da. Adult: 13 da. Adult: 19 da. Adult: 5 da. Adult: 9 da.	7900 ^a 4000 ^a - 4500 ^a 1172 1780 461 726 708 1420					All assays: Nitrogen determination by semimicro-Kjeldahl technique	Watanabe and Williams (1951) ^t
<i>Sarcophaga bullata</i> Fleshfly	30	Warburg	Thoracic muscle, including flight muscle: Homogenate (Same as above)	Succinate (0.05 M) + cytochrome c (1.5 × 10 ⁻⁵ M) (Same as above)	2.5-5.0 mg./ml. wet wt. (Same as above)	9 5	♂ ♀	Adult: 4-8 da. Adult: 4-8 da.	778 814		15.0 15.6			All assays: Nitrogen determination by method of Ma and Zuazaga (1942)	Allen and Richards (1954) ^t
<i>Sceliphron cementarius</i> Mud dauber wasp	38	Warburg	Flight muscle: Homogenate	Succinate (0.2 M ^c) + cytochrome c (2 × 10 ⁻⁵ M ^c)			♀	Adult				128			Kramer (1954)
<i>Schistocerca gregaria</i> Desert locust	10	Spectrophotometer	Fat body: Homogenate	DPNH (2.5 × 10 ⁻⁴ M) + cytochrome c (2.4 × 10 ⁻⁵ M ^a)									7 × 10 ⁻⁹	For units of enzymatic activity, see footnote p With KCN (9 × 10 ⁻⁴ M)	Kilby and Neville (1957) ^t

^a Estimated or calculated from available data.
^b Initial concentration.
^c Final concentration.
^d Decrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.
^e Decrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

^f $\Delta \log [\text{cytochrome } c] / \text{mg. wet wt.} / \text{min.}$
^g $-\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
^h Moles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).
ⁱ $\Delta \log [\text{ferricytochrome } c] / \text{mg. protein} / \text{min.}$
^j $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^k Activity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \frac{\text{final tissue dilution}}{100}$
^l Activity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome } c]}{\Delta t} (\text{min.})$

^m µ moles cytochrome c reduced (mg. N)⁻¹ min.⁻¹
ⁿ µ moles DPNH oxidized (mg. N)⁻¹ min.⁻¹
^o µ moles cytochrome c oxidized (mg. N)⁻¹ min.⁻¹
^p Moles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as 2.8 × 10⁻⁷ cm.²/mol.)

^q O. D. of clear supernatant when measured at 520 mµ.
^r Δ O. D./mg. protein/min.
^s Moles DPN reduced/g. wet wt./hr.
^t Additional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

ANIMAL PHYLUM Class Scientific name Common name	PROCEDURE					SPECIMEN			RESULTS				REMARKS	REFERENCE	
	Temp. °C.	Method and Apparatus	Tissue and Type of Preparation	Endogenous Respiration or Substrate Added	Amount of Tissue	No.	Sex	Stage, Size, or Age	Microliters of Oxygen per Hour per Milligram						Enzymatic Activity
									Nitrogen	Protein	Wet Weight	Dry Weight			
<i>Schistocerca infumata</i> South American locust	25	Volumetric microrespirometer (see Scholander, 1942)	Flight muscle (teased)	Endogenous	10-20 mg. wet wt.	4		Adult			1.67			In Wilder and Smith saline In Wilder and Smith saline	Pérez-González and Edwards (1954) ^t
			Leg muscle (coxal levator, teased)	Endogenous	10-20 mg. wet wt.	3		Adult			1.22				
<i>Tachycines asynamorus</i> (formerly <i>Diestramena japonica</i>) Japanese or green-house stone cricket	25	Warburg	Femur, intact	Endogenous		6					0.16 ^a			Gas phase: Air O ₂ O ₁	Kubišta (1956)
			Femur, intact	Endogenous		7					0.16 ^a				
			Femur, cut	Endogenous		7					0.23 ^a				
<i>Telea polyphemus</i> Polyphemus moth	25	Warburg	Wing	Endogenous		3	♀	Pupa				3.2		Harvey (MSb)	
<i>Tenebrio molitor</i> Yellow mealworm	30	Warburg	Flight and leg muscle: Homogenate (Same as above)	Succinate (0.25-0.75M) + cytochrome c (1.5-3 × 10 ⁻⁶ M) (Same as above)		10	♂	Adult: 15-30 da.	963		14.6			All assays: Nitrogen determination by method of Ma and Zuazaga (1942)	Allen and Richards (1954) ^t
						8	♀	Adult: 15-30 da.	1115		15.5				
<i>Tenebrio molitor</i> Yellow mealworm	30	Fenn	Fat body: Residues (mitochondria)	α-Ketoglutarate				Larva		61.8			Protein determination by method of Lowry <i>et al.</i> , (1951)	Young (1959) ^t	
ECHINODERMATA															
Holothuroidea															
<i>Isostichopus badionotus</i> (formerly <i>Stichopus mōbii</i>) Sea cucumber	25	Warburg	Intestine	Endogenous		12						0.7		Robbie (1949) ^t	
					Branchial tree	Endogenous		11					0.6		
<i>Thyone sp.</i> Sea cucumber	25	Warburg	Muscle: Thin sheets or slices	Glucose (0.011 M ^a)		30					0.0314 ^a			Villee, Lichtenstein, Nathanson, and Rolander (1950)	

^aEstimated or calculated from available data.

^bInitial concentration.

^cFinal concentration.

^dDecrease in log of molar concentration of oxidized cytochrome c per minute for 1:150 tissue dilution.

^eDecrease in log of molar concentration of reduced cytochrome c per minute for 1:100 tissue dilution.

¹ $\Delta \log [\text{cytochrome c}] / \text{mg. wet wt.} / \text{min.}$

^g $-\Delta \log [\text{ferricytochrome c}] / \text{mg. protein} / \text{min.}$

^hMoles substrate converted/kilo protein/hour (For axoplasm, protein = total protein; for sheath, protein of non-collagenous component).

¹ $\Delta \log [\text{ferricytochrome c}] / \text{mg. protein} / \text{min.}$

^j $\Delta \log [\text{CyFe}^{++}] / \text{min.}$

^kActivity/mg. N when standard activity = $\frac{\Delta \log (\text{CyFe}^{++})}{\Delta t} \times \text{final tissue dilution} \times 100$

^lActivity/mg. protein when activity = $\frac{\Delta \log [\text{cytochrome c}]}{\Delta t} (\text{min.})$

^m $\mu\text{moles cytochrome c reduced (mg. N)}^{-1} \text{min.}^{-1}$

ⁿ $\mu\text{moles DPNH oxidized (mg. N)}^{-1} \text{min.}^{-1}$

^o $\mu\text{moles cytochrome c oxidized (mg. N)}^{-1} \text{min.}^{-1}$

^pMoles cytochrome c reduced/mg. tissue/5 min. at 10°C. (extinction coefficient of reduced cytochrome c taken as $2.8 \times 10^{-2} \text{ cm.}^2 / \text{mol.}$)

^qO. D. of clear supernatant when measured at 520 $\mu\mu$

^r $\Delta \text{O. D.} / \text{mg. protein} / \text{min.}$

^sMoles DPN reduced/g. wet wt./hr.

^tAdditional respiratory data on invertebrate tissues present in original paper and not included in Section 2.

Section 3: ANALYSIS OF DATA

EFFECTS OF CERTAIN INHIBITORS ON RESPIRATORY RATE

2, 4-DINITROPHENOL (DNP)

Effect: Respiration maximally stimulated by the concentration of DNP that produces maximal inhibition of ciliary activity; this effect noted in:

Mollusca

Pelecypoda

Crassostrea virginica: Mantle; Maroney, Barber, and Wilbur, 1957

Mytilus: Gill; Weller and Ronkin, 1952

Effect: Rise in respiratory rate; this effect noted in:

Aschelminthes

Nematoda

Ascaris lumbricoides: Muscle; Chin and Bueding, 1954

Mollusca

Pelecypoda

Pinctada martensii: Gill; Kawai, 1957

Effect: Stability of rate of esterification of phosphate in suspension to which DNP has been added; suggests that the phosphorylations result from anaerobic reactions; this effect noted in:

Mollusca

Gastropoda

Helix pomatia: Midgut gland; Rees, 1953

CARBON MONOXIDE (CO)

Effect: Photoreversible inhibition of respiration, i.e., inhibition of respiration by CO in darkness but not in light; strongly suggests the involvement of cytochrome oxidase in the electron transport system; this effect noted in:

Mollusca

Pelecypoda

Crassostrea gigas: Gill, mantle; Kawai, 1958

Cephalopoda

Octopus macropus: Salivary gland; Ghiretti-Magaldi, Giuditta, and Ghiretti, 1958

CYANIDE

Effect: Inhibition of endogenous respiration; may indicate the involvement of cytochrome oxidase in the electron transport system; effect noted in:

Porifera

Demospongia

Cinachyra cavernosa, *Dysidea crawshayi*, *Geodia gibberosa*, *Ircinia fasciculata*, *Lissodendoryx isodictyalis*, *Pseudaxinella rosacea*, *Spheciospongia* sp., *Tedania ignis*, *Terpios fugax*, *Tethya aurantia*: Slices; Robbie, 1949

Coelenterata

Hydrozoa

Physalia physalis: Tentacles; Robbie, 1949

Anthozoa

Condylactis gigantea: Tentacles; Robbie, 1949

Gorgonia flabellum: Branches; Robbie, 1949

Plexaura flexuosa: Slices; Robbie, 1949

Mollusca

Pelecypoda

Crassostrea virginica: Mantle; Jodrey and Wilbur, 1955

Isognomon alata: Gill; Robbie, 1949

Mercenaria mercenaria: Gill, mantle, adductor muscle; Hopkins, 1949

Pinctada martensii: Gill; Kawai, 1957. Heart; Navez, Crawford, Benedict, and DuBois, 1941

Cephalopoda

Loligo pealeii: Gill; also retina, lens and "cornea" of eye; Robbie, 1949

Arthropoda

Crustacea

Panulirus argus: Leg nerve, leg muscle, midgut gland; Robbie, 1949

Effect: Inhibition of endogenous respiration and complete or partial reversal of this inhibition by methylene blue; suggests the involvement of cytochrome oxidase; this effect noted in:

Mollusca

Pelecypoda

Crassostrea gigas: Mantle, gill; Kawai, 1958

Cristaria plicata: Gill; Higashi and Kawai, 1959

Hyriopsis schlegelii: Gill; Higashi and Kawai, 1959

Arthropoda

Crustacea

Homarus americanus: Leg nerves and nerve cord; Chang, 1931

Effect: Inhibition of endogenous respiration by cyanide but the inhibition not reversible by methylene blue; suggests that some terminal oxidase other than cytochrome oxidase may be involved in electron transport; this effect noted in:

Mollusca

Pelecypoda

Crassostrea gigas: Gill; Okamura, 1959

Crassostrea virginica: Mantle; Jodrey and Wilbur, 1955

ANTIMYCIN A

Effect: Inhibition of respiration because the oxidation of succinate via the pathway involving the Slater factor is blocked; this effect noted in:

Arthropoda

Insecta

Hyalophora cecropia: Wing epithelium of pupa and adult, Shappirio and Williams, 1957b

Periplaneta americana: Coxal muscles of legs of adult; Harvey and Beck, 1953

COMPARISON OF RESPIRATORY RATES OF VARIOUS TISSUES

The following studies are concerned with the comparative endogenous respiratory rates of various tissues of invertebrates; *the results of no study are given here in their entirety.*

Mollusca

Gastropoda

Helix pomatia: Cerebral ganglion > midgut gland > muscle of foot; Kerkut and Laverack, 1957

Pelecypoda

Crassostrea gigas: Gill > heart > mantle; Kawai, 1959

Cristaria plicata: Gill > heart > mantle > adductor muscle; Higashi and Kawai, 1959

Gryphaea angulata: Gill > midgut gland > mantle > muscle; Chapheau, 1932

Hyriopsis schlegelii: Gill > heart > mantle > adductor muscle; Higashi and Kawai, 1959

Mercenaria mercenaria: Gill > mantle > muscle; Hopkins, 1946

Pinctada martensii: Gill > midgut gland > muscle of foot; Kawai, 1957

Cephalopoda

Octopus vulgaris: Optic ganglion > branchial heart > gill > central heart > midgut gland > mantle muscle; Ghiretti-Magaldi, Giuditta, and Ghiretti, 1958

Arthropoda

Merostomata

Limulus polyphemus: Forebrain > foregut > optic nerve (axon) > muscle > optic nerve (sheath); Shapiro, 1937

Crustacea

Callinectes sapidus: Midgut gland > gill; Vernberg, 1956

Clibinarius vittatus: Midgut gland > gill; Vernberg, 1956

Lobster (sci. name not given): Midgut gland > muscle; Kermack, Lees, and Wood, 1954

Libinia dubia: Midgut gland > gill; Vernberg, 1956

Menippe mercenaria: Midgut gland > gill; Vernberg, 1956

Ocyropode quadrata: Gill > midgut gland; Vernberg, 1956

Panopeus herbstii: Midgut gland > gill; Vernberg, 1956

Sesarma cinereum: Gill > midgut gland; Vernberg, 1956

Uca minax: Midgut gland > gill in male; gill > midgut gland in female; Vernberg, 1956

Uca pugilator: Gill > midgut gland; Vernberg, 1956

Insecta

Belostoma spp.: Flight muscle of adult > leg muscle; Pérez-González and Edwards, 1954

Hydrophilus ater: Flight muscle of adult > leg muscle; Pérez-González and Edwards, 1954

Periplaneta americana: Flight muscle of adult > leg muscle; Pérez-González and Edwards, 1954

Schistocerca infumata: Flight muscle of adult > leg muscle; Pérez-González and Edwards, 1954

SEX DIFFERENCES IN RESPIRATORY RATE

The following studies deal in part with the differences in respiratory rate between males and females; in some cases the differences are slight.

Arthropoda

Crustacea

Callinectes sapidus: Midgut gland, gill; female > male; Vernberg, 1956

Libinia dubia: Midgut gland, gill; female > male; Vernberg, 1956

Menippe mercenaria: Midgut gland, gill; female > male; Vernberg, 1956

Ocyropode quadrata: Midgut gland, gill; male > female; Vernberg, 1956

Panopeus herbstii: Midgut gland, male > female; gill, female > male; Vernberg, 1956

Pugettia producta: Midgut gland; male > female; Belding, Field, Weymouth, and Allen, 1942

Uca minax: Midgut gland, male > female; gill, female > male; Vernberg, 1956

Uca pugilator: Midgut gland, gill; male > female; Vernberg, 1956

Insecta

Carpocapsa pomonella: Muscle, fat body of larva; female > male; Graham, 1946

Leucophaea maderae: Thoracic muscle; rate of female approximately equal to rate of male; Samuels, 1956

Periplaneta americana: Leg muscle of adult; male > female; Barron and Tahmisian, 1948. Leg

muscle of adult; male > female; Allen and Richards, 1954. Flight and leg muscles of adult; male > female; Pérez-González and Edwards, 1954. Many tissues of adult; with exception of foregut, male > female; Sacktor and Thomas, 1955. Metathorax of adult; male > female; Kubišta, 1956. Fat body of nymph; male > female; Young, 1958
Sarcophaga bullata: Thoracic muscles of adult; female > male; Allen and Richards, 1954
Tenebrio molitor: Flight and leg muscles of adult; female > male; Allen and Richards, 1954

VARIATION IN RESPIRATORY RATE WITH AGE

Mollusca

Pelecypoda

Crassostrea virginica: Adductor muscle; decline in endogenous respiratory rate with age (from shell length of 5.0 cm. to one of 14.7 cm.); Hopkins, 1930
Gryphaea angulata: Mantle, gill, muscle, midgut gland; decline in endogenous respiratory rate with age (from 10-15 mos. to 6 yrs.); Chappeau, 1932
Mercenaria mercenaria: Posterior adductor muscle; decline in endogenous respiratory rate with age (from shell length of 6.5 cm. to one of 9 cm.); Hopkins, 1930. Adductor muscle, mantle, gill; decline in endogenous respiratory rate with age (from 2-6 yrs. to 7-20 yrs.), except respiratory rate of gill tissue of both size classes essentially the same during winter and spring; Hopkins, 1946

VARIATION IN RESPIRATORY RATE DURING CRUSTACEAN MOLT CYCLE

Arthropoda

Crustacea

Carcinus maenas: Muscle; cyanide-insensitive respiration (with added fructose) lowest just before ecdysis, then rising during ecdysis and in the post-ecdysial, soft-shelled stage, with maximum rate during intermolt; no oxygen uptake in the absence of fructose or glucose; Krishnan, 1954
Gecarcinus lateralis: Integumentary tissues; endogenous respiration just before ecdysis 1.6 times that during intermolt period; Skinner (MS.)

VARIATION IN RESPIRATORY RATE DURING INSECT LIFE CYCLE

Arthropoda

Insecta

Calliphora erythrocephala: Flight muscle; α -ketoglutaric oxidase activity relatively high during first seven days after adult emergence, lower during eighth to tenth day, then up again at 15 to 17 days; Lewis and Slater, 1954; Slater and Lewis, 1954
Hyalophora cecropia: Wing epithelium; fall in the activity of several enzymes within 24 hours of pupation, and then a marked rise in their activity during adult development; Shappirio and Williams, 1957b
Periplaneta americana: Leg muscle; no marked difference in respiratory activity between 10- to 20-day adults and 95- to 185-day adults; Allen and Richards, 1954
Periplaneta americana: Leg and wing muscle, pigmented ("pink") or destined to be pigmented; respiratory activity low in nymphs, higher in 1- to 5-day adults, and still higher in 15- to 65-day adults; Brooks, 1957
Phormia regina: Muscle; cytochrome oxidase activity higher in 1-day adults than in 3- to 22-day adults; activity of certain other enzymes higher in older than in younger adults; Watanabe and Williams, 1951

VARIATION IN RESPIRATORY RATE WITH SEASON

Mollusca

Pelecypoda

Mercenaria mercenaria: Gill, mantle, muscle; in general, endogenous respiratory rate highest in winter and early spring and lowest in August and September; Hopkins, 1946

Pinctada martensii: Gill; rise in endogenous respiratory rate from June to the middle of January; Kawai, 1957

VARIATION IN RESPIRATORY RATE WITH SALINITY

Mollusca

Pelecypoda

Mercenaria mercenaria: Gill, mantle, increase in endogenous respiratory rate with lowered salinity; adductor muscle, decrease in rate with lowered salinity; Hopkins, 1949

Arthropoda

Crustacea

Carcinus maenas: Gill; increase in endogenous respiratory rate with lowered salinity; Pieh, 1936

EFFECTS OF VARIOUS IONS ON RESPIRATORY RATE

Mollusca

Gastropoda

Helix aspersa: Heart; rise in endogenous respiratory rate with increasing concentration of K^+ ion, compared to the concentrations of Na^+ , Ca^{++} , and Mg^{++} ; Cardot, Faure, and Arvanitaki, 1950

Pelecypoda

Mytilus galloprovincialis: Ventricle of heart; same as above; Cardot, Faure, and Arvanitaki, 1950

Cephalopoda

Sepia officinalis: Nerve; same as above; Cardot, Faure, and Arvanitaki, 1950

Arthropoda

Crustacea

Libinia emarginata: Claw nerve; rise in endogenous respiratory rate with increasing concentration of K^+ ion to a maximum at 40 mM K^+ , then sharp drop in endogenous respiratory rate; Shanes and Hopkins, 1948

GRADIENT OF RESPIRATORY RATE ALONG LONG AXIS OF BODY

Annelida

Clitellata

Eisenia foetida: Viscera and body wall; U-shaped gradient in the endogenous respiratory rate and in succinoxidase activity along the long axis of the body; O'Brien, 1957

Octolasion cyaneum: Body wall; U-shaped gradient in succinoxidase activity; O'Brien, 1957

Arthropoda

Insecta

Periplaneta americana: Prothorax, mesothorax, metathorax, abdomen; decrease in endogenous respiratory rate from prothorax through metathorax, and then a rise in respiratory rate in abdomen; Kubiřta, 1956

GRADIENT OF RESPIRATORY RATE ALONG A NERVE

Arthropoda

Merostomata

Limulus polyphemus: Optic nerve; at 31° and 28° C., endogenous respiratory rate highest in

medial region of nerve, but at 16° C. rate highest in proximal region; endogenous respiratory rate at distal end lower than at proximal end; Guttman, 1935

Limulus polyphemus: Optic nerve; at 24° C., endogenous respiratory rate highest in medial region of nerve; gradient much more pronounced for axon than for sheath; Shapiro, 1937

RESPIRATORY RATE AFTER REMOVAL OF ENDOCRINE GLANDS

Arthropoda

Crustacea

Carcinus maenas: Muscle; respiration (with added succinate) lower after eyestalk removal, higher again after addition of eyestalk extract; Scheer, Schwabe, and Scheer, 1952

Carcinus maenas: Muscle; cyanide-insensitive respiration (with added fructose) much lower than its pre-surgical level three days after eyestalk removal; remains low (but shows a gradual slight increase in level) up to 15 days after surgery; Krishnan, 1954

Homarus gammarus: Muscle; respiration (with added succinate) lower after eyestalk removal; Scheer, Schwabe, and Scheer, 1952

Palaemon squilla: Muscle; respiration (with added succinate) lower after eyestalk removal, in some cases higher again after addition of eyestalk extract; Scheer, Schwabe, and Scheer, 1952

Insecta

Leucophaea maderae: Thoracic muscle; endogenous respiration of animals without corpora allata 1.2 times that of animals with corpora allata; Samuels, 1956

RESPIRATORY RATE FOLLOWING INJURY

Arthropoda

Insecta

Tachycines asynamorus: Muscles of hind femur; endogenous respiratory rate of cut muscles 1.4 times that of the intact muscles; Kubišta, 1956

Section 4: DISCUSSION

In Section 2, data on tissue respiration in invertebrates are presented; in Section 3 some of these data plus others from the same investigations are analyzed. In the present section we

discuss the broader implications of certain studies presented here and suggest some conclusions regarding invertebrate tissue respiration that may be drawn from them.

ENZYMES OF CITRIC ACID CYCLE

Respiratory activity of a tissue preparation, or fraction thereof, when measured in the presence of added substrate, can be attributed solely to an enzyme acting on the added substrate only if controls are included to indicate any increment of respiratory activity due to action of other enzymes on other substrates that may result from oxidation of the original substrate. For example, in order to determine the authentic α -ketoglutaric dehydrogenase activity of insect sarcosomes, one should measure, as did Lewis and Slater (1954), the respiratory rate of the preparation first in the presence of α -ketoglutarate and subsequently in the presence of α -ketoglutarate plus malonate, the latter being a substance that inhibits succinic dehydrogenase. One may then attribute a difference in respiratory rate to authentic α -ketoglutaric dehydrogenase activity (although one must still recognize the possibility that, with malonate present, accumulation of succinate may affect the rate at which α -ketoglutarate is oxidized).

Without controls such as described above, one may not necessarily conclude that, because a particular citric cycle substrate is metabolized, only the enzyme acting specifically upon that substrate is being assayed. Other components of the chain of enzymes may be concerned with the reaction, and the assay may be a measure of their activity as well.

Consequently in Section 2 we make no mention of individual enzymes or enzyme systems. We indicate merely that a given assay measures endogenous respiration or, alternatively, respiration in the presence of added substrate or substrates.

Although the data of Section 2 do not always justify a conclusion regarding the activity of any *particular* enzyme of the citric acid cycle, nevertheless they clearly indicate that at least some enzymes of that cycle are present in the tissues of invertebrates.

For other reviews dealing with this subject, see Krebs (1954), Gumbman, Brown, and Tappel (1958), and Hammen and Osborne (1959).

CYTOCHROME SYSTEM

There is convincing evidence for the presence of cytochrome oxidase as the terminal oxidase in tissues of certain mollusks and arthropods (see data of Section 2; see also Shappirio and Williams, 1957a, 1957b; Tappel, 1960; Pablo and Tappel, 1961; Sacktor, 1961). The possibility that cytochrome oxidase may be part of the terminal electron transfer system of other invertebrates, including some sponges and coelenterates, is suggested by the work of Robbie

(1949). Cyanide sensitivity is usually taken to indicate that cytochrome oxidase and certain other enzymes may be involved in the terminal electron transport system. Except under unusual conditions (see pp. 82-83) cyanide insensitivity is generally considered evidence for the non-involvement of these enzymes. With cyanide as a respiratory poison, Robbie recorded marked inhibition of endogenous respiration in all invertebrate tissues so treated, with the exception

of the subumbrella of the jellyfish (*Cassiopea frondosa*) and the branchial tree of the sea cucumber (*Isostichopus badiotus*). Concentrations of cyanide employed by Robbie ranged from 1×10^{-2} to 1×10^{-5} M. The fact that even the lower concentrations of cyanide were inhibitory suggests that the cyanide may have been acting on cytochrome oxidase.

It should be added here parenthetically that cyanide is a less specific inhibitor of cytochrome oxidase than is azide. Furthermore, although both cytochrome oxidase and tyrosinase are inhibited by carbon monoxide, the inhibition of cytochrome oxidase is reversible by light, whereas the inhibition of tyrosinase is not.

Possibly the inhibition of endogenous respiration produced by cyanide in Robbie's study was due to an inhibition of catalase, peroxidase, or tyrosinase. Such a possibility, however, is slight, for the concentration of these enzymes in animal tissues is too low for them to be playing a major role in respiration. The lower concentrations of cyanide that Robbie found to be effective (e.g., 1×10^{-5} M) also rule out the possibility that the inhibition depended upon a reaction of this poison with carbonyl groups in keto acids of the citric acid cycle.

Laser (1944) has found that cyanide can cause an *increase* in respiratory activity. When he added 0.01 M cyanide to muscle homogenates of *Ascaris lumbricoides* containing methylene blue, Laser noted an increase in the rate of respiration greater than that shown by homogenates containing methylene blue but lacking high concentrations of cyanide. Apparently cyanide can combine with oxaloacetate to form a complex that, unlike oxaloacetate itself, is incapable of competitively inhibiting succinic dehydrogenase.

Neither cytochrome oxidase nor cytochrome *c* is enzymatically detectable in muscle homogenates of the nematodes *Ascaris lumbricoides* and *Litomosoides carinii*, although a low level of cytochrome *c* and cytochrome oxidase activity is apparent in muscle homogenates of the trematode *Schistosoma mansoni* (Bueding and Charms, 1952). However, a pigment with the same absorption maxima as reduced cytochrome *c* has been demonstrated spectroscopically in tissues of *Parascaris equorum* and *A. lumbricoides* (Keilin, 1925) and in those of *A. lumbricoides* at the temperature of liquid air (Keilin and Hartree, 1949). Thus the conclusion that these parasitic

nematodes have a unique terminal electron transport system (Bueding and Charms, 1952) remains open to question.

Because the respiration of the diapausing Cecropia moth is unaffected by cyanide and carbon monoxide, Schneiderman and Williams (1954a, 1954b) postulated that a terminal oxidase other than cytochrome oxidase functions during pupal diapause. Subsequently, by use of low temperature spectroscopy (see Keilin and Hartree, 1949), which intensifies the absorption bands of the cytochromes 10- to 20-fold, Shappirio and Williams (1957a) observed that cytochrome oxidase is still present in diapausing Cecropia pupae. During their study, in which they carefully traced the activity of the enzymes of the terminal electron transport system in wing epithelium during a portion of the life cycle, Shappirio and Williams (1957b) found that the *activity* of cytochrome oxidase falls to low (but still detectable) levels during diapause and then rises during adult development. They also found (1957a) that the *concentration* of this and other respiratory enzymes drops markedly during pupal diapause and then rises again during adult development. Significantly, however, whereas during diapause the concentration of cytochrome *c* is less than 5 per cent of its pre-diapause level, that of cytochrome oxidase remains relatively high (20% of its non-diapause level).

Recently Harvey and Williams (1958a, 1958b) and Kurland and Schneiderman (1959) reinvestigated the question of the terminal oxidase in diapausing pupae. Respiration of the whole animal throughout diapause is relatively insensitive to inhibition by carbon monoxide, azide, and cyanide. Nonetheless, Harvey (1956), Kurland and Schneiderman (1959), and Harvey and Williams (1961) showed that injury-stimulated and dinitrophenol-stimulated uptake of oxygen by diapausing pupae is indeed sensitive to carbon monoxide. Furthermore, in their independent investigations, Kurland and Schneiderman (1959), studying total uptake of oxygen, and Harvey and Williams (1958b), studying the heart beat of uninjured diapausing pupae, demonstrated that at low oxygen tensions the diapausing pupa is carbon monoxide sensitive. The manometric studies were measurements of the *total* gas uptake in the presence of either oxygen or oxygen and carbon monoxide mixtures. That diapausing pupae may consume carbon monoxide as well as oxygen has

recently been shown by Harvey (1961), who found that carbon monoxide can stimulate oxygen uptake (see also Kurland and Schneiderman, 1959) and that 5 per cent of the total gas consumed may be carbon monoxide.

On the basis of their findings, these several workers have concluded that during pupal diapause in *Cecropia* (and also in three closely related species of saturniid moths) cytochrome oxidase does serve as the terminal oxidase. They account for the fact that respiration of diapausing pupae at reasonable oxygen tensions and when unstimulated by dinitrophenol or by injury is apparently carbon monoxide-, azide- and cyanide-insensitive by pointing to the excess of cytochrome oxidase in most tissues of dia-

pausing pupae compared to the low concentrations of cytochrome *c* (Shappirio and Williams, 1957a, 1957b). Thus, although a large portion of the oxidase may be inhibited by a respiratory poison, enough oxidase remains unbound to permit the transfer of electrons from cytochrome *c* to molecular oxygen. Clearly the apparent insensitivity of diapausing pupal respiration to the inhibitors of cytochrome oxidase is not an actual insensitivity. Provided that respiration is stimulated or, alternatively, provided that the oxygen tension is lowered sufficiently for the concentration of uninhibited cytochrome oxidase to become rate-limiting, a sensitivity to carbon monoxide, azide, and cyanide during pupal diapause can be demonstrated.

COMPARISON OF RESPIRATORY RATES OF VARIOUS TISSUES

Let us leave the subject of respiratory enzymes and their inhibitors at this point and discuss certain other aspects of invertebrate tissue respiration that have been investigated in the papers cited in this volume. Among the most interesting work is that which concerns the comparative respiratory rates of different tissues. In three investigations (Shapiro, 1937, on *Limulus polyphemus*; Kerkut and Laverack, 1957, on *Helix pomatia*; Ghiretti-Magaldi, Giuditta, and Ghiretti, 1958, on *Octopus vulgaris*) ganglionic tissue proved to have the greatest endogenous respiratory activity. In general, ganglionic tissue respire most rapidly, foot or leg muscle most slowly, and various other tissues at intermediate rates (Chapheau, 1932; Shapiro, 1937; Hopkins, 1946; Kawai, 1957; Kerkut and Laverack, 1957; Ghiretti-Magaldi, Giuditta, and Ghiretti, 1958; Higashi and Kawai, 1959; Kawai, 1959). Among insects, flight muscles have consistently higher endogenous respiratory rates than have leg muscles (Pérez-González and Edwards, 1954). In most brachyuran crustaceans the mid-

gut gland has a higher endogenous metabolic rate than has the gill. However, in certain active terrestrial and intertidal species, the gill exhibits a greater respiratory activity (Kermack, Lees, and Wood, 1954; Vernberg, 1956).

A comment concerning the particulate fractions assayed by Ghiretti-Magaldi, Giuditta, and Ghiretti (1957) is advisable. In order to facilitate homogenization, these investigators chose to freeze the tough muscles from the mantle and tentacles of *Octopus vulgaris* before fractionating them. In later work on *Octopus* (Ghiretti-Magaldi, Giuditta, and Ghiretti, 1958), they again used frozen muscle tissue for their preparations. In still later studies on *Aplysia*, the sea hare (Ghiretti, Ghiretti-Magaldi, and Tosi, 1959), frozen buccal mass muscle, frozen midgut gland, and frozen gizzard muscle were employed in the preparation of slices and particles. Since freezing disrupts both cells and intracellular organelles of most tissues, the particulate material used in these investigations may well have been fragmented.

SEX DIFFERENCES IN RESPIRATORY RATE

The results of studies dealing in part with sex differences in respiratory rate present no clear picture. In some species of brachyuran crusta-

ceans, the respiratory rate of both midgut gland and gill is higher in the female than in the male; in other species the reverse is true; in still

other species the respiratory rate of the midgut gland is higher in the male while that of the gill is higher in the female (Vernberg, 1956; Belding, Field, Weymouth, and Allen, 1942).

Among insects, the cockroach (*Periplaneta americana*) exhibits a certain consistency as regards sex differences in the respiratory rate of its various tissues. With the exception of the foregut, all tissues in the male cockroach respire at a higher rate than do those in the female (Barron and Tahmisian, 1948; Allen and Rich-

ards, 1954; Pérez-González and Edwards; 1954; Sacktor and Thomas, 1955; Kubišta, 1956; Young, 1958). In several other species of insects, however, tissues of the female have a higher respiratory rate than have those of the male (Graham, 1946; Allen and Richards, 1954). Furthermore, Samuels (1956) found that the endogenous respiration of teased thoracic muscle is approximately equal in both sexes of the Madeira cockroach (*Leucophaea maderae*).

VARIATION IN RESPIRATORY RATE WITH AGE

Studies on the variation in endogeneous respiratory rate with age have been carried out on three species of pelecypod mollusks, namely, the oysters *Crassostrea virginica* (Hopkins, 1930) and *Gryphaea angulata* (Chapheau, 1932), and the quahog *Mercenaria mercenaria* (Hopkins, 1930, 1946). In each of these species the respiratory rate was found generally to decline with advancing age.

What effect aging may have on the respiratory rate of arthropods is not easy to evaluate. The level of respiratory metabolism in crustaceans and insects depends so completely upon the stage of an animal in the molt cycle or life cycle that its relation to the animal's chronological age is often obscure.

VARIATION IN RESPIRATORY RATE DURING CRUSTACEAN MOLT CYCLE

Increase in size in arthropods is discontinuous and periodic. It occurs only at the time of ecdysis when the old exoskeleton is cast off, to expose the new soft one underneath. Through uptake of water, as in some crustaceans, or uptake of air, as in some crustaceans and insects, the soft new exoskeleton is rapidly enlarged to greater dimensions before it becomes hardened by tanning and, in the case of crustaceans, calcification. Growth (i.e., increase in the amount of body tissue), although a more extended process than is increase in size, nevertheless is timed to coincide with other preparations for ecdysis and with subsequent post-ecdysial events.

Two studies involving the respiration of crustacean tissues during the molt cycle are cited in Section 2. In the first (Krishnan, 1954), the cyanide-insensitive respiration (with added fructose) of muscle from the green crab (*Carcinus maenas*) proved to be lowest during the period just preceding ecdysis; the rate of respiration rose during the soft-shelled stage immediately following ecdysis and reached a maximum

during the intermolt period. In a second study, Skinner (MS) traced changes in endogenous respiration shown by integumentary tissues of the land crab (*Gecarcinus lateralis*). Oxygen uptake is highest during the period just preceding ecdysis, being 1.6 times that recorded during the intermolt period. The apparent contradiction between these two sets of results can be explained as follows: metabolism of muscle can be expected to be maximal during the non-growth, intermolt stage when the animal is active, while the metabolism of integumentary tissues presumably will be highest during the premolt period when these tissues are synthesizing the new exoskeleton.

To induce pre-ecdysial changes, ecdysis, and (if the animal survives) post-ecdysial alterations in a decapod crustacean, one need only remove both eyestalks, for in these structures are certain neurosecretory cells (X organ cells) that synthesize and release a neurohormone capable of inhibiting molting. Before its release, the molt-inhibiting hormone is stored within the eyestalks in the sinus glands, which consist of

swollen endings of neurosecretory cells that synthesize the hormone.

Krishnan (1954) has studied the effects of eyestalk removal on the rate of tissue respiration. Three days after performing this operation on *Carcinus maenas*, he found the respiratory rate of muscle from animals without eyestalks to be decidedly lower than that of muscle from unoperated crabs. Krishnan noted, nevertheless, that when all his data were plotted, the resulting curves for the two groups of animals were similar. They differed mainly in that the curve for unoperated crabs was displaced to the right of the curve for operated crabs by a distance representing six days. In other words, comparable decreases (and subsequent increases) in respiratory rate of muscle occur in operated and unoperated animals, although in the latter only after a lag of six days. Krishnan did not offer an explanation of these observations. The levels may be related to the stage of the animals in their molt cycle. If the unoperated crabs were gradually approaching molt, the respiratory rate of their muscle would reflect this and would yield a curve resembling that of premolt crabs without eyestalks. Because eyestalk removal accelerates molt-preparatory processes, however, the two curves would remain separated in time.

It may be noted that Bliss (1953), working with whole specimens of *Gecarcinus lateralis*, found the respiratory rate to be high immediately after eyestalk removal and to remain high throughout the entire period preceding ecdysis. Thus a difference exists between the respiratory rates of animals without eyestalks and of their isolated tissues during the premolt period.

As mentioned above, a molt-inhibiting hormone occurs in the eyestalks of crustaceans. In the preparation of an extract, the eyestalks are homogenized, boiled, and centrifuged, and then the supernatant is removed for use. In this way, an investigator obtains a protein-free extract, the chemical composition of which is in other respects unknown.

Several workers have attempted to demonstrate a direct effect of crustacean molt-inhibiting hormone on tissue respiration by the addition of such eyestalk extracts to homogenates. Scheer, Schwabe, and Scheer (1952) have reported that, in general, homogenates of muscle from eyestalkless individuals of the green

crab (*Carcinus maenas*), the lobster (*Homarus gammarus*), and the shrimp (*Palaemon squilla*) respire at a lower rate than do homogenates of muscle from unoperated individuals, and that the rate increases after the addition of eyestalk extract to the homogenates. However, the data submitted by these authors show that the effects are rather small and quite variable. Furthermore, their data indicate that the addition of eyestalk extracts to homogenates of muscle from *Palaemon squilla* in some cases increases and in others decreases the respiratory rate. As noted above, crustaceans and their excised tissues respire at different rates according to stage in the molt cycle. Variability in results, therefore, may be related to stage. Schwabe, Scheer, and Scheer (1952) consider that synthesis of the new exoskeleton begins during the late intermolt period, that is, in late stage C. This concept does not agree with that of Drach (1939), according to whom the synthesis of a new exoskeleton begins during the early premolt period, that is, in early stage D. If Drach's criteria, which are accepted by the majority of workers (see Renaud, 1949; Travis, 1955; Charniaux-Cotton, 1957; Skinner, 1958, [MS]; Passano, 1960), are valid, the variability in the results of Scheer, Schwabe, and Scheer (1952) may be attributed to the fact that some of their animals were in the intermolt stage and some were in the premolt stage.

For several species of crustaceans, Kuntz (1946) noted that low concentrations of sinus gland extract increased the rate of reduction of methylene blue by midgut gland and that high concentrations decreased the rate. A more complete report of this work has not appeared.

In a series of experiments on *Carcinus maenas* (Skinner and Bliss, unpublished data), we found that homogenates of midgut gland containing extracts of one to five sinus glands reduced methylene blue at essentially equivalent rates. On the other hand, homogenates that contain leg muscle equal in wet weight to two sinus glands carry out this reduction one and one-half times faster.

The variability of results in experiments of this kind emphasizes the need for the use of (1) more highly purified hormonal preparations, and (2) more definitive systems, such as those containing isolated mitochondria or submitochondrial particles.

VARIATION IN RESPIRATORY RATE DURING INSECT LIFE CYCLE

Just as the respiratory metabolism of crustaceans is correlated closely with the stage of the animal in the intermolt cycle, so the respiratory rate of an insect varies with the phase of the insect in its life cycle (see also pp. 82-83). Brooks (1957) reported the respiratory activity of the cockroach (*Periplaneta americana*) to be low in pink muscles of the leg and wing from nymphs, higher in those of adults just after emergence, and still higher in those of older adults. On the other hand, no clear difference was detected by

Allen and Richards (1954) in the leg muscle of young (10- to 20-day) adults when compared with older (95- to 185-day) adults. Lewis and Slater (1954) and Slater and Lewis (1954) found that the activity of the α -ketoglutaric oxidase system in the flight muscle from adults of the bluebottle fly (*Calliphora erythrocephala*) was relatively high right after adult emergence, lower from the eighth to the tenth day, and high again from the fifteenth to the seventeenth day.

RESPIRATORY RATE FOLLOWING INJURY

Kubišta (1956) reported that the endogenous respiratory rate shown by isolated muscle of a cut femur in the stone cricket (*Tachycines asynamorus*) was 1.4 times that shown by muscle of an uncut femur.

When making respiratory measurements on

tissues of a diapausing pupa, one must exercise caution, for injury alone can increase the metabolic rate both of the pupa (whole or subdivided) and of its isolated tissues (see Schneiderman and Williams, 1953; Harvey, 1956, 1961, MS a; Shappirio, 1960).

EFFECT OF ENVIRONMENT ON RESPIRATORY RATE

With regard to the magnitude of the respiratory rate at various seasons, it appears that endogenous oxygen uptake is greater in certain tissues of pelecypod mollusks found in the North Temperate Zone during the winter and early spring than at other times during the year (Hopkins, 1946; Kawai, 1957). Two investigations concerned with the effects of salinity on

respiratory rate have revealed a general rise with increasing dilution, as in the gill and mantle of the quahog *Mercenaria mercenaria* (Hopkins, 1949) and the gill of the green crab *Carcinus maenas* (Pieh, 1936), or a fall, as in the adductor muscle of *M. mercenaria* (Hopkins, 1949).

EFFECT OF VARIOUS IONS ON RESPIRATORY RATE

Increasing concentrations of the potassium (K^+) ion induce a rise in endogenous respiration in the heart of *Helix aspersa*, the dented garden snail, and *Mytilus galloprovincialis*, a mussel, as well as in the nerve of *Sepia officinalis*, the cuttlefish (Cardot, Faure, and

Arvanitaki, 1950). With the claw nerve of the spider crab (*Libinia emarginata*) there is a rise in endogenous respiratory rate with increasing concentrations of K^+ ion up to a maximum of 40 mM per liter, then as a sharp drop (Shanes and Hopkins, 1948).

GRADIENTS IN RESPIRATORY RATE

In the brandling or manure worm (*Eisenia foetida*) the respiratory rate varies along the length of the worm. If one plots respiratory rate

against distance from the head, a U-shaped curve with maxima at head and tail results. A similar U-shaped curve of succinoxidase activ-

ity occurs along the length of the blue worm, *Octolasion cyaneum* (O'Brien, 1957). Guttman (1935) and Shapiro (1937) recorded inverted, U-shaped curves in respiratory rate along the length of the optic nerve of *Limulus polyphemus*, the horseshoe crab, at 28° C. to 31° C. (but not

at 16° C.). The axon of *Limulus* shows most of the activity when compared with the sheath. Lastly, Kubišta (1956) found a decrease in the rate of oxygen uptake along the thorax of the cockroach (*Periplaneta americana*), with a rise again in the region of the abdomen.

Section 5: ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

For the most part, the abbreviations listed below are identical with those given in Webster's New International Dictionary, second edition, unabridged, 1958.

<i>ca.</i> , <i>circa</i>	ml., milliliter, milliliters
cm., centimeter, centimeters	mo., month, months
cm. ² , square centimeter or centimeters	mol., mole, moles
da., day, days	no., number
equiv., equivalent	O.D., optical density
exp., experiment	R.Q., respiratory quotient
f.p., freezing point	S, salinity
g., gram, grams	sci. name, scientific name
hr., hour, hours	s.g., specific gravity
log, logarithm	sp., species (singular) not indicated by author
max., maximum	spp., species (plural) not indicated by author
mg., milligram, milligrams	temp., temperature
μg., microgram, micrograms	wks., weeks
μl., microliter, microliters	wt., weight
min., minute, minutes	yrs., years

SYMBOLS

CHEMICAL SYMBOLS AND FORMULAS

ADP, adenosine diphosphate	K ⁺ , potassium ion
ATP, adenosine triphosphate	KCl, potassium chloride
Ca ⁺⁺ , calcium ion	KCN, potassium cyanide
CaCl ₂ , calcium chloride	M, molar concentration; molarity; molar
CO, carbon monoxide	mM, millimol, millimols
CyFe ⁺⁺ , ferrocytochrome <i>c</i> (reduced cytochrome <i>c</i>)	Mg ⁺⁺ , magnesium ion
CyFe ⁺⁺⁺ , ferricytochrome <i>c</i> (oxidized cytochrome <i>c</i>)	MgCl ₂ , magnesium chloride
DDT, dichlorodiphenyltrichloroethane	N, nitrogen (element)
DNP, 2, 4-dinitrophenol	N ₂ , nitrogen (gas)
DPN or DPN ⁺ , oxidized diphosphopyridine nucleotide	Na ⁺ , sodium ion
DPNH, reduced diphosphopyridine nucleotide	NaCl, sodium chloride
EDTA, ethylenediaminetetraacetic acid (versene)	Na ⁺ /K ⁺ , ratio of sodium ions to potassium ions
HCN, hydrocyanic acid	O ₂ , oxygen (gas)
H ₂ O ₂ , hydrogen peroxide	P/O, ratio of phosphate formed to oxygen utilized; referred to as the P/O ratio
	TPN, triphosphopyridine nucleotide
	TPNH, reduced triphosphopyridine nucleotide

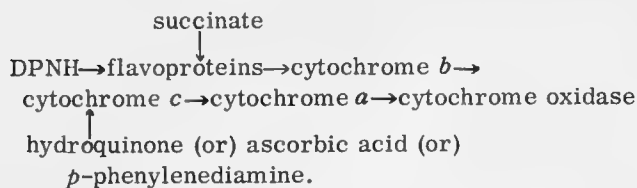
MISCELLANEOUS SYMBOLS

♂, male	10^{-5} , 1/100,000 or 0.00001
♀, female	>, more than
α, alpha	<, less than
Δ, delta	/, per
μ, micron	‰, parts per thousand
mμ, millimicro- (prefix)	t, time
(mg.N) ⁻¹ , 1/mg.N	× g, times the acceleration of gravity
p, para	° C, degrees Centigrade

Section 6: GLOSSARY

- absorbancy:** Synonymous with optical density; equal to $-\log_{10} T$, where T =transmittancy; molar absorbancy index or extinction coefficient is the absorbancy of a 1-molar solution through a 1-cm. light path.
- accessory glands:** In insects and other invertebrates; secretory organs associated with reproductive function.
- adductor muscle:** In bivalve mollusks, a muscle that closes the valves of the shell.
- albuminous or albumen gland:** In the higher gastropod mollusks; a part of the female reproductive system, it secretes an albuminous material around the egg before the shell is added. The albuminous material serves as food for the developing embryo.
- antimycin A:** An antibiotic isolated from *Streptomyces* spp.; inhibits the oxidation of succinate at the level of the Slater factor.
- ascorbate:** The salt of ascorbic acid; a reducing agent used to reduce cytochrome *c*.
- axoplasm:** The cytoplasm of a nerve fiber.
- Barcroft respirometer:** A differential respirometer consisting of two flasks connected to a manometer. In this closed system one flask serves as a thermobarometer; the other, as a tissue chamber. As the tissue consumes oxygen and produces carbon dioxide, which is absorbed by alkali, both volume and pressure in the respiration chamber change. The difference in pressure between the two flasks is measured on the column of the manometer.
- brachyuran:** Pertaining to the true crabs or Brachyura.
- branchial or respiratory tree:** In sea cucumbers (Echinodermata), consists of two long, branching tubes that arise from the cloaca and terminate blindly in the anterior portion of the body cavity; functions in respiration and excretion.
- buccal mass:** In mollusks, exclusive of bivalves; a more or less compact mass of muscles and cartilage that supports and operates the radula.
- catalase:** An enzyme that catalyzes the conversion of hydrogen peroxide to water and molecular oxygen.
- citric acid cycle:** Another name for tricarboxylic acid cycle or Krebs cycle; the primary mechanism by which the aerobic oxidation of metabolic intermediates to carbon dioxide and water takes place.
- clitellate:** Indicative of the fact that an annelid, such as an earthworm or a leech, is sexually mature and bears a clitellum.
- clitellum:** A glandular thickened region that secretes a capsule for eggs and may assist in attachment during copulation.
- collagenous:** Pertaining to collagen, a protein that is found in large amounts in connective tissue.
- columella muscle:** In gastropod mollusks; is attached to the columella (central column) and serves to retract the body of the animal into the shell.
- corpora allata:** In insects; glands that secrete a hormone (juvenile hormone) capable of preventing metamorphosis while permitting larval molting; also involved in the control of reproduction.
- coxal muscles:** In insects, crustaceans, and other arthropods; muscles of the coxa, which is the first segment of a leg and which effects the articulation of the leg with the body.
- cytochrome *c*:** A heme protein, the position of which in the terminal electron transport chain is such that it may be reduced from the ferric (Fe^{+++}) to the ferrous (Fe^{++}) form by cytochrome *c*₁, cytochrome *b*, flavoproteins, or certain added reducing agents; also may be oxidized by cytochrome oxidase or by certain added oxidizing agents.
- cytochrome oxidase (cytochrome *a*₃):** A heme protein that oxidizes cytochrome *c* and reduces molecular oxygen; its activity is inhibited by cyanide, azide, and carbon monoxide, the inhibition by carbon monoxide being light reversible.
- cytochrome system:** A group of respiratory

enzymes of primary importance in cellular respiration. The members of the chain are thought to be aligned as follows:



dart sac: Found in one superfamily of land snails, the Helicacea; consists of a muscular caecum arising from the vagina and contains a fine-pointed calcareous shaft. The shaft is exchanged by the hermaphroditic partners during courtship and serves as a releaser stimulus for courtship behavior.

dehydrogenases: Enzymes that are generally DPN- or TPN-linked and that catalyze the oxidation of certain metabolites. Neither DPN nor TPN, however, is required by succinic dehydrogenase, which transfers electrons to the cytochrome chain directly.

dialysis: A method for the separation of large molecules from small by means of their unequal rates of diffusion through natural or synthetic membranes.

diapause: The condition of arrested growth, development, or reproductive activity that occurs at a given stage in the life cycle of many arthropods, notably certain hemimetabolous and holometabolous insects.

differential manometer: See Barcroft, Fenn, and Thunberg respirometers.

digestive diverticula: See midgut gland.

2, 4-dinitrophenol (DNP): Dissociates or uncouples ATP synthesis from aerobic respiration.

diphosphopyridine nucleotide (DPN): Or coenzyme I; a hydrogen acceptor that is reduced by a variety of substrates in the presence of specific dehydrogenases; in turn, it reduces a flavoprotein.

ecdysis: In arthropods, the act of shedding or casting the exoskeleton (shell).

electron transport system: See cytochrome system.

endogenous respiration: Respiration without added substrate.

endoplasmic reticulum: An intracellular cytoplasmic system consisting of tubules and vesicles that form a continuous network of

membrane-bound cavities; some of the membranes have small granules (ribonucleoprotein particles) attached to them, so that these membranes may appear rough-surfaced.

ethylenediaminetetraacetic acid (EDTA): Or versene; a complexing agent used to chelate divalent metals and so effectively remove them from solution.

extinction coefficient: See absorbancy.

eyestalk extract: The supernatant obtained when eyestalks of a decapod crustacean are homogenized, boiled, and centrifuged.

fat body: In insects, a tissue that fills the body cavity and contains large amounts of fat, protein, and glycogen.

femur: The third (counting distad) and often the broadest segment of the leg of an insect. In the metathoracic leg, the femur may be considerably enlarged to contain the muscles used in jumping (as in a grasshopper or cricket).

Fenn respirometer: A type of differential respirometer; consists of two vessels connected by a horizontal capillary tube containing an oil drop. As volume or pressure changes within the respiration chamber, the oil drop moves.

flavoproteins: A group of conjugated proteins of primary importance in the electron transport system.

fluorescence: The light emitted by a molecule as a result of absorption of radiation from an external source; persists only during irradiation; is of longer wave length than is the incident light.

giant axon: A type of nerve fiber of exceptionally large diameter; found in lower vertebrates and in certain invertebrates, including annelids, crustaceans, insects, and cephalopod mollusks; permits rapid conduction of nerve impulses.

gizzard: In *Aplysia* and other Aplysiomorpha (opisthobranchiate mollusks), most of which feed by cropping live seaweeds with paired jaws and radula. The gizzard has two chambers, an anterior one for masticating and a posterior one with delicate teeth for straining.

hemimetabolous: Refers to an insect that undergoes incomplete metamorphosis (egg → nymph → adult).

hepatopancreas: See midgut gland.

holometabolous: Refers to an insect that under-

- goes complete metamorphosis (egg → larva → pupa → adult).
- homogenate:** Ideally, a cell-free suspension obtained by grinding tissues in such a way that cell structure is destroyed.
- hydroquinone:** A reducing agent used to reduce cytochrome *c*.
- Krebs cycle:** See citric acid cycle.
- larva:** Immature, wingless, generally worm-like form into which holometabolous insects hatch from the egg and in which they remain until they change into pupae.
- liver:** See midgut gland.
- malonate:** The salt of malonic acid; a dicarboxylic acid that competitively inhibits the oxidation of succinic acid.
- Malpighian tubules:** Tubular organs opening into the midgut or hindgut of insects; generally believed to be excretory in function.
- mantle:** In mollusks, the fold of the body wall which, in shell-bearing forms, lines and secretes the shell.
- microsomes:** An operational term referring to the fraction obtained when homogenates freed of large particulate matter are centrifuged at high centrifugal forces; the fraction obtained is composed essentially of fragments of ruptured endoplasmic reticulum (see definition) and its attached particles.
- midgut gland:** Name preferred by many invertebrate zoologists for the digestive gland of mollusks and crustaceans; in mollusks, sometimes called hepatopancreas, digestive diverticula, or liver; in crustaceans, often called hepatopancreas or liver.
- mitochondria:** Intracellular particles (average diameter, 1μ) containing the enzymes and coenzymes that comprise the electron transport system; involved in oxidative phosphorylation, and citric and fatty acid oxidations; can be collected in a relatively homogeneous fraction by centrifugation (at $5000 \times g$) of a homogenate from which nuclei and cellular debris have been removed by a low-speed centrifugation.
- molt:** A term frequently used, as in this volume, to indicate the growth processes undergone by arthropods both before and after ecdysis, as well as during ecdysis.
- nymph:** Immature stage into which hemimetabolous insects hatch from the egg.
- optical density:** See absorbancy.
- oxidative phosphorylation:** The process by which adenosine diphosphate (ADP) and inorganic orthophosphate are converted to the high-energy compound adenosinetriphosphate (ATP); energy for this conversion is derived from the transport of electrons through the terminal electron transport system.
- pallial:** Refers to the mantle, especially of a mollusk.
- particulate fraction:** Any of several fractions that are usually obtained from a tissue homogenate by differential centrifugation.
- pedal retractor:** In mollusks, a muscle that retracts the foot.
- perienteric:** Refers to the cavity that surrounds the digestive tract.
- p*-phenylenediamine:** A reducing agent used to reduce cytochrome *c*.
- P/O ratio:** Ratio of inorganic phosphate esterified (to ATP) to the oxygen consumed during the aerobic oxidation of a metabolite; denotes the efficiency of utilization of energy made available by the transfer of electrons through the electron transport system.
- polarograph:** An instrument used in polarography, which is concerned with oxidation-reduction reactions at an electrode. If potentials are measured while known currents are flowing through the cell, and these two parameters are plotted against each other, a curve is obtained from which the character and concentration of a given material can be ascertained.
- pupa:** The intermediate, quiescent form assumed by holometabolous insects following the larval stage, or stages, and prior to the adult stage.
- quinol:** See hydroquinone.
- radula:** A chitinous, tooth-bearing ribbon used by mollusks, exclusive of bivalves, for rasping food into minute particles.
- respiratory quotient:** Ratio of the volume of carbon dioxide produced to the volume of oxygen consumed during respiration.
- retractor muscle of foot:** See pedal retractor.
- sarcosomes:** Mitochondria of muscle.
- Slater factor:** A component of the electron transport chain operative between cytochrome *b* and cytochrome *c*; inhibited by antimycin A.
- spectrophotometer:** An instrument for the quantitative measurement of the transmission of light of a given wave length through a solution,

the transmission of the solvent being set at unity or at 100 per cent.

stellar nerve (see Connelly, 1952): In cephalopod mollusks; this term presumably refers to the large nerve trunks that run from the brain to each stellate ganglion; these nerve trunks are usually called the mantle or pallial nerves.

subumbrella: In jellyfishes; the concave or oral surface of the umbrella (see definition).

succinoxidase system: An enzyme system that includes succinic dehydrogenase and part of the electron transport system; catalyzes the oxidation of succinate to fumarate and transfers the electrons so removed to oxygen via a portion of the terminal electron transport system.

Thunberg respirometer: A type of differential respirometer.

tricarboxylic acid cycle: See citric acid cycle.

triphosphopyridine nucleotide (TPN): Or co-

enzyme II; a hydrogen acceptor which is reduced by a variety of substrates in the presence of specific dehydrogenases; in turn, it reduces a flavoprotein.

umbrella: The gelatinous bell-shaped or disk-shaped structure that comprises the greater part of the body of a jellyfish.

volumeter: A closed-system, constant-pressure respirometer with two flasks connected by a manometer and with an additional calibrated arm permitting direct measurement of changes in volume that result from respiration in one flask; the second flask serves as a thermobarometer.

Warburg respirometer: A single-flask, constant-volume manometer in which the consumption of oxygen is measured as a function of a change in pressure.

Winkler method: A chemical method for the determination of dissolved oxygen based on the oxidation of manganese.

Section 7: GUIDE TO LITERATURE

Popular, semi-popular, and semi-technical references are indicated by an asterisk.

BIOCHEMISTRY: GENERAL REFERENCES

Baldwin (1957)
Fruton and Simmonds (1958)
Long, King, and Sperry (1961)

CELL FRACTIONS

Allfrey (1959)
De Robertis, Nowinski, and Saez (1960)
Duve (1957)
Green and Järnefelt (1959)*
Hogeboom, Kuff, and Schneider (1957)
Lehninger (1951)
Novikoff (1957, 1959, 1961)
Palade (1958)
Siekevitz (1957)*

CELL STRUCTURE

(See also under Subcellular Morphology)

De Robertis, Nowinski, and Saez (1960)
Mercer (1961)
Siekevitz (1957)*
Wilson (1925)
Zamecnik (1958)*

CITRIC ACID CYCLE

Baldwin (1957)
Colowick and Kaplan, vol. 1 (1955), vol. 3 (1957)
Cross, Taggart, Covo, and Green (1949)
Green (1949, 1951, 1954, 1957, 1958*)
Gumbman, Brown, and Tappel (1958)
Hammen and Osborne (1959)
Hogeboom, Kuff, and Schneider (1957)
Krebs (1954)
Lehninger (1951, 1960*)
Long, King, and Sperry (1961)

CRUSTACEANS: CONTROL OF MOLTING

Arvy, Gabe, and Scharrer (1956)
Bliss (1956, 1959, 1960)
Carlisle and Knowles (1959)

Kleinholz (1957)
Knowles and Carlisle (1956)
Passano (1960)

CRUSTACEANS: GENERAL BIOLOGY

(See also under Invertebrates)

Balss (1940-1957)
Korschelt (1944)

CRUSTACEANS: HORMONES

(See also under Invertebrates)

Carlisle and Knowles (1959)
Kleinholz (1957)
Knowles and Carlisle (1956)
Koller (1960)

CRUSTACEANS: NEUROENDOCRINE SYSTEMS

(See also under Invertebrates)

Bliss (1956, 1959, 1960)
Carlisle and Knowles (1959)
Kleinholz (1957)
Knowles (1959)
Knowles and Carlisle (1956)
Koller (1960)
Passano (1960)
Scheer (1960)
Turner (1960)
Welsh (1955, 1961a)

CRUSTACEANS: PHYSIOLOGY

Buddenbrock (1945-1954)
Waterman (1960-1961)

CYTOCHROMES

Baldwin (1957)
Chance and Williams (1956)
Cooperstein and Lazarow (1951)
De Robertis, Nowinski, and Saez (1960)
Green (1958)*
Green and Hatefi (1961)

Horecker and Stannard (1948)
 Keilin (1925)
 Keilin and Slater (1953)
 Lehninger (1960,* 1961*)
 Long, King, and Sperry (1961)
 Lundegårdh (1959)
 Morrison (1961)
 Pablo and Tappel (1961)
 Sacktor (1961)
 Schneider and Potter (1943)
 Shappirio and Williams (1957a)
 Stannard and Horecker (1948)
 Tappel (1960)

ELECTRON MICROSCOPY

Bargmann, Peters, and Wolpers (1960)
 Bessis (1960)*
 Clark (1961)
 Colowick and Kaplan, vol. 4 (1957)
 De Robertis, Nowinski, and Saez (1960)
 Novikoff (1957)
 Palade (1956, 1958)
 Selby (1959)
 Sjöstrand (1957)

ELECTRON TRANSPORT SYSTEM

Chance and Williams (1956)
 Green (1954, 1957, 1958,* 1959)
 Green and Hatefi (1961)
 Green and Järnefelt (1959)*
 Lehninger (1960,* 1961*)
 Long, King, and Sperry (1961)
 Potter and Reif (1952)

ENZYMES: GENERAL CONSIDERATIONS

Baldwin (1957)
 Boyer, Lardy, and Myrbäck (1959)
 De Robertis, Nowinski, and Saez (1960)
 Dixon and Webb (1958)
 Duve (1957)
 Frieden (1959)*
 Green (1949, 1957)
 Green and Järnefelt (1959)*
 Sumner and Myrbäck (1950-1952)

ENZYMES, RESPIRATORY

Baldwin (1949,* 1957)
 Chance and Williams (1956)
 Colowick and Kaplan, vol. 2 (1955)
 Cooperstein, Lazarow, and Kurfess (1950)

Lehninger (1951, 1961*)
 Long, King, and Sperry (1961)
 Schneider and Potter (1943)

INHIBITORS, METABOLIC

General Considerations

Sizer (1957)

Antimycin A

Potter and Reif (1952)
 Reif and Potter (1953)

Azide

Horecker and Stannard (1948)
 Stannard and Horecker (1948)

Carbon Monoxide

Lilienthal (1950)

Cyanide

Horecker and Stannard (1948)
 Robbie (1948, 1949)
 Stannard and Horecker (1948)

2, 4-Dinitrophenol (DNP)

Chance and Williams (1956)
 Cross, Taggart, Covo, and Green (1949)
 Green (1951)
 Loomis and Lipmann (1948)
 Slater and Lewis (1954)

INSECTS: CONTROL OF GROWTH AND METAMORPHOSIS

Arvy, Gabe, and Scharrer (1956)
 Harvey (MS a)
 Lees (1955)
 Raabe (1959)
 Schneiderman and Gilbert (1959)
 Turner (1960)
 Wigglesworth (1954, 1957, 1959*)
 Williams (1958)*

INSECTS: GENERAL BIOLOGY (See also under Invertebrates)

Richards and Davies (1957)

INSECTS: HORMONES

(See also under Invertebrates)

Karlson (1956)
 Raabe (1959)
 Schneiderman and Gilbert (1959)
 Wigglesworth (1954, 1957, 1959*)
 Williams (1958)*

INSECTS: NEUROENDOCRINE SYSTEMS

(See also under Invertebrates)

Bargmann, Hanström, Scharrer, and Scharrer
 (1958)
 Koller (1960)
 Raabe (1959)
 Scharrer, B. (1959)
 Scheer (1960)
 Turner (1960)
 Welsh (1955)
 Wigglesworth (1957)

INSECTS: PHYSIOLOGY

Roeder (1953)
 Wigglesworth (1951)

INTERMEDIARY METABOLISM

(See also under Enzymes:
General Considerations)

Baldwin (1957)
 Dickens (1959)
 Krebs (1953)
 Prosser and Brown (1961)
 Sallach and McGilvery (1960)

INVERTEBRATES: BOOKS WITH
ANNOTATED BIBLIOGRAPHIES

Borradaile, Potts, Eastham, and Saunders
 (1958)*
 Brown (1950)
 Crowder (1931)*
 Roeder (1953)
 Smith, Pitelka, Abbott, and Weesner (1954)

INVERTEBRATES: GENERAL BIOLOGY

Borradaile, Potts, Eastham, and Saunders
 (1958)*
 Bronn (1880-1961)
 Brown (1950)
 Buchsbaum and Milne (1960)*

Cadart (1957)*

Cambridge Natural History (see Harmer and
Shipley, 1895-1909)

Carter (1940)

Carthy (1958)

Crowder (1931)*

Galtsoff, Lutz, Welch, and Needham (1937)*

Grassé (1948-1960)

Harmer and Shipley (1895-1909)*

Hyman (1940-1959)

Kükenthal and Krumbach (1923-1938)

Lankester (1900-1909)*

MacGinitie and MacGinitie (1949)*

Morton (1958)*

Pennak (1953)

Ricketts and Calvin (1952)*

Sedgwick (1898-1909)

Smith, Petelka, Abbott, and Weesner (1954)

Traité de Zoologie (see Grassé)

Ward and Whipple (1959)

Wilson (1947,* 1951*)

Yonge (1949)*

INVERTEBRATES: HORMONES

(See also under Crustaceans and Insects)

Arvy, Gabe, and Scharrer (1956)

Kleinholz (1957)

Koller (1960)

Scharrer and Scharrer (1954a, 1954b)

INVERTEBRATES:

NEUROENDOCRINE SYSTEMS

(See also under Crustaceans and Insects)

Bargmann, Hanström, Scharrer, and Scharrer
 (1958)

Gabe (1954)

Koller (1960)

Naisse (1959)

Schneiderman and Gilbert (1959)

Stazione Zoologica di Napoli (1954)

Welsh (1959, 1961b)

INVERTEBRATES: PHYSIOLOGY

Buddenbrock (1950-1961)

Galtsoff (1961)

Nicol (1960)

Prosser and Brown (1961)

Scheer (1948)

Scheer, Bullock, Kleinholz, and Martin (1957)

Van der Kloot (MS)

Micro-Winkler Method

METHODS

*Determination of Respiratory Rate:**General Treatment*

De Robertis, Nowinski, and Saez (1960)

Dixon (1951)

Umbreit, Burris, and Stauffer (1957)

*Determination of Respiratory Rate:**Special Techniques*

Barcroft Respirometer

Dixon (1951)

Umbreit, Burris, and Stauffer (1957)

Fenn Respirometer

Dixon (1951)

Polarograph

Barker and Miner (1961)

Umbreit, Burris, and Stauffer (1957)

Spectrophotometer

Bayliss (1959)

Chance (1954)

Colowick and Kaplan, vol. 4 (1957)

Drabkin (1950)

Lundegårdh (1959)

Umbreit, Burris, and Stauffer (1957)

Thunberg Respirometer

Thunberg (1905)

Volumetric Microrespirometer (Volumeter)

Scholander (1942)

Scholander, Claff, Andrews, and Wallach (1952)

Wennesland (1951)

Warburg Respirometer

De Robertis, Nowinski, and Saez (1960)

Dixon (1951)

Umbreit, Burris, and Stauffer (1957)

Warburg (1931)

Winkler Method

American Public Health Association (1955)

Barth (1942)

Dam (1935)

Fox and Wingfield (1938)

Preparation of Tissues

General

Baldwin (1957)

Differential Centrifugation

Allfrey (1959)

Claude (1946a, 1946b)

Duve (1957)

Hogeboom, Kuff, and Schneider (1957)

Novikoff (1959)

Schneider (1946)

Siekevitz (1957)

Umbreit, Burris, and Stauffer (1957)

Density Gradient Centrifugation

Allfrey (1959)

Hogeboom, Kuff, and Schneider (1957)

Homogenate Technique

Allfrey (1959)

Umbreit, Burris, and Stauffer (1957)

Isolation of Particulate Components

Allfrey (1959)

Umbreit, Burris, and Stauffer (1957)

Slicing

Deutsch (1936)

Field (1948)

Stadie and Riggs (1944)

Warburg (1931)

Ultracentrifugation

Colowick and Kaplan, vol. 4 (1957)

MICROSOMES

Allfrey and Mirsky (1961)*

De Robertis, Nowinski, and Saez (1954)

Hogeboom, Kuff, and Schneider (1957)

Novikoff (1959)

Palade (1956, 1958)

Zamecnik (1958)*

MITOCHONDRIA

Bessis (1960)*
 Brachet (1957)
 Chance and Williams (1956)
 Colowick and Kaplan, vol. 4 (1957)
 Dalton and Felix (1957)
 Dempsey (1958)
 De Robertis, Nowinski, and Saez (1960)
 Green (1951, 1954, 1957, 1958,* 1959)
 Green and Hatefi (1961)
 Green and Järnefelt (1959)*
 Hogeboom, Kuff, and Schneider (1957)
 Lehninger (1951, 1956, 1959, 1960,* 1961*)
 Lehninger, Wadkins, Cooper, Devlin, and
 Gamble (1958)
 Novikoff (1957, 1959, 1961)
 Palade (1956)
 Rouiller (1960)
 Sacktor (1961) - (sarcosomes)
 Selby (1959)
 Siekevitz (1957)*
 Sjöstrand (1957)
 Slater (1957) - (sarcosomes)
 Watanabe and Williams (1951, 1953) -
 (sarcosomes)

NEUROSECRETION, NEUROSECRETORY
 SYSTEMS, NEUROENDOCRINE SYSTEMS,
 AND NEUROHORMONES

(See also under Crustaceans,
 Insects, Invertebrates)

Arvy, Gabe, and Scharrer (1956)
 Bargmann, Hanström, Scharrer, and Scharrer
 (1958)
 Bliss (1956)
 Knowles (1959)
 Koller (1960)
 Naisse (1959)
 Scharrer, B. (1959)
 Scharrer, E. (1959)
 Scharrer and Scharrer (1954a, 1954b)
 Stazione Zoologica di Napoli (1954)
 Turner (1960)
 Welsh (1955, 1957, 1959, 1961a, 1961b)

OXIDATIVE PHOSPHORYLATION

Chance and Williams (1956)
 Cross, Taggart, Covo, and Green (1949)
 Dickens (1959)

Green (1951, 1954, 1958*)
 Green and Hatefi (1961)
 Green and Järnefelt (1959)*
 Keilin and Slater (1953)
 Krebs (1953, 1954)
 Lehninger (1951, 1956, 1959, 1960,* 1961*)
 Lehninger, Wadkins, Cooper, Devlin, and
 Gamble (1958)
 Long, King, and Sperry (1961)
 Loomis and Lipmann (1948)
 Morrison (1961)
 Sacktor (1961)
 Siekevitz (1957)*

PHYSIOLOGY, GENERAL AND COMPARATIVE

Buddenbrock (1950-1961)
 Gorbman (1959)
 Heilbrunn (1952)
 Martin (1961)
 Prosser and Brown (1961)
 Scheer (1948)
 Waterman (1961)
 Winterstein (1910-1925)

RESPIRATORY DATA

Tissues

De Robertis, Nowinski, and Saez (1960)
 Dittmer and Grebe (1958)
 Fruton and Simmonds (1953)
 Heilbrunn (1952)
 Robbie (1949)
 Wolvekamp and Waterman (1960)

Whole Animals

Dittmer and Grebe (1958)
 Heilbrunn (1952)
 Prosser and Brown (1961)
 Wolvekamp and Waterman (1960)

SUBCELLULAR MORPHOLOGY

Bargmann, Peters, and Wolpers (1960)
 Bessis (1960)*
 Brachet (1957, 1961*)
 Butler (1959)*
 Clark (1961)
 Colowick and Kaplan, vol. 4 (1957)

Dempsey (1958)

De Robertis, Nowinski, and Saez (1960)

Novikoff (1961)

Palade (1956, 1958)

Schmitt and Geschwind (1957)

Selby (1959)

Sjöstrand (1957)

Zamecnik (1958)*

Section 8: BIBLIOGRAPHY

- Allen, Willard R., and A. Glenn Richards
1954. Oxygen uptake of muscle homogenates from three species of insects, in the presence of added succinate, cytochrome *c*, and phosphate. *Canadian Jour. Zool.*, vol. 32, pp. 1-8, figs. 1-5, tables 1, 2.
- Allfrey, Vincent
1959. The isolation of subcellular components. *In* Brachet, Jean, and Alfred E. Mirsky, *The cell: biochemistry, physiology, morphology*. New York, Academic Press, vol. 1, pp. 193-290, figs. 1-11, table 1.
- Allfrey, Vincent, and Alfred E. Mirsky
1960. How cells make molecules. *Sci. Amer.*, vol. 205, pp. 74-82, illus.
- American Public Health Association
1955. *Standard methods for the examination of water, sewage, and industrial wastes*. Tenth edition. New York, pp. 1-522, illus., tables.
- Arvy, L., M. Gabe, and B. Scharrer (eds.)
1956. Colloque international sur l'endocrinologie des invertébrés. *Ann. Sci. Nat., Zool. Biol. Animale*, ser. 11, vol. 18, pp. 123-337, illus.
- Baldwin, Ernest
1938. On the respiratory metabolism of *Helix pomatia*. *Biochem. Jour.*, vol. 32, pp. 1225-1237, fig. 1, tables 1-5.
1949. *An introduction to comparative biochemistry*. Third edition. Cambridge, University Press, pp. i-xiii, 1-164, figs. 1-12, tables 1-9.
1957. *Dynamic aspects of biochemistry*. Third edition. Cambridge, University Press, pp. i-xx, 1-526, figs. 1-39, tables 1-37.
- Balss, Heinrich
1940-1957. *Decapoda*. *In* Bronn, H. G., *Klassen und Ordnungen des Tierreichs*. Leipzig, Akademische Verlagsgesellschaft, vol. 5, div. 1, book 7, nos. 1-5 (morphology), 10-11 (ecology), 12 (systematics), 13 (geographical distribution), pp. 1-669, 1285-1770, figs. 1-740, 1043-1212.
- Bargmann, W., B. Hanström, B. Scharrer, and E. Scharrer (eds.)
1958. *Zweites internationales Symposium über Neurosekretion*. Berlin, Göttingen, and Heidelberg, Springer-Verlag, pp. i-v, 1-126, 71 figs.
- Bargmann, W., D. Peters, and C. Wolpers (eds.)
1960. *Fourth international conference on electron microscopy*, Berlin, Sept. 10-17, 1958. Berlin, Göttingen, and Heidelberg, Springer-Verlag, vol. 2, Biological-medical section, pp. i-xii, 1-639, 650 figs.
- Barker, G. C., and G. W. C. Miner
1961. *Polarography*. *Endeavour*, vol. 20, pp. 26-31, figs. 1-6.
- Barron, E. S. Guzman
1958. The regulatory mechanisms of cellular respiration. *Union Internatl. Sci. Biol.*, ser. B (Colloques), no. 27, *Perspectives in Marine Biology*, pp. 211-232, figs. 1-16, tables 1-14.
- Barron, E. S. Guzman, and Theodore N. Tahmizian
1948. The metabolism of cockroach muscle (*Periplaneta americana*). *Jour. Cellular Comp. Physiol.*, vol. 32, pp. 57-76, figs. 1-4, tables 1-14.
- Barth, L. G.
1942. Regional differences in oxygen consumption of the amphibian gastrula. *Physiol. Zool.*, vol. 15, pp. 30-46, figs. 1-4, pl. 1, tables 1-11.
- Bayliss, L. E.
1959. *Principles of general physiology*. London, Longmans, Green and Co., Ltd., vol. 1, *The physico-chemical background* pp. 370-381.
- Belding, Harwood S., John Field, II, Frank W. Weymouth, and Shannon C. Allen

1942. Studies on the metabolism of marine invertebrate tissue. I. Respiration of the midgut gland of the kelp crab (*Pugettia producta*). *Physiol. Zool.*, vol. 15, pp. 75-88, figs. 1-4, tables 1-6.
- Bessis, Marcel
1960. The ultrastructure of cells. Basel, Sandoz Monographs, pp. 1-112, figs. 1-81.
- Bliss, Dorothy E.
1953. Endocrine control of metabolism in the land crab, *Gecarcinus lateralis* (Fréminville). I. Differences in the respiratory metabolism of sinusglandless and eyestalkless crabs. *Biol. Bull.*, vol. 104, pp. 275-296, figs. 1-9, table 1.
1956. Neurosecretion and the control of growth in a decapod crustacean. In Wingstrand, Karl Georg (ed.), Bertil Hanström. Zoological papers in honour of his sixty-fifth birthday, November 20th, 1956. Lund, Zoological Institute, pp. 56-75, figs. 1-7.
1959. Factors controlling regeneration of legs and molting in land crabs. In Campbell, Frank L. (ed.), Physiology of insect development. Developmental Biology Conference Series, 1956. Chicago, University of Chicago Press, pp. 131-140, figs. 8-13.
1960. Autotomy and regeneration. In Waterman, Talbot H. (ed.), The physiology of Crustacea. New York, Academic Press, vol. 1, pp. 561-589, figs. 1-6.
- Borradaile, L. A., F. A. Potts, L. E. S. Eastham, and J. T. Saunders
1958. The Invertebrata. Third edition revised by G. A. Kerkut. Cambridge, University Press, pp. i-xvii, 1-795, figs. 1-523.
- Boyer, Paul D., Henry Lardy, and Karl Myrback
1959. The enzymes. New York, Academic Press, pp. i-xiii, 1-785, illus., tables.
- Brachet, Jean
1957. Biochemical cytology. New York, Academic Press, pp. i-xiii, 1-535, figs. 1-190.
1961. The living cell. *Sci. Amer.*, vol. 205, pp. 51-61, illus.
- Brecht, K., R. Behrens, and H. Bartels
1954. Untersuchungen über den Sauerstoffverbrauch glatter Muskeln von Kaltblütern. *Pflüger's Arch. Ges. Physiol.*, vol. 259, pp. 306-316, figs. 1-5, tables 1, 2.
- Brecht, K., G. Utz, and E. Lutz
1955. Über die Atmung quergestreifter und glatter Muskeln von Kaltblütern in Ruhe, Dehnung, Kontraktion und Kontraktur. *Pflüger's Arch. Ges. Physiol.*, vol. 260, pp. 524-537, figs. 1-8, table 1.
- Bronn, H. G.
1880-1961. Klassen und Ordnungen des Tierreichs. Leipzig, Akademische Verlagsgesellschaft, vols. 1-6.
- Brooks, Marion A.
1957. Succinoxidase in the American cockroach. *Ann. Ent. Soc. Amer.*, vol. 50, pp. 122-125, fig. 1.
- Brown, Frank A., Jr. (ed.)
1950. Selected invertebrate types. New York, John Wiley and Sons, Inc., London, Chapman and Hall, Ltd., pp. i-xx, 1-597, figs. 1-235.
- Buchsbaum, Ralph, and Lorus J. Milne
1960. The lower animals: Living invertebrates of the world. In The world of nature series. Garden City, New York, Doubleday and Co., Inc., pp. 1-303, illus.
- Buddenbrock, W. von
1945-1954. Physiologie der Decapoden. In Bronn, H. G., Klassen und Ordnungen des Tierreichs. Leipzig, Akademische Verlagsgesellschaft, vol. 5, div. 1, book 7, nos. 7-9, pp. 863-1283, figs. 842-1042, tables 1-151.
- 1950-1961. Vergleichende Physiologie. Lehrbücher und Monographien aus dem Gebiete der exakten Wissenschaften, Reihe der experimentellen Biologie, vols. 6-10. Basel und Stuttgart, Verlag Birkhäuser, vol. 1, Sinnesphysiologie (1952), pp. 1-504, figs. 1-256, tables 1-91; vol. 2, Nervenphysiologie (1953), pp. 1-396, figs. 1-185, tables 1-23; vol. 3, Ernährung, Wasserhaushalt und Mineralhaushalt der Tiere (1956), pp. 1-677, figs. 1-205, tables 1-241; vol. 4, Hormone (1950), pp. 1-492, figs. 1-134, tables 1-106; vol. 5, Physiologie der Erfolgsorgane (1961), pp. 1-390, figs. 1-161, pls. 1-4, tables 1-110.
- Bueding, Ernest, and Bernard Charms
1952. Cytochrome *c*, cytochrome oxidase, and succinoxidase activities of helminths. *Jour. Biol. Chem.*, vol. 196, pp. 615-627, tables 1-9.

- Butler, J. A. V.
1959. Inside the living cell; some secrets of life. London, George Allen and Unwin, Ltd., pp. 1-174, figs. 1-28, pls. 1-8, pls. 1-16, table 1.
- Cadart, Jean
1957. The edible snail. *Sci. Amer.*, vol. 197, pp. 113-118, illus.
- Cardot, H., S. Faure, and A. Arvanitaki
1950. La consommation d'oxygène *in vivo* du myocarde et du nerf des mollusques en relation avec la composition ionique du milieu. *Jour. de Physiol.*, vol. 42, pp. 849-863, figs. 1-4, tables 1-10.
- Carlisle, David B., and Sir Francis G. W. Knowles, Bt.
1959. Endocrine control in crustaceans. Cambridge Monogr. Exp. Biol., no. 10, pp. 1-120, figs. 1-18, pls. 1-5.
- Carter, G. S.
1940. A general zoology of the invertebrates. New York, the Macmillan Co., pp. i-xxviii, 1-509, figs. 1-172.
- Carthy, J. D.
1958. An introduction to the behaviour of invertebrates. London, George Allen and Unwin Ltd., pp. i-xi, 1-380, figs. 1-148, pl. 1, tables 1-15.
- Chance, Britton
1954. Spectrophotometry of intracellular respiratory pigments. *Science*, vol. 120, pp. 767-775, figs. 1-19, table 1.
- Chance, Britton, and G. R. Williams
1956. The respiratory chain and oxidative phosphorylation. In Nord, F. F. (ed.), *Advances in enzymology*. New York and London, Interscience Publishers, vol. 17, pp. 65-134, figs. 1-16, tables 1-7.
- Chang, T. H.
1931. Metabolism of peripheral leg nerves and the ganglionated nerve cord of the lobster. *Proc. Soc. Exp. Biol. Med.*, vol. 28, pp. 954-955.
- Chapheau, Marc
1932. Recherches sur le métabolisme cellulaire de quelques invertébrés marins. *Bull. Sta. Biol. d'Arcachon*, vol. 29, pp. 85-152, figs. 1, 2, tables 1-20.
- Charniaux-Cotton, Hélène
1957. Croissance, régénération et déterminisme endocrinien des caractères sexuels d'*Orchestia gammarella* (Pallas) crustacé amphipode. *Ann. Sci. Nat., Zool.*, ser. 11, vol. 19, pp. 411-560, figs. 1-20, pls. 1-2, graphs 1-13, tables 1-18.
- Chin, Chi-Han, and Ernest Bueding
1954. Occurrence of oxidative phosphorylations in the muscle of *Ascaris lumbricooides*. *Biochim. et Biophys. Acta*, vol. 13, pp. 331-337, tables 1-5.
- Clark, George L. (ed.)
1961. The encyclopedia of microscopy. New York, Reinhold Publ. Co., London, Chapman and Hall, Ltd., pp. i-xiii, 1-693, illus.
- Claude, Albert
1946a. Fractionation of mammalian liver cells by differential centrifugation. I. Problems, methods and preparation of extract. *Jour. Exp. Med.*, vol. 84, pp. 51-59.
1946b. Fractionation of mammalian liver cells by differential centrifugation. II. Experimental procedures and results. *Ibid.*, vol. 84, pp. 61-89, figs. 1-8, tables 1-4.
- Coelho, Rose Robyns, Joan Wright Goodman, and M. Blair Bowers
1959. Chemical studies of the satellite cells of the squid giant nerve fiber. *Exp. Cell Res.*, vol. 20, pp. 1-11, figs. 1, 2, tables 1-4.
- Colowick, Sidney P., and Nathan O. Kaplan (eds.)
1955-1957. *Methods in enzymology*. New York, Academic Press, vol. 1 (1955), pp. i-xxv, 1-835; vol. 2 (1955), pp. i-xx, 1-987; vol. 3 (1957), pp. i-xxiv, 1-1154; vol. 4 (1957), pp. i-xii, 1-979, illus., tables.
- Connelly, C. M.
1952. The oxygen consumption of squid nerve. *Biol. Bull.*, vol. 103, p. 315.
- Conway, Edward J.
1950. *Microdiffusion analysis and volumetric error*. Third revised edition. London, Crosby Lockwood and Son, Ltd., pp. i-xxiv, 1-391, figs. 1-66, tables 1-38.
- Cooperstein, S. J., and Arnold Lazarow
1950. The cytochrome oxidase and succinic dehydrogenase contents of squid (*Loligo pealii*) axoplasm and other nervous tissue. *Biol. Bull.*, vol. 99, p. 356.
1951. A microspectrophotometric method for

- the determination of cytochrome oxidase. *Jour. Biol. Chem.*, vol. 189, pp. 665-670, fig. 1, table 1.
- Cooperstein, S. J., Arnold Lazarow, and Nancy J. Kurfess
1950. A microspectrophotometric method for the determination of succinic dehydrogenase. *Jour. Biol. Chem.*, vol. 186, pp. 129-139, fig. 1, tables 1-3.
- Cross, R. J., John V. Taggart, G. A. Covo, and D. E. Green
1949. Studies on the cyclophorase system. VI. The coupling of oxidation and phosphorylation. *Jour. Biol. Chem.*, vol. 177, pp. 655-678, figs. 1, 2, tables 1-17.
- Crowder, William
1931. *Between the tides*. New York, Dodd, Mead and Co., pp. 1-461, figs. 1-451, pls. 1-34.
- Dalton, Albert J., and Marie D. Felix
1957. Electron microscopy of mitochondria and the Golgi complex. *In Mitochondria and other cytoplasmic inclusions. Symposia Soc. Exp. Biol.*, no. 10, pp. 148-159, pls. 1-13.
- Dam, L. Van
1935. A method for determining the amount of oxygen dissolved in 1 c.c. of water. *Jour. Exp. Biol.*, vol. 12, pp. 80-85, figs. 1-3, tables 1, 2.
- Dann, Margaret, and Edith M. Gardner
1930. Oxygen consumption of the cardiac ganglion of *Limulus polyphemus*. *Proc. Soc. Exp. Biol. Med.*, vol. 28, pp. 200-202, table 1.
- Dempsey, E. W.
1958. Current concepts of cellular structures. *In Palay, Sanford L. (ed.), Frontiers in cytology*. New Haven, Yale University Press, pp. 9-18.
- De Robertis, E. D. P., W. W. Nowinski, and Francisco A. Saez
1960. *General cytology*. Third edition. Philadelphia and London, W. B. Saunders Co., pp. i-xvi, 1-555, illus.
- Deutsch, W.
1936. An improvement of Warburg's method for cutting tissue slices for respiratory experiments. *Jour. Physiol.*, vol. 87, pp. 56P-57P, fig. 1.
- Dickens, Frank
1959. The intracellular regulation of carbohydrate metabolism. *Australian Jour. Exp. Biol. Med. Sci.*, vol. 37, special suppl., pp. S1-S11, fig. 1.
- Dittmer, Dorothy S., and Rudolph M. Grebe (eds.)
1958. *Handbook of respiration*. Wright-Patterson Air Force Base, Ohio, pp. i-xv, 1-403.
- Dixon, Malcolm
1951. *Manometric methods as applied to the measurement of cell respiration and other processes*. Third edition. Cambridge, University Press, pp. i-xvi, 1-165, illus., tables.
- Dixon, Malcolm, and Edwin C. Webb
1958. *Enzymes*. New York, Academic Press, pp. i-xxxiii, 1-782, illus., tables.
- Drabkin, David L.
1950. Spectroscopy: photometry and spectrophotometry. *In Glasser, Otto (ed.), Medical physics*. Chicago, Yearbook Publishers, Inc., vol. 2, pp. 1039-1089, figs. 1-18, tables 1-9.
- Drach, Pierre
1939. Mue et cycle d'intermue chez les crustacés décapodes. *Ann. Inst. Oceanogr.*, vol. 19, pp. 103-391, figs. 1-13, pls. 2-7, tables 1-69.
- Durrani, Muhammad Zarif
1958. Oxidative metabolism of *Parascaris equorum*. *Pakistan Jour. Sci. Res.*, vol. 10, pp. 129-132, figs. 1-3, tables 1-3.
- Duve, Christian de
1957. The enzymic heterogeneity of cell fractions isolated by differential centrifuging. *In Mitochondria and other cytoplasmic inclusions. Symposia Soc. Exp. Biol.*, no. 10, pp. 50-61, tables 1-2.
- Eckstein, B., and M. Abraham
1959. Succinic dehydrogenase activity in estivating and active snails (*Helix Levantina hierosolyma*). *Physiol. Zool.*, vol. 32, pp. 210-212, table 1.
- Ewer, R. F., and H. Munro Fox
1940. On the function of chlorocruorin. *Proc. Roy. Soc. London, ser. B*, vol. 129, pp. 137-153, figs. 1-4, tables 1-4.
- Field, John, II
1948. Respiration of tissue slices. *Methods in Med. Res.*, vol. 1, pp. 289-307.
- Folin, Otto, and Chester J. Farmer
1912. A new method for the determination of total nitrogen in urine. *Jour. Biol. Chem.*, vol. 11, pp. 493-501, figs. 1, 2.

- Foster, John M.
1956. Enzymatic studies of mitochondria and other constituents of lobster and squid nerve fibres. *Jour. Neurochem.*, vol. 1, pp. 84-90, table 1-3.
- Fox, H. Munro
1938. On the blood circulation and metabolism of sabellids. *Proc. Roy. Soc. London, ser. B*, vol. 125, pp. 554-569, fig. 1, tables 1-4.
- Fox, H. Munro, and C. A. Wingfield
1937. Rate of tissue metabolism of marine cold-blooded animals in different latitudes. *Nature*, vol. 139, p. 369, fig. 1.
1938. A portable apparatus for the determination of oxygen dissolved in a small volume of water. *Jour. Exp. Biol.*, vol. 15, pp. 437-445, figs. 1, 2, tables 1-3.
- Frieden, Earl
1959. The enzyme-substrate complex. *Sci. Amer.*, vol. 201, pp. 119-125, illus.
- Fruton, Joseph S., and Sofia Simmonds
1958. *General biochemistry*. Second edition. New York and London, John Wiley and Sons, Inc., pp. i-xii, 1-1077, illus.
- Gabe, M.
1954. La neuro-sécrétion chez les invertébrés. *Ann Biol.*, vol. 30, pp. 5-62, figs. 1-17, tables 1-4.
- Galtsoff, Paul S.
1961. Physiology of reproduction in molluscs. *Amer. Zool.*, vol. 1, pp. 273-289, figs. 1-16, tables 1, 2.
- Galtsoff, Paul S., Frank E. Lutz, Paul S. Welch, and James G. Needham (eds.)
1937. *Culture methods for invertebrate animals*. Ithaca, Comstock Publishing Co., New York, Dover Publications, pp. i-xxxii, 1-590, figs. 1-84, tables.
- Gerard, R. W., and H. K. Hartline
1934. Respiration due to natural nerve impulses. A method for measuring respiration. *Jour. Cellular Comp. Physiol.*, vol. 4, pp. 141-160, figs. 1-3, table 1.
- Ghiretti, F., Anna Ghiretti-Magaldi, and Luisa Tosi
1959. Pathways of terminal respiration in marine invertebrates. II. The cytochrome system of *Aplysia*. *Jour. Gen. Physiol.*, vol. 42, pp. 1185-1205, figs. 1-9, tables 1-9.
- Ghiretti-Magaldi, Anna, A. Giuditta, and F. Ghiretti
1957. A study of the cytochromes of *Octopus vulgaris* Lam. *Biochem. Jour.*, vol. 66, pp. 303-307, figs. 1-7.
1958. Pathways of terminal respiration in marine invertebrates. I. The respiratory system in cephalopods. *Jour. Cellular Comp. Physiol.*, vol. 52, pp. 389-429, figs. 1-10, tables 1-10.
- Gilmour, Darcy
1941. Repayment of the anaerobic oxygen debt in grasshopper skeletal muscle. *Biol. Bull.*, vol. 80, pp. 45-49, tables 1, 2.
- Glaister, Deborah, and Margaret Kerly
1936. The oxygen consumption and carbohydrate metabolism of the retractor muscle of the foot of *Mytilus edulis*. *Jour. Physiol.*, vol. 87, pp. 56-66, tables 1-6.
- Gorbman, Aubrey (ed.)
1959. *Comparative endocrinology*. New York, John Wiley and Sons, Inc., London, Chapman and Hall, Ltd., pp. i-xx, 1-746, illus.
- Gordon, Edwin E., Melvin Spiegel, and Claude A. Villee
1955. An insulin effect on sponge metabolism. *Jour. Cellular Comp. Physiol.*, vol. 45, pp. 479-483, fig. 1, table 1.
- Graham, Kenneth
1946. Respiratory enzyme mechanisms in an insect, with reference to the qualitative and quantitative effects of inhibitors as an approach to insect toxicology. *Trans. Roy. Soc. Canada, ser. 3*, vol. 40, sect. 5 (biol. sci.), pp. 41-76, pls. 1-4, tables 1-15.
- Grassé, Pierre P. (ed.)
1948-1960. *Traité de zoologie. Anatomie, systématique, biologie*. Paris, Masson et Cie, vol. 1, pt. 1, *Phylogénie, protozoaires, généralités, flagelles* (1952), pp. i-xii, 1-1071, figs. 1-830, pl. 1; vol. 1, pt. 2, *Protozoaires, rhizopodes, actinopodes, sporozoaires, cnidosporidies* (1953), pp. 1-1160, figs. 1-833, pls. 1, 2; vol. 5, pt. 1, *Annélides, myzostomides, sipunculien, echiuriens, priapulien, endoproctes, phoronidiens* (1959), pp. 1-1053, mlv-mcxvi, figs.

- 1-875, I-XXIX, pls. 1-5; vol. 5, pt. 2, Bryozoaires, brachiopodes, chetognathes, pogonophores, mollusques (generalités, aplacophores, polyplacophores, mono-placophores, bivalves) (1960), pp. 1053-2219, figs. 876-1830, pls. 1-10; vol. 6, Onycophores, tardigrades, arthropodes, trilobitomorphes, chélicérates (1949), pp. 1-979, figs. 1-719, 4 pls.; vol. 9, Insectes, paléontologie, géonémie, aptérygotes, éphéméroptères, odonoptères, blattoptéroïdes, orthopteroïdes, dermoptéroïdes, coleoptères (1949), pp. 1-1117, figs. 1-752, 2 pls.; vol. 10, pt. 1, Insectes supérieurs et hemiptéroïdes (1951), pp. 1-975, figs. 1-905, pls. 1-5; vol. 11, Échinodermes, stomocordés, procordés (1948), pp. 1-1077, figs. 1-460.
- Green, David E.
 1949. The citric acid cycle and the cyclophorase system. *In* Lardy, Henry A. (ed.), *Respiratory enzymes*. Revised edition. Minneapolis, Burgess Publishing Co., pp. 201-225, figs. 1-4, tables 1-10.
 1951. The cyclophorase system. *In* Edsall, John T. (ed.), *Enzymes and enzyme systems*. Cambridge, Harvard University Press, pp. 15-46, figs. 1-4, tables 1-4.
 1954. Enzymes in metabolic sequences. *In* Greenberg, David M. (ed.), *Chemical pathways of metabolism*. New York, Academic Press, vol. 1, pp. 27-65, table 1.
 1957. Organization in relation to enzymic function. *In* *Mitochondria and other cytoplasmic inclusions*. Symposia Soc. Exp. Biol., no. 10, pp. 30-49, figs. 1-8, tables 1-5.
 1958. Biological oxidation. *Sci. Amer.*, vol. 199, pp. 56-62, illus.
 1959. Mitochondrial structure and function. *In* Hayashi, Teru (ed.), *Subcellular particles*. New York, Ronald Press Co., pp. 84-103, figs. 1-7, tables 1-9.
- Green, David E., and Y. Hatefi
 1961. The mitochondrion and biochemical machines. *Science*, vol. 133, pp. 13-19, figs. 1-5, tables 1-4.
- Green, David E., and Johan Järnefelt
 1959. Enzymes and biological organization. *Perspectives in Biol. and Med.*, vol. 2, pp. 163-184.
- Greenstein, Jesse P.
 1956. Some biochemical characteristics of morphologically separable cancers. *Cancer Res.*, vol. 16, pp. 641-653, figs. 1-12, tables 1-11. Copyright 1956 by the University of Chicago.
- Gumbmann, M., W. Duane Brown, and A. L. Tappel
 1958. Intermediary metabolism of fishes and other aquatic animals. *U. S. Fish and Wildlife Serv., Special Sci. Rept., Fish.*, no. 288, pp. 1-51, figs. 1-6.
- Guttman, Rita
 1935. Differential oxygen uptake of regions of *Limulus* optic nerve as related to distance from the sense organ. *Biol. Bull.*, vol. 69, pp. 356-360, fig. 1.
- Hammen, Carl S., and Paul J. Osborne
 1959. Carbon dioxide fixation in marine invertebrates: a survey of major phyla. *Science*, vol. 130, pp. 1409-1410, tables 1, 2.
- Harmer, S. F. and A. E. Shipley (eds.)
 1895-1909. *The Cambridge natural history*. London, Macmillan and Co., Ltd., vol. 1, Protozoa, Porifera, Coelenterata, Ctenophora, Echinodermata (1906), pp. i-xvii, 1-671, figs. 1-296; vol. 2, Flatworms, Mesozoa, nemertines, threadworms and *Sagitta*, rotifers, polychaet worms, earthworms and leeches, *Gephyrea* and *Phoronis*, Polyzoa (1910), pp. i-xii, 1-560, figs. 1-257; vol. 3, Molluscs, brachiopods (recent), brachiopods (fossil) (1895), pp. i-xi, 1-535, figs. 1-334; vol. 4, Crustacea, trilobites, arachnids, Eurypterida, scorpions and spiders, Tardigrada, Pentastomida, Pycnogonida (1909), pp. i-xviii, 1-566, figs. 1-287; vol. 5, *Peripatus*, myriapods, insects (1910), pp. i-xi, 1-584, figs. 1-371; vol. 6, Insects (1909), pp. i-xii, 1-626, figs. 1-293; vol. 7, Hemichordata, ascidians and *Amphioxus*, fishes (1910), pp. i-xvii, 1-760, figs. 1-440.
- Harvey, George T., and Stanley D. Beck
 1953. Muscle succinoxidase in the American

- cockroach. Jour. Biol. Chem., vol. 201, pp. 765-773, figs. 1, 2, tables 1-3.
- Harvey, William R.
 1956. The effect of carbon monoxide and diphtheria toxin on the injury metabolism of diapausing *Cecropia* silkworms. *Anat. Rec.*, vol. 125, p. 556.
 1961. The respiratory exchange of diapausing pupae of the *Cecropia* silkworm in the presence of carbon¹⁴ monoxide. *Biol. Bull.*, vol. 120, pp. 11-28, figs. 1-5, tables 1-4.
 [MS a.] Metabolic aspects of insect diapause. *Ann. Rev. Ent.*, vol. 7.
 [MS b.] Metabolic studies on the *Cecropia* silkworm with special reference to the pupal diapause. Unpublished thesis for the Ph.D. degree, 1957. Cambridge, Harvard University, pp. 1-115, figs. 1-28, tables 1-21.
- Harvey, William R., and Carroll M. Williams
 1958a. Physiology of insect diapause. XI. Cyanide-sensitivity of the heartbeat of the *Cecropia* silkworm, with special reference to the anaerobic capacity of the heart. *Biol. Bull.*, vol. 114, pp. 23-35, figs. 1-4, tables 1, 2.
 1958b. Physiology of insect diapause. XII. The mechanism of carbon monoxide-sensitivity and -insensitivity during the pupal diapause of the *Cecropia* silkworm. *Ibid.*, vol. 114, pp. 36-53, figs. 1-8, tables 1-5.
 1961. The injury metabolism of the *Cecropia* silkworm - I. Biological amplification of the effects of localized injury. *Jour. Insect Physiol.*, vol. 7, pp. 81-99, figs. 1-9, tables 1-3.
- Hearfield, D. A. H., and B. A. Kilby
 1958. Enzymes of the tricarboxylic acid cycle and cytochrome oxidase in the fat body of the desert locust. *Nature*, vol. 181, pp. 546-547.
- Heilbrunn, L. V.
 1952. An outline of general physiology. Third edition. Philadelphia, W. B. Saunders Co., pp. i-xiii, 1-818, figs. 1-123, tables.
- Higashi, Satoru, and Kiyozo Kawai
 1959. The respiratory metabolism of the tissues of fresh-water mussels. *Bull. Japanese Soc. Sci. Fish.*, vol. 25, pp. 222-227, figs 1, 2, tables 1-3.
- Hogeboom, George H., Edward L. Kuff, and Walter C. Schneider
 1957. Recent approaches to the cytochemical study of mamalian tissues. *Internatl. Rev. Cytol.*, New York, vol. 6, pp. 425-467, table 1.
- Hopkins, Hoyt S.
 1930. Age differences and the respiration in muscle tissues of mollusks. *Jour. Exp. Zool.*, vol. 56, pp. 209-239, figs. 1, 2, pl. 1, tables 1-7.
 1946. The influence of season, concentration of sea water and environmental temperature upon the oxygen consumption of tissues in *Venus mercenaria*. *Ibid.*, vol. 102, pp. 143-158, tables 1-4.
 1949. Metabolic reactions of clams' tissues to change in salinity. I. Ciliary activity, narcotic and cyanide effects, and respiratory quotient. *Physiol. Zool.*, vol. 22, pp. 295-308, tables 1-4.
- Hopkins, Hoyt S., and S. Wing Handford
 1943. Respiratory metabolism during development in two species of *Amblystoma*. *Jour. Exp. Zool.*, vol. 93, pp. 403-414, figs. 1, 2, tables 1-3.
- Horecker, B. L., and J. N. Stannard
 1948. The cytochrome *c*-azide complex. *Jour. Biol. Chem.*, vol. 172, pp. 589-597, figs. 1-5, tables 1, 2.
- Hoskins, Dale D., Vernon H. Cheldelin, and R. W. Newburgh
 1956. Oxidative enzyme systems of the honey bee, *Apis mellifera* L. *Jour. Gen. Physiol.*, vol. 39, pp. 705-713, figs. 1-5, tables 1-5.
- Humphrey, George Frederick
 1946. The endogenous respiration of homogenates of oyster muscle. *Australian Jour. Exp. Biol. Med. Sci.*, vol. 24, pp. 261-267, fig. 1, tables 1-7.
 1947. The succinoxidase system in oyster muscle. *Jour. Exp. Biol.*, vol. 24, pp. 352-360, fig. 1, tables 1-7.
 1948. The effect of narcotics on the endogenous respiration and succinate oxidation in oyster muscle. *Jour. Marine Biol. Assoc. United Kingdom*, vol. 27, pp. 504-512, figs. 1-6, table 1.

Hyman, Libbie Henrietta

1940-1959. The invertebrates. New York and London, McGraw-Hill Book Co., Inc., vol. 1, Protozoa through Ctenophora (1940), pp. i-xii, 1-726; vol. 2, Platyhelminthes and Rhynchocoela (1951), pp. i-vii, 1-550; vol. 3, Acanthocephala, Aschelminthes, and Entoprocta (1951), pp. i-vii, 1-572; vol. 4, Echinodermata (1955), pp. i-vii, 1-763; vol. 5, Chaetognatha, Hemichordata, Pogonophora, Phoronida, Ectoprocta, Brachiopoda, Sipunculida (1959), pp. i-viii, 1-783, illus., tables.

Ito, Toshio, Yasuhiro Horie, and Shigeo Ishikawa

1958. Oxidative enzymes of the midgut of the silkworm *Bombyx mori*. Jour. Insect Physiol., vol. 2, pp. 313-323, figs. 1, 2, tables 1-7.

Jodrey, Louise H., and Karl M. Wilbur

1955. Studies on shell formation. IV. The respiratory metabolism of the oyster mantle. Biol. Bull., vol. 108, pp. 346-358, figs. 1-4, tables 1-5.

Johnson, M. L.

1942. The respiratory function of the haemoglobin of the earthworm. Jour. Exp. Biol., vol. 18, pp. 266-277, figs. 1, 2, tables 1, 2.

Kabat, Elvin A., and Manfred M. Mayer

1948. Experimental immunochemistry. Springfield, Illinois, Charles C. Thomas, pp. i-xv, 1-567, figs. 1-88, tables.

Kalckar, Herman M.

1947. Differential spectrophotometry of purine compounds by means of specific enzymes. III. Studies of the enzymes of purine metabolism. Jour. Biol. Chem., vol. 167, pp. 461-475, figs. 1-4, tables 1, 2.

Karlson, Peter

1956. Biochemical studies on insect hormones. In Harris, Robert S., G. F. Marrian, and Kenneth V. Thimann (eds.), Vitamins and hormones. New York, Academic Press, vol. 14, pp. 227-266, figs. 1-6, tables 1-5.

Kawai, Kiyozo

1957. The metabolism of the pearl oyster, *Pinctada martensii*. III. On the tissue

oxidation. Bull. Japanese Soc. Sci. Fish., vol. 22, pp. 626-630, figs. 1, 2, tables 1-3.

1958. Cytochrome system in oyster tissues. Nature, vol. 181, p. 1468, table 1.

1959. The cytochrome system in marine lamellibranch tissues. Biol. Bull., vol. 117, pp. 125-132, figs. 1-4, tables 1, 2.

Keilin, D.

1925. On cytochrome, a respiratory pigment, common to animals, yeast, and higher plants. Proc. Roy. Soc. London, ser. B, vol. 98, pp. 312-339, figs. 1-6.

Keilin, D., and E. F. Hartree

1949. Effect of low temperature on the absorption spectra of haemoproteins; with observations on the absorption spectrum of oxygen. Nature, vol. 164, pp. 254-259.

Keilin, D., and E. C. Slater

1953. Cytochrome. Brit. Med. Bull., vol. 9, pp. 89-96, figs. 1-5.

Kerkut, G. A., and M. S. Laverack

1957. The respiration of *Helix pomatia*, a balance sheet. Jour. Exp. Biol., vol. 34, pp. 97-105, figs. 1, 2, tables 1-3.

Kermack, W. O., H. Lees, and J. D. Wood

1954. Enzymes of lobster tissues. Biochem. Jour., vol. 57, pp. xxii-xxiii.

Keynes, Richard D.

1958. The nerve impulse and the squid. Sci. Amer., vol. 199, pp. 83-90, illus.

Kilby, B. A., and Elisabeth Neville

1957. Amino-acid metabolism in locust tissues. Jour. Exp. Biol., vol. 34, pp. 276-289, figs. 1-5, tables 1-3.

Kleinholz, L. H.

1957. Endocrinology of invertebrates, particularly of crustaceans. In Scheer, Bradley T. (ed.), Recent advances in invertebrate physiology. Eugene, University of Oregon Publications, pp. 173-196, fig. 1.

Knowles, Sir Francis G. W., Bt.

1959. The control of pigmentary effectors. In Gorbman, Aubrey (ed.), Comparative endocrinology. New York, John Wiley and Sons, Inc., London, Chapman and Hall, Ltd., pp. 223-232, figs. 1, 2.

Knowles, Sir Francis G. W., Bt., and David B. Carlisle

1956. Endocrine control in the Crustacea.

Biol. Rev. (Cambridge Phil. Soc.), vol. 31, pp. 396-473, table 1.

Koller, G.

1960. Die Hormone der wirbellosen Tiere. In Ammon, Robert, and Wilhelm Dirscherl (eds.), *Fermente, Hormone, Vitamine*. Dritte erweiterte Auflage. Stuttgart, Georg Thieme Verlag, vol. 2, Hormone, pp. 814-868, figs. 106-141, tables 85-88.

Korschelt, Eugen

1944. Ontogenie der Decapoden. In Bronn, H. G., *Klassen und Ordnungen des Tierreichs*. Leipzig, Akademische Verlagsgesellschaft, vol. 5, div. 1, book 7, no. 6, pp. 671-861, figs. 741-841.

Kramer, Sol

1954. Succinoxidase activity of the flight muscles of the wasp, *Sceliphron cementarium*. *Nature*, vol. 174, p. 43, fig. 1, tables 1, 2.

Krebs, H. A.

1950. Body size and tissue respiration. *Biochim. and Biophys. Acta*, vol. 4, pp. 249-269, tables 1-9.
1953. Some aspects of the energy transformation in living matter. *Brit. Med. Bull.*, vol. 9, pp. 97-104, tables 1-7.
1954. The tricarboxylic acid cycle. In Greenberg, David M. (ed.), *Chemical pathways of metabolism*. New York, Academic Press, vol. 1, pp. 109-171, figs. 1-4, tables 1-12.

Krishnan, G.

1954. Tyrosinase activity in relation to phenolic tanning of the cuticle in *Carcinus maenas*. *Proc. Natl. Inst. Sci. India*, vol. 20, pp. 157-169, figs. 1, 2, tables 1-5.

Kubišta, Václav

1956. The resting oxygen consumption of insect muscles. *Věstník Československé Zoologické Společnosti (Acta Soc. Zool. Bohemoslovenicae)*, vol. 20, pp. 188-192.

Kükenthal, Willy, and Thilo Krumbach

- 1923-1938. *Handbuch der Zoologie*. Berlin, Walter de Gruyter und Co., vol. 1, Protozoa, Porifera, Coelenterata, Mesozoa (1923-1925); vol. 2, Vermes Apera, Vermes Polymera, Echiurida,

Sipunculida, Priapulida (1928-1934); vol. 3, Tardigrada, Pentastomida, Myzostomida, Arthropoda: Allgemeines, Crustacea, Chelicerata, Pantopoda, Onychophora, Vermes Oligomera (1926-1932); vol. 4, Progoneata, Chilopoda, Insecta (1926-1938); vol. 5, Solenogastres, Mollusca, Echinodermata, Chordata: Tunicata (1925-1933).

Kun, Ernest, and Abood, L. G.

1949. Colorimetric estimation of succinic dehydrogenase by triphenyltetrazolium chloride. *Science*, vol. 109, pp. 144-146, figs. 1-3, table 1.

Kuntz, Eloise

1946. Hormone control of dehydrogenase activity of crustacean tissues. *Biol. Bull.*, vol. 91, pp. 227-228.

Kurland, Charles G., and Howard A. Schneiderman

1959. The respiratory enzymes of diapausing silkworm pupae: a new interpretation of carbon monoxide-insensitive respiration. *Biol. Bull.*, vol. 116, pp. 136-161, figs. 1-11, tables 1-3.

Lankester, Sir Ray (ed.)

- 1900-1909. *A treatise on zoology*. London, Adam and Charles Black, pt. 1, fasc. 1, Introduction and Protozoa (1909), pp. i-xxii, 1-296, illus.; pt. 1, fasc. 2, Introduction and Protozoa (1903), pp. i-vi, 1-451, illus.; pt. 2, Porifera and Coelenterata (1900), pp. i-vi, 1-178, 1-81, 1-84, 1-25, illus.; pt. 3, Echinoderma (1900), pp. i-vi, 1-344, illus.; pt. 4, Platyhelminia, Mesozoa, and Nemertini (1901), pp. i-vi, 1-204, illus.; pt. 5, Mollusca (1906), pp. 1-355, illus.; pt. 7, Appendiculata, fasc. 3 only, Crustacea (1909), pp. i-viii, 1-346, illus.

Laser, H.

1944. The oxidative metabolism of *Ascaris suis*. *Biochem. Jour.*, vol. 38, pp. 333-338, figs. 1-10.

Lees, A. D.

1955. *The physiology of diapause in arthropods*. Cambridge, University Press, pp. i-x, 1-151, figs. 1-25, tables 1-7.

Lehninger, Albert L.

1951. The organized respiratory activity of isolated rat-liver mitochondria. In

- Edsall, John T. (ed.), Enzymes and enzyme systems. Cambridge, Harvard University Press, pp. 1-14, tables 1-3.
1956. Physiology of mitochondria. Relationships between mitochondrial structure, oxidative phosphorylation, and the action of thyroxine. *In* Gaebler, Oliver H. (ed.), Enzymes: units of biological structure and function. New York, Academic Press, pp. 217-233, figs. 1-5, tables 1-5.
1959. Relation of oxidation, phosphorylation, and active transport to the structure of mitochondria. *In* Zirkle, Raymond E. (ed.), A symposium on molecular biology. Chicago, University of Chicago Press, pp. 122-136.
1960. Energy transformations in the cell. *Sci. Amer.*, vol. 202, pp. 102-114, illus.
1961. How cells transform energy. *Ibid.*, vol. 205, pp. 62-73, illus.
- Lehninger, Albert L., Charles L. Wadkins, Cecil Cooper, Thomas M. Devlin, and James L. Gamble, Jr.
1958. Oxidative phosphorylation. *Science*, vol. 128, pp. 450-456, figs. 1-3, table 1.
- Lewis, S. E., and E. C. Slater
1954. Oxidative phosphorylation in insect sarcosomes. *Biochem. Jour.*, vol. 58, pp. 207-217, figs. 1-5, tables 1-9.
- Lilienthal, Joseph L., Jr.
1950. Carbon monoxide. *Pharmacol. Rev.*, vol. 2, pp. 324-354.
- Lindeman, Verlus F.
1939. The respiratory metabolism of the nerves of the blue crab (*Callinectes sapidus*). *Physiol. Zool.*, vol. 12, pp. 214-217, tables 1-3.
- Long, Cyril, Earl J. King, and Warren M. Sperry (eds.)
1961. Biochemists' handbook. Toronto, New York, London, D. Van Nostrand Co., Inc., pp. i-xxii, 1-1192, illus., tables.
- Loomis, W. F., and Fritz Lipmann
1948. Reversible inhibition of the coupling between phosphorylation and oxidation. *Jour. Biol. Chem.*, vol. 173, pp. 807-808, tables 1, 2.
- Lowry, Oliver H., Nira J. Rosebrough, A. Lewis Farr, and Rose J. Randall
1951. Protein measurement with the Folin phenol reagent. *Jour. Biol. Chem.*, vol. 193, pp. 265-275, figs. 1-3, tables 1-4.
- Ludwig, Daniel, Mary C. Barsa, and Carmen T. Cali
1955. The effect of DDT on the activity of cytochrome oxidase. *Ann. Ent. Soc. Amer.*, vol. 48, pp. 165-170, figs. 1-3, tables 1, 2.
- Lundegårdh, H.
1959. Spectrophotometric technique for studies of respiratory enzymes in living material. *Endeavour*, vol. 18, pp. 191-199, figs. 1-13, table 1.
- Ma, T. S., and G. Zuazaga
1942. Micro-Kjeldahl determination of nitrogen. A new indicator and an improved rapid method. *Indus. and Engin. Chem., Analyt. Ed.*, vol. 14, pp. 280-282, figs. 1, 2, tables 1-3.
- MacGinitie, G. E., and Nettie MacGinitie
1949. Natural history of marine animals. New York and London, McGraw-Hill Book Co., Inc., pp. i-xii, 1-473, figs. 1-282.
- McShan, W. H., Sol Kramer, and Vera Schlegel
1954. Oxidative enzymes in the thoracic muscles of the woodroach *Leucophaea maderae*. *Biol. Bull.*, vol. 106, pp. 341-352, figs. 1-4, tables 1-5.
- Maroney, Samuel P., Jr., Albert A. Barber, and Karl M. Wilbur
1957. Studies on shell formation. VI. The effects of dinitrophenol on mantle respiration and shell deposition. *Biol. Bull.*, vol. 112, pp. 92-96, fig. 1, tables 1-3.
- Martin, Arthur W. (ed.)
1961. Comparative physiology of carbohydrate metabolism in heterothermic animals. Seattle, University of Washington Press, pp. i-vii, 1-144, illus.
- Mercer, E. H.
1961. Cells and cell structure. London, Hutchinson Educational Ltd., pp. 1-100, illus., tables.
- Meyerhof, Otto, and Walter Schulz
1929. Über die Atmung des marklosen Nerven.

Biochem. Zeitschr., vol. 206, pp. 158-170, figs. 1-4, tables 1-3.

Morrison, Martin

1961. Biological oxidation. *Ann. Rev. Biochem.*, Palo Alto, vol. 30, pp. 11-44, fig. 1, tables 1, 2.

Morrison, P. E., and A. W. A. Brown

1954. The effects of insecticides on cytochrome oxidase obtained from the American cockroach. *Jour. Econ. Ent.*, vol. 47, pp. 723-730, figs. 1-9, table 1.

Morton, J. E.

1958. Molluscs. London, Hutchinson University Library, New York, Harper and Brothers, pp. 1-232, figs. 1-23.

Nachmansohn, D., H. B. Steinbach, A. L.

Machado, and S. Spiegelman

1943. Localization of enzymes in nerves. II. Respiratory enzymes. *Jour. Neurophysiol.*, vol. 6, pp. 203-211, figs. 1-4, tables 1-3.

Naisse, Jacqueline

1959. Neurosécrétion et glandes endocrines chez les opilions. *Arch. de Biol.*, vol. 70, pp. 217-264, figs. 1-7, pls. 10, 11, table 1.

Navez, A. E., J. D. Crawford, D. Benedict, and A. B. DuBois

1941. On metabolism of the heart of *Venus mercenaria*. *Biol. Bull.*, vol. 81, pp. 289-290.

Nelson, Walter L.

1958. Fat metabolism with reference to insects. *Proc. 10th Internatl. Congr. Ent.*, vol. 2, pp. 359-364, fig. 1, table 1.

Nicol, J. A. Colin

1960. The biology of marine animals. New York, Interscience Publishers, Inc., pp. i-xi, 1-707, illus., tables.

Nomura, Shichiroku

1950. Energetics of the heart muscle of the oyster, work performed and oxygen consumption. *Sci. Rept. Tôhoku Univ.*, ser. 4 (Biol.), vol. 18, pp. 279-285, table 1.

Novikoff, Alex B.

1957. Biochemical heterogeneity of the cytoplasmic particles of rat liver. *In* Mitochondria and other cytoplasmic inclusions. *Symposia Soc. Exp. Biol.*,

no. 10, pp. 92-109, fig. 1, pls. 1-7, tables 1-3.

1959. The intracellular localization of chemical constituents. *In* Mellors, Robert C. (ed.), *Analytical cytology*. Second edition. New York and London, McGraw-Hill Book Co., Inc., pp. 69-168, figs. 1-11.

1961. Mitochondria (chondriosomes). *In* Brachet, Jean, and Alfred E. Mirsky (eds.), *The cell: biochemistry, physiology, morphology*. New York and London, Academic Press, vol. 2, *Cells and their component parts*, pp. 299-421, figs. 1-33.

O'Brien, B. R. A.

1957. Evidence in support of an axial metabolic gradient in the earthworm. *Australian Jour. Exp. Biol. Med. Sci.*, vol. 35, pp. 83-92, figs. 1-3, tables 1-5.

Okamura, Nabuko

1959. Effects of some metabolic inhibitors on the oxygen consumption of the oyster gill. *Sci. Rept. Tôhoku Univ.*, ser. 4 (Biol.), vol. 25, pp. 91-97, figs. 1, 2, tables 1-3.

Pablo, I. S., and A. L. Tappel

1961. Cytochromes of marine invertebrates. *Jour. Cellular Comp. Physiol.*, vol. 58, pp. 185-194, figs. 1, 2, tables 1, 2.

Palade, George E.

1956. Electron microscopy of mitochondria and other cytoplasmic structures. *In* Gaebler, Oliver H. (ed.), *Enzymes: units of biological structure and function*. New York, Academic Press, pp. 185-215, figs. 1-15.

1958. A small particulate component of the cytoplasm. *In* Palay, Sanford L. (ed.), *Frontiers in cytology*. New Haven, Yale University Press, pp. 283-304, figs. 135-149, table 1.

Passano, L. M.

1960. Molting and its control. *In* Waterman, Talbot H. (ed.), *The physiology of Crustacea*. New York, Academic Press, vol. 1, pp. 473-536, figs. 1-6, tables 1, 2.

Pennak, Robert W.

1953. *Fresh-water invertebrates of the United States*. New York, Ronald Press Co., pp. i-ix, 1-769, figs. 1-470, tables 1-12.

- Pérez-González, Maria Dolores, and George A. Edwards
1954. Metabolic differences among several specialized insect muscles. *Bol. Fac. Fil. Ciên. Letr. da Univ. São Paulo, Zool.*, no. 19, pp. 373-389, tables 1, 2.
- Pieh, Sylvia
1936. Über die Beziehungen zwischen Atmung, Osmoregulation und Hydratation der Gewebe bei euryhalinen Meeresevertebraten. *Zool. Jahrb., Abt. Allg. Zool. Physiol. der Tiere*, vol. 56, pp. 129-160, figs. 1-6, tables 1-13.
- Potter, Van R., and Arnold E. Reif
1952. Inhibition of an electron transport component by antimycin A. *Jour. Biol. Chem.*, vol. 194, pp. 287-297, figs. 1-8.
- Prosser, C. Ladd, and Frank A. Brown, Jr.
1961. Comparative animal physiology. Second edition. Philadelphia, W. B. Saunders Co., pp. i-ix, 1-688, figs. 1-278, tables 1-55.
- Raabe, Marie
1959. Neurohormones chez les insectes. *Bull. Soc. Zool. France*, vol. 84, pp. 272-316, figs. 1-17, pls. 1, 2.
- Rees, K. R.
1953. Aerobic metabolism of the hepatopancreas of *Helix pomatia*. *Biochem. Jour.*, vol. 55, pp. 478-484, tables 1-11.
1954. Aerobic metabolism of the muscle of *Locusta migratoria*. *Ibid.*, vol. 58, pp. 196-202, tables 1-12.
- Reif, Arnold E., and Van R. Potter
1953. Studies on succinoxidase inhibition. I. Pseudoirreversible inhibition by a naphthoquinone and by antimycin A. *Jour. Biol. Chem.*, vol. 205, pp. 279-290, figs. 1-4, tables 1, 2.
- Renaud, Lucienne
1949. Le cycle des réserves organiques chez les crustacés décapodes. *Ann. Inst. Oceanogr.*, vol. 24, pp. 259-357, graphs 1-33, tables 1-20, tables I-LXXVIII.
- Richards, O. W., and R. G. Davies
1957. A general textbook of entomology, including the anatomy, physiology, development and classification of insects. Ninth edition, revised. London, Methuen and Co., Ltd., pp. i-xi, 1-886, figs. 1-609.
- Ricketts, Edward F., and Jack Calvin
1952. *Between Pacific tides*. Third edition, revised by Joel W. Hedgpeth. Stanford, University Press, pp. i-xiii, 1-502, figs. 1-134.
- Robbie, W. A.
1948. Use of cyanide in tissue respiration studies. *Methods in Med. Res.*, vol. 1, pp. 307-316, figs. 1-5, tables 1,2.
1949. Respiration of the tissues of some invertebrates and its inhibition by cyanide. *Jour. Gen. Physiol.*, vol. 32, pp. 655-670, figs. 1-7, tables 1-4.
- Roberts, John L.
1957. Thermal acclimation of metabolism in the crab *Pachygrapsus crassipes* Randall. II. Mechanisms and the influence of season and latitude. *Physiol. Zool.*, vol. 30, pp. 242-255, figs. 1-4, tables 1-3.
- Roberts, Nira R., Rose Robyns Coelho, O. H. Lowry, and Elizabeth J. Crawford
1958. Enzyme activities of giant squid axoplasm and axon sheath. *Jour. Neurochem.*, vol. 3, pp. 109-115, fig. 1, tables 1-3.
- Roeder, Kenneth D. (ed.)
1953. *Insect physiology*. New York, John Wiley and Sons, London, Chapman and Hall, Ltd., pp. i-xiv, 1-1100, figs. 1-257.
- Rotta, Andrés, and J. N. Stannard
1939. Studies on the oxygen debt of frog tissues. *Amer. Jour. Physiol.*, vol. 127, pp. 281-289, figs. 1, 2, tables 1, 2.
- Rouiller, Ch.
1960. Physiological and pathological changes in mitochondrial morphology. *Internatl. Rev. Cytol.*, New York, vol. 9, pp. 227-292, figs. 1-23, tables 1-5.
- Sacktor, Bertram
1955. Cell structure and the metabolism of insect flight muscle. *Jour. Biophys. Biochem. Cytol.*, vol. 1, pp. 29-46, tables 1-6.
1961. The role of mitochondria in respiratory metabolism of flight muscle. *Ann. Rev. Ent.*, Palo Alto, vol. 6, pp. 103-130, figs. 1, 2, tables 1-4.
- Sacktor, Bertram, and Dietrich Bodenstern
1952. Cytochrome *c* oxidase activity of vari-

- ous tissues of the American cockroach *Periplaneta americana* (L.). Jour. Cellular Comp. Physiol., vol. 40, pp. 157-161, fig. 1, table 1.
- Sacktor, Bertram, and Gerard M. Thomas
1955. Succino-cytochrome *c* reductase activity of tissues of the American cockroach, *Periplaneta americana* (L.). Jour. Cellular Comp. Physiol., vol. 45, pp. 241-245, table 1.
- Sacktor, Bertram, Gerard M. Thomas, John C. Moser, and Donald I. Block
1953. Dephosphorylation of adenosine triphosphate by tissues of the American cockroach, *Periplaneta americana* (L.). Biol. Bull., vol. 105, pp. 166-173, fig. 1, tables 1-3.
- Sallach, H. J., and R. W. McGilvery
1960. Intermediary metabolism. [A chart.] Middleton, Wisconsin, Gilson Medical Electronics, pts. 1, 2.
- Samuels, Arthur
1956. The effect of sex and allatectomy on the oxygen consumption of the thoracic musculature of the insect, *Leucophaea maderae*. Biol. Bull., vol. 110, pp. 179-183, tables 1-3.
- Sanborn, Richard C., and Carroll M. Williams
1950. The cytochrome system in the Cecropia silkworm, with special reference to the properties of a new component. Jour. Gen. Physiol., vol. 33, pp. 579-588, figs. 1-3, tables 1-3.
- Scharrer, Berta
1959. The role of neurosecretion in neuroendocrine integration. In Gorbman, Aubrey (ed.), Comparative endocrinology. New York, John Wiley and Sons, Inc., London, Chapman and Hall, Ltd., pp. 134-148, figs. 1-3.
- Scharrer, Ernst
1959. General and phylogenetic interpretations of neuroendocrine interrelations. In Gorbman, Aubrey (ed.), Comparative endocrinology. New York, John Wiley and Sons, Inc., London, Chapman and Hall, Ltd., pp. 233-249, figs. 1-3.
- Scharrer, Ernst, and Berta Scharrer
1954a. Hormones produced by neurosecretory cells. In Pincus, Gregory (ed.), Recent progress in hormone research. New York, Academic Press, vol. 10, pp. 183-240, figs. 1-14, tables 1, 2.
- 1954b. Neurosekretion. In von Möllendorff, Wilhelm, and Wolfgang Bargmann (eds.), Handbuch der mikroskopischen Anatomie des Menschen. Berlin, Göttingen, and Heidelberg, Springer-Verlag, vol. 6, pt. 5, pp. 953-1066, figs. 1-71, tables 1-3.
- Scheer, Bradley T.
1948. Comparative physiology. New York, John Wiley and Sons, Inc., London, Chapman and Hall, Ltd., pp. i-x, 1-563, figs. 1-72, tables 1-23.
1960. The neuroendocrine system of arthropods. In Harris, Robert S., and Dwight J. Ingle (eds.), Vitamins and hormones. New York, Academic Press, vol. 18, pp. 141-204.
- Scheer, Bradley T., Theodore H. Bullock, Lewis H. Kleinholz, and Arthur W. Martin (eds.)
1957. Recent advances in invertebrate physiology. Eugene, University of Oregon Publications, pp. i-vi, 1-304, illus.
- Scheer, Bradley T., Calvin W. Schwabe, and Marlin Ann Ray Scheer
1952. Tissue oxidations in crustaceans. Part III of The hormonal regulation of metabolism in crustaceans. Physiol. Comp. et Oecol., vol. 2, pp. 327-338, tables 1-8.
- Schlieper, Carl
1931. Über das Eindringen mariner Tiere in das Süßwasser. Biol. Zentralbl., vol. 51, pp. 401-412.
- Schmitt, F. O., and N. Geschwind
1957. The axon surface. In Butler, J. A. V., and B. Katz (eds.), Progress in biophysics and biophysical chemistry. New York, London, Paris, and Los Angeles, Pergamon Press, vol. 8, pp. 165-215, figs. 1-4, tables 1-7.
- Schneider, W. C.
1946. Intracellular distribution of enzymes. I. The distribution of succinic dehydrogenase, cytochrome oxidase, adenosine triphosphatase and phosphorus compounds in normal rat tissues. Jour. Biol. Chem., vol. 165, pp. 585-593, tables 1-3.
- Schneider, W. C., and V. R. Potter
1943. The assay of animal tissues for respir-

- atory enzymes. II. Succinic dehydrogenase and cytochrome oxidase. *Jour. Biol. Chem.*, vol. 149, pp. 217-227, fig. 1, tables 1-3.
- Schneiderman, Howard A., and Lawrence I. Gilbert
1959. The chemistry and physiology of insect growth hormones. *In* Rudnick, Dorothea (ed.), *Cell, organism and milieu*. New York, Ronald Press Co., pp. 157-187, figs. 1-6, tables 1-6.
- Schneiderman, Howard A., and Carroll M. Williams
1953. The physiology of insect diapause. VII. The respiratory metabolism of the *Cecropia* silkworm during diapause and development. *Biol. Bull.*, vol. 105, pp. 320-334, figs. 1-7, tables 1, 2.
1954a. The physiology of insect diapause. VIII. Qualitative changes in the metabolism of the *Cecropia* silkworm during diapause and development. *Ibid.*, vol. 106, pp. 210-229, figs. 1-6, tables 1-6.
1954b. The physiology of insect diapause. IX. The cytochrome oxidase system in relation to the diapause and development of the *Cecropia* silkworm. *Ibid.*, vol. 106, pp. 238-252, fig. 1, tables 1-6.
- Scholander, P. F.
1942. Volumetric microrespirometers. *Rev. Sci. Instruments*, vol. 13, pp. 32-33, figs. 1-3.
- Scholander, P. F., C. Lloyd Claff, J. R. Andrews, and D. F. Wallach
1952. Microvolumetric respirometry. Methods for measuring O₂ consumption and CO₂ production by cells and enzymic reactions. *Jour. Gen. Physiol.*, vol. 35, pp. 375-395, figs. 1-12, tables 1-3.
- Schwabe, Calvin W., Bradley T. Scheer, and Marlin Ann Ray Scheer
1952. The molt cycle in *Panulirus japonicus*. *Part II of* The hormonal regulation of metabolism in crustaceans. *Physiol. Comp. et Oecol.*, vol. 2, pp. 310-320, figs. 1-4, tables 1-5.
- Sedgwick, Adam
1898-1909. A student's text-book of zoology. London, Swan Sonnenschein and Co., Ltd., New York, the Macmillan Co., vol. 1, Protozoa to Chaetognatha (1898), pp. i-xii, 1-619, figs. 1-472; vol. 2, Am-
phioxus and Vertebrata (1905), pp. i-xv, 1-705, figs. 1-333; vol. 3, Tunicata, Enteropneusta, Echinodermata, and Arthropoda (1909), pp. i-xi, 1-905, figs. 1-570.
- Selby, Cecily Cannan
1959. Electron microscopy: techniques and applications in cytology. *In* Mellors, Robert C. (ed.), *Analytical cytology*. New York and London, McGraw-Hill Book Co., Inc., pp. 273-341, figs. 1-20.
- Shanes, Abraham M., and Hoyt S. Hopkins
1948. Effect of potassium on "resting" potential and respiration of crab nerve. *Jour. Neurophysiol.*, vol. 11, pp. 331-342, figs. 1-6, tables 1, 2.
- Shapiro, Herbert
1937. The relative respiratory activity of sheath and axones in resting *Limulus* optic nerve. *Jour. Cellular Comp. Physiol.*, vol. 9, pp. 381-396, figs. 1, 2, tables 1-3.
- Shappirio, David G.
1960. Oxidative enzymes and the injury metabolism of diapausing *Cecropia* silkworms. *Ann. New York Acad. Med.*, vol. 89, pp. 537-548, figs. 1, 2, tables 1, 2.
- Shappirio, David G., and Carroll M. Williams
1957a. The cytochrome system of the *Cecropia* silkworm. I. Spectroscopic studies of individual tissues. *Proc. Roy. Soc. London, ser. B*, vol. 147, pp. 218-232, figs. 1-5, table 1.
1957b. The cytochrome system of the *Cecropia* silkworm. II. Spectrophotometric studies of oxidative enzyme systems in the wing epithelium. *Ibid.*, ser. B, vol. 147, pp. 233-246, fig. 1, table 1.
- Siekevitz, Philip
1957. Powerhouse of the cell. *Sci. Amer.*, vol. 197, pp. 131-140, illus.
- Sizer, Irwin W.
1957. Chemical aspects of enzyme inhibition. *Science*, vol. 125, pp. 54-59, figs. 1-6.
- Sjöstrand, Fritiof S.
1957. Electron microscopy of cellular constituents. *In* Colowick, Sidney P., and Nathan O. Kaplan (eds.), *Methods in enzymology*. New York, Academic Press, vol. 4, pp. 391-422, figs. 1-14, tables 1, 2.

- Skinner, Dorothy M.
1958. The molt cycle of the land crab, *Gecarcinus lateralis*. *Anat. Rec.*, vol. 132, p. 507.
[MS.] Structure and metabolism of a crustacean tissue during a molt cycle. Unpublished thesis for the Ph.D. degree, 1958. Cambridge, Radcliffe College, pp. 1-88, figs. 1-32, tables 1-19.
- Slater, E. C.
1957. Sarcosomes (muscle mitochondria). In *Mitochondria and other cytoplasmic inclusions*. Symposia Soc. Exp. Biol., no. 10, pp. 110-133, figs. 1-6, tables 1-5.
- Slater, E. C., and S. E. Lewis
1954. Stimulation of respiration by 2:4-dinitrophenol. *Biochem. Jour.*, vol. 58, pp. 337-345, figs. 1-3, tables 1-4.
- Smith, Ralph I., Frank A. Pitelka, Donald P. Abbott, and Frances M. Weesner
1954. Intertidal invertebrates of the central California coast. S. F. Light's "Laboratory and field text in invertebrate zoology," revised. Berkeley and Los Angeles, University of California Press, pp. i-xiv, 1-446, figs. 1-138.
- Stadie, William C., and Benjamin C. Riggs
1944. Microtome for the preparation of tissue slices for metabolic studies of surviving tissues *in vitro*. *Jour. Biol. Chem.*, vol. 154, pp. 687-690, figs. 1-3, tables 1, 2.
- Stannard, J. N., and B. L. Horecker
1948. The *in vitro* inhibition of cytochrome oxidase by azide and cyanide. *Jour. Biol. Chem.*, vol. 172, pp. 599-608, figs. 1-3, table 1.
- Stazione Zoologica di Napoli
1954. Convegno sulla neurosecrezione. *Pubbl. Staz. Zool. Napoli*, vol. 24, suppl., pp. 1-98.
- Sumner, James B., and Karl Myrbäck (eds.)
1950-1952. The enzymes: chemistry and mechanism of action. New York, Academic Press, vol. 1, pt. 1 (1950), pp. i-xvii, 1-724; vol. 1, pt. 2 (1951), pp. i-x, 725-1361; vol. 2, pt. 1 (1951), pp. i-xi, 1-790; vol. 2, pt. 2 (1952), pp. i-xi, 791-1440, illus., tables.
- Tappel, A. L.
1960. Cytochromes of muscles of marine invertebrates. *Jour. Cellular Comp. Physiol.*, vol. 55, pp. 111-126, figs. 1-14, tables 1-3.
- Thunberg, T.
1905. Eine einfache Anordnung, um die Sauerstoffzehrung kleinerer Organismen oder Organe zu demonstrieren. *Zentralbl. für Physiol.*, vol. 19, pp. 308-310, fig. 2.
- Travis, Dorothy F.
1955. The molting cycle of the spiny lobster, *Panulirus argus* Latreille. II. Preecdysial histological and histochemical changes in the hepatopancreas and integumental tissues. *Biol. Bull.*, vol. 108, pp. 88-112, figs. 1-34.
- Turner, C. Donnell
1960. General endocrinology. Third edition. Philadelphia and London, W. B. Saunders Co., pp. i-xi, 1-511, illus.
- Umbreit, W. W., R. H. Burris, and J. F. Stauffer
1957. Manometric techniques. Minneapolis, Burgess Publishing Co., pp. i-iii, 1-338, figs. 1-80, tables 1-38.
- Van der Kloot, William
[MS.] The comparative endocrinology of the invertebrates. *Ann. Rev. Physiol.*, vol. 24.
- Vernberg, F. John
1956. Study of the oxygen consumption of excised tissues of certain marine decapod Crustacea in relation to habitat. *Physiol. Zool.*, vol. 29, pp. 227-234, fig. 1, tables 1-4.
- Villee, Claude, Robert Lichtenstein, Neal Nathanson, and Brita Rolander
1950. Studies of the carbohydrate metabolism of invertebrate tissues *in vitro*. *Biol. Bull.*, vol. 99, p. 365.
- Vincentiis, Mario de
1952. Il ricambio della retina nei teleostei (*Scorpaena scrofa*) e nei cefalopodi (*Octopus vulgaris*). Contributo allo studio del metabolismo retinico. *Pubbl. Staz. Zool. Napoli*, vol. 23, pp. 215-223, tables 1-3.
- Warburg, Otto (ed.)
1931. The metabolism of tumours. Translated by F. Dickens. New York, R. R. Smith, Inc., pp. i-xxx, 1-327, illus., tables.
- Ward, Henry Baldwin, and George Chandler Whipple
1959. Fresh-water biology. Second edition

(Edmondson, W. T., ed.). New York, John Wiley and Sons, Inc., London, Chapman and Hall, Ltd., pp. i-xx, 1-1248, illus.

Watanabe, Mary Ishimoto, and Carroll M.

Williams

1951. Mitochondria in the flight muscles of insects. I. Chemical composition and enzymatic content. *Jour. Gen. Physiol.*, vol. 34, pp. 675-689, figs. 1-5, tables 1-3.

1953. Mitochondria in the flight muscles of insects. II. Effects of the medium on the size, form, and organization of isolated sarcosomes. *Ibid.*, vol. 37, pp. 71-90, figs. 1-5, pl. 1, tables 1-4.

Waterman, Talbot H. (ed.)

1960-1961. The physiology of Crustacea. New York, Academic Press, vol. 1 (1960), pp. i-xvii, 1-670; vol. 2 (1961), pp. i-xiv, 1-681, illus., tables.

Waterman, Talbot H.

1961. Comparative physiology. *In* Waterman, Talbot H. (ed.), The physiology of Crustacea. New York, Academic Press, vol. 2, pp. 521-593, figs. 1-3.

Weichselbaum, T. E.

1946. An accurate and rapid method for the determination of proteins in small amounts of blood serum and plasma. *Tech. Bull. Amer. Jour. Clin. Pathol.*, vol. 10, pp. 40-49, table 1.

Weinbach, Eugene C.

1956. The influence of pentachlorophenol on oxidative and glycolytic phosphorylation in snail tissue. *Arch. Biochem. and Biophys.*, vol. 64, pp. 129-143, fig. 1, tables 1-4.

Weller, Harry, and R. R. Ronkin

1952. Effects of 2, 4-dinitrophenol upon oxygen consumption and ciliary activity in the ctenidia of *Mytilus*. *Proc. Soc. Exp. Biol. Med.*, vol. 81, pp. 65-66, table 1.

Welsh, John H.

1955. Neurohormones. *In* Pincus, G., and K. V. Thimann (eds.), The hormones. New York, Academic Press, vol. 3, pp. 97-151, figs. 1-8, tables 1-4.

1957. Neurohormones or transmitter agents. *In* Scheer, Bradley T. (ed.), Recent advances in invertebrate physiology.

Eugene, University of Oregon Publications, pp. 161-171.

1959. Neuroendocrine substances. *In* Gorbman, Aubrey (ed.), Comparative endocrinology. New York, John Wiley and Sons, Inc., London, Chapman and Hall, Ltd., pp. 121-133, figs. 1, 2.

1961a. Neurohumors and neurosecretion. *In* Waterman, Talbot H. (ed.), The physiology of Crustacea. New York, Academic Press, vol. 2, pp. 281-311, figs. 1-3, table 1.

1961b. Neurohormones of Mollusca. *Amer. Zool.*, vol. 1, pp. 267-272, figs. 1-3, tables 1, 2.

Wennesland, Reidar

1951. A volumetric microrespirometer for studies of tissue metabolism. *Science*, vol. 114, pp. 100-103, figs. 1-3.

Wernstedt, Christer

1944. Metabolism of gill epithelium of a freshwater mussel. *Nature*, vol. 154, p. 463.

Wigglesworth, V. B.

1951. The principles of insect physiology. Fourth edition, revised. London, Methuen and Co., Ltd., pp. i-viii, 1-544, illus.

1954. The physiology of insect metamorphosis. *Cambridge Monogr. Exp. Biol.*, no. 1, pp. i-viii, 1-152, figs. 1-45, pls. 1-4.

1957. The action of growth hormones in insects. *In* The biological action of growth substances. *Symposia Soc. Exp. Biol.*, no. 11, pp. 204-227, figs. 1-6, pls. 1-3.

1959. Metamorphosis, polymorphism, differentiation. *Sci. Amer.*, vol. 200, pp. 100-110, illus.

Williams, Carroll M.

1958. The juvenile hormone. *Sci. Amer.*, vol. 198, pp. 67-74, illus.

Wilson, Douglas P.

1947. They live in the sea. London, Collins, pp. 1-128, pls. 1-90.

1951. Life of the shore and shallow sea. Second edition. London, Nicholson and Watson, pp. i-xvii, 1-213, figs. 1-10, pls. 1-44.

Wilson, Edmund B.

1925. The cell in development and heredity. New York, the Macmillan Co., pp. i-xxxvii, 1-1232, figs. 1-529.

Winterstein, Hans (ed.)

1910-1925. Handbuch der vergleichenden

Physiologie. Jena, Verlag von Gustav Fischer, vol. 1, Physiologie der Körpersäfte Physiologie der Atmung, Erste Hälfte (1925), pp. i-xiii, 1-1456, illus., tables; Zweite Hälfte (1921), pp. i-xii, 1-1052, illus.; vol. 2, Physiologie der Stoffwechsels, Erste Hälfte (1911), pp. i-x, 1-1563, illus.; Zweite Hälfte (1924), pp. i-xi, 1-1152, illus., tables; vol. 3, Physiologie der Energiewechsels, Physiologie der Formwechsels, Erste Hälfte, teil 1 (1914), pp. i-xiii, 1-1188, illus., tables, teil 2 (1914), pp. i-viii, 1-2041, illus.; Zweite Hälfte (1910-1914), pp. i-xii, 1-1060, illus., tables; vol. 4, Physiologie der Reizaufnahme, Reizleitung, und Reizbeantwortung (1913), pp. i-xii, 1-997, illus.

Winterstein, Hans, and Muhtar Basoglu
1939. Sur le métabolisme de la corde nerveuse ventrale du ver de terre. Arch.

Internatl. de Physiol., vol. 48, pp. 370-372.

Wolvekamp, H. P., and Talbot H. Waterman
1960. Respiration. In Waterman, Talbot H. (ed.), The physiology of Crustacea. New York, Academic Press, vol. 1, pp. 35-100, figs. 1-10, tables 1-14.

Yonge, C. M.

1949. The sea shore. London, Collins, pp. i-xvi, 1-311, figs. 1-88, pls. 1-40.

Young, Roger G.

1958. Aldolase and malic dehydrogenase in the fat body of *Periplaneta americana*. Proc. 10th Internatl. Congr. Ent., vol. 2, pp. 369-370.

1959. Oxidative metabolism of insect fat body. Ann. Ent. Soc. Amer., vol. 52, pp. 567-570, figs. 1-3, table 1.

Zamecik, Paul C.

1958. The microsome. Sci. Amer., vol. 198, pp. 118-124.



Section 9: INDEXES

Figures in boldface refer to Section 2: Presentation of Data: A Table of Respiratory Rates of Invertebrate Tissues. Figures in italics refer to Section 6: Glossary.

SYSTEMATIC INDEX

- Acheta domesticus* (Linnaeus), Insecta, **55**
Annelida, 1, 2, **39-43**, 79, 86, 87, 91, 92
Anodonta celensis, Pelecypoda, **21**
Anodonta cellensis (Schröter), **21**
American cockroach. See *Periplaneta americana*
American lobster. See *Homarus americanus*
anemone, sea. See *Condylactis gigantea*
Anthozoa, Coelenterata, 1, 2, **11**, 76
Apis mellifera Linnaeus, Insecta, **55**
Aplysia, Gastropoda, 15-17, 83, 92
Aplysia limacina de Blainville, **17**
Arca ponderosa, **31**
ark shell. See *Noetia ponderosa*
Arthropoda, 1, 2, **43-73**, 76-81, 83-87, 91-93
ascarid, horse. See *Parascaris equorum*
ascarid, pig. See *Ascaris lumbricoides*
Ascaris lumbricoides Linnaeus, Nematoda, **11-13**,
75, 82
Ascaris megalcephala, **13**, 82
Aschelminthes, 1, 2, 11-13, 75, 82
Astacus, Crustacea, **45**
Atrina serrata Sowerby, Pelecypoda, **33**
Australian rock oyster. See *Saxostrea*
commercialis
Axinella rosacea, 9, 75
bee, honey. See *Apis mellifera*
beetle, water scavenger. See *Hydrophilus ater*
Belostoma, Insecta, **55**, 77
bivalve mollusks. See Cephalopoda, Mollusca
black blow fly. See *Phormia regina*
Blattella germanica Linnaeus, Insecta, **55**
blue crab. See *Callinectes sapidus*
blue worm. See *Octolasion cyaneum*
bluebottle fly. See *Calliphora erythrocephala*
Bombyx mori (Linnaeus), Insecta, **55**
brandling. See *Eisenia foetida*
bug, giant water. See *Belostoma*
Burgundy snail. See *Helix pomatia*
Busycon, Gastropoda, **17**
Callinectes sapidus Rathbun, Crustacea, **45**, 77
Calliphora erythrocephala (Meigen), Insecta, **57**,
78, 86
Carcinides maenas, **45-47**, 78-80, 84-86
Carcinus maenas (Linnaeus), Crustacea, **45-47**,
78-80, 84-86
Carpocapsa pomonella (Linnaeus), Insecta, **57**, 77
Cassiopea frondosa (Pallas), Scyphozoa, **11**, 82
Cecropia moth. See *Hyalophora cecropia*
cephalopod mollusks. See Cephalopoda, Mollusca
Cephalopoda, Mollusca, 1, 2, **33-39**, 75-77, 79,
83, 86, 91-94
Chaetopterus, Polychaeta, **39**
Cinachyra cavernosa (Lamarck), Demospongiae,
9, 75
clam. See *Mactra*
clam, hard-shelled. See *Mercenaria mercenaria*
clam, soft-shelled. See *Mya*
Clibinarius vittatus, Crustacea, **47**, 77
Clibinarius vittatus (Bosc), **47**, 77
Clitellata, Annelida, 1, 2, **41-43**, 79, 86, 87, 91, 92
cockroach, American. See *Periplaneta americana*
cockroach, German. See *Blattella germanica*
cockroach, Madeira. See *Leucophaea maderae*
codling moth. See *Carpocapsa pomonella*
Coelenterata, 1, 2, **11**, 76, 81, 82, 94
conch. See *Busycon*
Condylactis gigantea Weinland, Anthozoa, **11**, 76
corals. See *Gorgonia flabellum* and *Plexaura*
flexuosa
crab, blue. See *Callinectes sapidus*
crab, fiddler. See *Uca minax* and *Uca pugilator*
crab, ghost. See *Ocyropsis quadrata*

- crab, green. See *Carcinus maenas*
 crab, hermit. See *Clibinarius vittatus*
 crab, horseshoe. See *Limulus polyphemus*
 crab, kelp. See *Pugettia producta*
 crab, marsh. See *Sesarma cinereum*
 crab, mud. See *Panopeus herbstii*
 crab, purple land. See *Gecarcinus lateralis*
 crab, red-jointed fiddler. See *Uca minax*
 crab, spider. See *Libinia* and *Maja*
 crab, stone. See *Menippe mercenaria*
 crab, striped shore. See *Pachygrapsus crassipes*
Crassostrea gigas (Thunberg), Pelecypoda, 21, 75-77
Crassostrea virginica (Gmelin), 23, 75, 76, 78, 84
 crawfish. See *Panulirus argus*
 crayfish. See *Astacus*
 cricket, greenhouse stone. See *Tachycines asynamorus*
 cricket, house. See *Acheta domesticus*
 cricket, Japanese stone. See *Tachycines asynamorus*
Cristaria plicata (Solander), Pelecypoda, 23, 76, 77
 Crustacea, Arthropoda, 1-2, 45-53, 76-80, 83-86, 91-93, 95
 cucumber, sea, 91. See also *Isostichopus badionotus* and *Thyone*
 cuttlefish. See *Sepia officinalis*
Cydia pomonella, 57, 77
 Demospongiae, Porifera, 1, 2, 9-11, 75
 dented garden snail. See *Helix aspersa*
 desert locust. See *Schistocerca gregaria*
Diastrammena japonica, 73, 80, 86
 differential grasshopper. See *Melanoplus differentialis*
Dreissena, Pelecypoda, 23
Dreissensia, 23
Dysidea crawshayi de Laubenfels, Demospongiae, 9, 75
 earthworm, 43, 91. See *Lumbricus terrestris*
 Echinodermata, 1, 2, 73, 82, 91
 edible land snail, little. See *Helix pisana*
 edible land snail, white-lipped. See *Helix vermiculata*
 edible mussel. See *Mytilus edulis*
Eisenia foetida (Savigny), Clitellata, 41, 79, 86
Eledone, Cephalopoda, 33
 fan, purple sea. See *Gorgonia flabellum*
 feather-duster worm. See *Sabella pavonina*
 fiddler crab. See *Uca minax* and *Uca pugilator*
 fleshfly. See *Sarcophaga bullata*
 fly, black blow. See *Phormia regina*
 fly, bluebottle. See *Calliphora erythrocephala*
 fly, flesh. See *Sarcophaga bullata*
 fly, house. See *Musca domestica*
 fresh-water mussel. See *Anodonta cellensis*, *Cristaria plicata*, and *Hyriopsis schlegelii*
Galleria mellonella (Linnaeus), Insecta, 57
 garden snail, dented. See *Helix aspersa*
 gastropod mollusks. See Gastropoda, Mollusca
 Gastropoda, Mollusca, 1, 2, 15-21, 75, 77, 79, 83, 86, 91-93
Gecarcinus lateralis (Fréminville), Crustacea, 47, 78, 84, 85
Geodia gibberosa Lamarck, Demospongiae, 9, 75
 German cockroach. See *Blattella germanica*
 ghost crab. See *Ocypode quadrata*
 giant water bug. See *Belostoma*
Gorgonia flabellum Linnaeus, Anthozoa, 11, 76
 gorgonian, purple. See *Plexaura flexuosa*
 grasshopper, differential. See *Melanoplus differentialis*
 grasshopper, red-legged. See *Melanoplus femurrubrum*
 greater wax moth. See *Galleria mellonella*
 green crab. See *Carcinus maenas*
 greenhouse stone cricket. See *Tachycines asynamorus*
Gryllus domesticus, 55
Gryphaea angulata Lamarck, Pelecypoda, 25, 77, 78, 84
 hard-shelled clam. See *Mercenaria mercenaria*
 hare, sea. See *Aplysia*
 Helicacea, Gastropoda, 92
Helix aspersa Müller, Gastropoda, 17, 79, 86
Helix hierosolyma, 19
Helix pisana Müller, 17
Helix pomatia Linnaeus, 17-19, 75, 77, 83
Helix vermiculata Müller, 19
 hermit crab. See *Clibinarius vittatus*
 Holothuroidea, Echinodermata, 1, 2, 73, 82
Homarus americanus Milne-Edwards, Crustacea, 47-49, 76
Homarus gammarus (Linnaeus), 49, 80, 85
Homarus vulgaris, 49, 80, 85
 honey bee. See *Apis mellifera*

- horseshoe crab. See *Limulus polyphemus*
- house cricket. See *Acheta domesticus*
- house fly. See *Musca domestica*
- Hyalophora cecropia* (Linnaeus), Insecta, 5, 57-63, 76, 78, 82, 83
- Hydrophilus ater* Olivier, Insecta, 63, 77
- Hydrozoa, Coelenterata, 1, 2, 11, 76
- Hyriopsis schlegelii* (von Martens), Pelecypoda, 25, 76, 77
- Insecta, Arthropoda, 1, 2, 55-73, 76-81, 83, 84, 86, 87, 91-93, 96, 97
- insects. See Insecta, Arthropoda
- Ircinia fasciculata* (Pallas), Demospongiae, 9, 75
- Isognomon alata* (Gmelin), Pelecypoda, 25, 76
- Isostichopus badionotus* (Selenka), Holothuroidea, 73, 82
- Japanese stone cricket. See *Tachycines asynamorus*
- jellyfish. See *Cassiopea frondosa* and *Pelagia noctiluca*
- jellyfishes, 94. See also Scyphozoa, Coelenterata
- Jerusalem land snail. See *Levantina hierosolyma*
- kelp crab. See *Pugettia producta*
- land crab, purple. See *Gecarcinus lateralis*
- land snails. See *Helix* and *Levantina*
- Leander adpersus*, 51, 80, 85
- leech, 43, 91
- Leucophaea maderae* (Fabricius), Insecta, 63, 77, 80, 84
- Levantina hierosolyma* (Boiss), Gastropoda, 19
- Libinia dubia* Milne-Edwards, Crustacea, 49, 77
- Libinia emarginata* Leach, 49, 79, 86
- Limulus polyphemus* (Linnaeus), Merostomata, 1, 43-45, 77, 79, 80, 83, 87
- Lissodendoryx isodictyalis* (Carter), Demospongiae, 9, 75
- little edible land snail. See *Helix pisana*
- Litomosoides carinii* (Travassos), Nematoda, 82
- lobster, 49, 77
- lobster, American. See *Homarus americanus*
- lobster, spiny. See *Panulirus argus*
- locust, desert. See *Schistocerca gregaria*
- locust, migratory. See *Locusta migratoria*
- locust, South American. See *Schistocerca infumata*
- Locusta migratoria* (Linnaeus), Insecta, 63
- Loligo pealeii* Lesueur, Cephalopoda, 33-35, 76
- Lumbricus terrestris* Linnaeus, Clitellata, 43
- Lymnaea stagnalis* (Linnaeus), Gastropoda, 21
- Mactra*, Pelecypoda, 27
- Madeira cockroach. See *Leucophaea maderae*
- Maja*, Crustacea, 51
- manure worm. See *Eisenia foetida*
- marsh crab. See *Sesarma cinereum*
- mealworm, yellow. See *Tenebrio molitor*
- Melanoplus differentialis* (Thomas), Insecta, 65
- Melanoplus femurrubrum* (De Geer), 65
- Menippe mercenaria* (Say), Crustacea, 51, 77
- Mercenaria mercenaria* (Linnaeus), Pelecypoda, 27-29, 76-79, 84, 86
- Merostomata, Arthropoda, 1, 2, 43-45, 77, 79, 80, 83, 87
- Microciona prolifera* (Ellis and Solander), Demospongiae, 9
- migratory locust. See *Locusta migratoria*
- Mollusca, 1, 2, 15-39, 75-79, 81, 83, 84, 86, 91-94
- mollusks, bivalve. See Pelecypoda, Mollusca
- mollusks, cephalopod. See Cephalopoda, Mollusca
- mollusks, gastropod. See Gastropoda, Mollusca
- moth, Cecropia. See *Hyalophora cecropia*
- moth, codling. See *Carpocapsa pomonella*
- moth, greater wax. See *Galleria mellonella*
- moth, Polyphemus. See *Telea polyphemus*
- moth, saturniid, 83. See also *Hyalophora cecropia* and *Telea polyphemus*
- mud crab. See *Panopeus herbstii*
- mud dauber wasp. See *Sceliphron cementarius*
- Musca domestica* Linnaeus, Insecta, 65
- mussel. See *Mytilus* and *Driessena*
- mussel, edible. See *Mytilus edulis*
- mussel, fresh-water. See *Anodonta cellensis*, *Cristaria plicata*, and *Hyriopsis schlegelii*
- Mya*, Pelecypoda, 29
- Mytilus*, Pelecypoda, 29, 75
- Mytilus crassitesta* Lischke, 29
- Mytilus edulis* Linnaeus, 29
- Mytilus galloprovincialis* Lamarck, 29, 79, 86
- Nematoda, Aschelminthes, 1, 2, 11-13, 75, 82
- night crawler. See *Lumbricus terrestris*
- Noetia ponderosa* (Say), Pelecypoda, 31
- Octolasion cyaneum* (Savigny), Clitellata, 43, 79, 87
- octopus. See *Eledone* and *Octopus*
- Octopus*, Cephalopoda, 37, 83

- Octopus macropus* Risso, 37, 75
Octopus vulgaris Lamarck, 37-39, 77, 83
Ocypode albicans, Crustacea, 51, 77
Ocypode quadrata (Fabricius), 51, 77
orange, sea. See *Tethya aurantia*
Ostrea circumpicta Pilsbry, Pelecypoda, 31
Ostrea gigas, 21, 75-77
Ostrea virginica, 23, 75-76, 78, 84
oyster. See *Crassostrea gigas* and *Ostrea circumpicta*
oyster, Australian rock. See *Saxostrea commercialis*
oyster, pearl. See *Pinctada martensii*
oyster, Portuguese. See *Gryphaea angulata*
oyster, tree. See *Isognomon alata*
oyster, Virginia. See *Crassostrea virginica*
- Pachygrapsus crassipes* Randall, Crustacea, 51
Palaemon squilla (Linnaeus), Crustacea, 51, 80, 85
Pandalus borealis Krøyer, Crustacea, 53
Pandalus montagui Leach, 53
Panopeus herbstii Milne-Edwards, Crustacea, 53, 77
Panulirus argus (Latreille), Crustacea, 53, 76
Parascaris equorum Goeze, Nematoda, 13, 82
parchment worm. See *Chaetopterus*
peacock worm. See *Sabella pavonina*
pearl oyster. See *Pinctada martensii*
Pecten, Pelecypoda, 31
Pecten irradians Lamarck, 31
Pedalion alata, 25, 76
Pelagia cyanella, Scyphozoa, 11
Pelagia noctiluca (Forskål), 11
Pelecypoda, Mollusca, 1, 2, 21-33, 75-79, 84, 86, 91, 93
pen shell. See *Pinna muricata*
Periplaneta americana (Linnaeus), Insecta, 65-71, 76-79, 84, 86, 87
petit-gris. See *Helix aspersa*
Phormia regina (Meigen), Insecta, 71, 78
Physalia pelagica, Hydrozoa, 11, 76
Physalia physalis (Linnaeus), 11, 76
Pinctada martensii (Dunker), Pelecypoda, 31, 75-77, 79
Pinna muricata Linnaeus, Pelecypoda, 33
Platyhelminthes, 1, 82
Platysamia cecropia, 5, 57-63, 76, 78, 82, 83
Plexaura flexuosa Kükenthal, Anthozoa, 11, 76
Polychaeta, Annelida, 1, 2, 39-41
Polyphemus moth. See *Telea polyphemus*
pond snail. See *Lymnaea stagnalis*
- Porifera, 1, 2, 9-11, 75, 81
Portuguese man-of-war. See *Physalia physalis*
Portuguese oyster. See *Gryphaea angulata*
prawn. See *Pandalus borealis*. See also shrimp
Pseudaxinella rosacea (Verrill), Demospongiae, 9, 75
Pugettia producta (Randall), Crustacea, 53, 77
purple gorgonian. See *Plexaura flexuosa*
purple land crab. See *Gecarcinus lateralis*
purple sea fan. See *Gorgonia flabellum*
- quahog. See *Mercenaria mercenaria*
- red-jointed fiddler crab. See *Uca minax*
red-legged grasshopper. See *Melanoplus femurrubrum*
- Sabella pavonina* Savigny, Polychaeta, 39-41
Sarcophaga bullata Parker, Insecta, 71, 78
saturniid moth, 83. See also *Hyalophora cecropia* and *Telea polyphemus*
Saxostrea commercialis Iredale, Pelecypoda, 33
scallop. See *Pecten*
Sceliphron cementarius (Drury), Insecta, 71
Schistocerca gregaria (Forskål), Insecta, 71
Schistocerca infumata Scudder, 73, 77
Schistosoma mansoni Sambon, Trematoda, 82
Scyphozoa, Coelenterata, 1, 2, 11, 82
sea anemone. See *Condylactis gigantea*
sea cucumber, 91. See also *Isostichopus badionotus* and *Thyone*
sea fan, purple. See *Gorgonia flabellum*
sea hare. See *Aplysia*
sea orange. See *Tethya aurantia*
Sepia officinalis Linnaeus, Cephalopoda, 39, 79, 86
Sesarma cinerea, Crustacea, 53, 77
Sesarma cinereum (Bosc), 53, 77
shore crab, striped. See *Pachygrapsus crassipes*
shrimp. See *Palaemon squilla*
shrimp, pink. See *Pandalus montagui*. See also prawn.
silkworm. See *Bombyx mori*
snail, Burgundy. See *Helix pomatia*
snail, dented garden. See *Helix aspersa*
snail, Jerusalem land. See *Levantina hierosolyma*
snail, little edible land. See *Helix pisana*
snail, pond. See *Lymnaea stagnalis*
snail, vineyard. See *Helix pomatia*
snail, white-lipped edible land. See *Helix vermiculata*

- snails. See Gastropoda, Mollusca
 snails, land. See *Helix* and *Levantina*
 soft-shelled clam. See *Mya*
 South American locust. See *Schistocerca infumata*
Sphaciospongia, Demospongiae, 9, 75
 spider crab. See *Libinia* and *Maja*
 spiny lobster. See *Panulirus argus*
 sponge, fire. See *Tedania ignis*
 sponge, red oyster. See *Microcionia prolifera*
 sponge, stinker. See *Ircinia fasciculata*
 sponges. See Porifera; also *Cinachyra cavernosa*, *Dysidea crawshayi*, *Geodia gibberosa*, *Lissodendoryx isodictyalis*, *Pseudaxinella rosacea*, *Sphaciospongia*, *Terpios fugax*, and *Tethya aurantia*
 squid, 37. See also *Loligo pealeii*
Stichopus mobii, 73, 82
 stone crab. See *Menippe mercenaria*
 stone cricket, greenhouse. See *Tachycines asynamorus*
 striped shore crab. See *Pachygrapsus crassipes*
Tachycines asynamorus Adelung, Insecta, 73, 80, 86
Tedania ignis (Duchassaing and Michelotti), Demospongiae, 9, 75
Telea polyphemus Cramer, Insecta, 73
Tenebrio molitor Linnaeus, Insecta, 73, 78
Terpios fugax (Duchassaing and Michelotti), Demospongiae, 11, 75
Tethya aurantia (Pallas), Demospongiae, 11, 75
Thyone, Holothuroidea, 73
 tree oyster. See *Isognomon alata*
 Trematoda, Platyhelminthes, 82
Uca minax (Le Conte), Crustacea, 53, 77
Uca pugilator (Bosc), 53, 77
Venus mercenaria, 27-29, 76-79, 84, 86
 vineyard snail. See *Helix pomatia*
 Virginia oyster. See *Crassostrea virginica*
 wasp, mud dauber. See *Sceliphron cementarius*
 wax moth, greater. See *Galleria mellonella*
 water scavenger beetle. See *Hydrophilus ater*
 white-lipped edible land snail. See *Helix vermiculata*
 worm, blue. See *Octolasion cyaneum*
 worm, earth, 43, 91. See also *Lumbricus terrestris*
 worm, feather-duster. See *Sabella pavonina*
 worm, manure. See *Eisenia foetida*
 worm, parchment. See *Chaetopterus*
 worm, peacock. See *Sabella pavonina*
Xiphosura polyphemus, 1, 43-45, 77, 79, 80, 83, 87
 yellow mealworm. See *Tenebrio molitor*

AUTHOR INDEX

- Abbott, D. P., 97
 Abood, L. G., 19
 Abraham, M., 19
 Allen, S. C., 53, 77, 84
 Allen, W. R., 67, 71-73, 78, 84, 86
 Allfrey, V., 95, 98
 American Public Health Association, 98
 Andrews, J. R., 35, 98
 Arvanitaki, A., 17-19, 29, 39, 79, 86
 Arvy, L., 95-97, 99
 Baldwin, E., 17-19, 95-98
 Balss, H., 95
 Barber, A. A., 23, 75
 Bargmann, W., 96-97, 99
 Barker, G. C., 98
 Barron, E. S. G., 37, 45, 65, 77, 84
 Barsa, M. C., 69
 Bartels, H., 43
 Barth, L. G., 98
 Basoglu, M., 43
 Bayliss, L. E., 98
 Beck, S. D., 67, 76
 Behrens, R., 43
 Belding, H. S., 53, 77, 84
 Benedict, D., 76
 Bessis, M., 96, 99
 Bliss, D. E., 85, 95, 99
 Block, D. I., 69
 Bodenstein, D., 67
 Borradaile, L. A., 97
 Bowers, M. B., 35
 Boyer, P. D., 96
 Brachet, J., 99
 Brecht, K., 21, 43
 Bronn, H. G., 97

- Brooks, M. A., 69, 78, 86
 Brown, A. W. A., 67
 Brown, F. A., Jr., 97, 99
 Brown, W. D., 81, 95
 Buchsbaum, R., 97
 Buddenbrock, W. von, 95, 97, 99
 Bueding, E., 13, 75, 82
 Bullock, T. H., 97
 Burris, R. H., 98
 Butler, J. A. V., 99
- Cadart, J., 97
 Cali, C. T., 69
 Calvin, J., 97
 Cardot, H., 17-19, 29, 39, 79, 86
 Carlisle, D. B., 95
 Carter, G. S., 97
 Carthy, J. D., 97
 Chance, B., 95, 96, 98, 99
 Chang, T. H., 43, 47, 76
 Chapeau, M., 25, 77, 78, 83-84
 Charms, B., 13, 82
 Charniaux-Cotton, H., 85
 Cheldelin, V. H., 55
 Chin, C.-H., 13, 75
 Claff, C. L., 35, 98
 Clark, G. L., 96, 99
 Claude, A., 3, 98
 Coelho, R. R., 35
 Colowick, S. P., 95, 96, 98, 99
 Connelly, C. M., 35, 94
 Conway, E. J., 71
 Cooper, C., 99
 Cooperstein, S. J., 35, 95, 96
 Covo, G. A., 95, 96, 99
 Crawford, E. J., 35
 Crawford, J. D., 76
 Cross, R. J., 95, 96, 99
 Crowder, W., 97
- Dalton, A. J., 99
 Dam, L. Van, 98
 Dann, M., 43
 Davies, R. G., 96
 Dempsey, E. W., 99, 100
 De Robertis, E. D. P., 95, 96, 98-100
 Deutsch, W., 1, 98
 Devlin, T. M., 99
 Dickens, F., 97, 99
 Dittmer, D. S., 99
 Dixon, M., 96, 98
 Drabkin, D. L., 98
- Drach, P., 85
 DuBois, A. B., 76
 Durrani, M. Z., 13
 Duve, C. de, 95, 96, 98
- Eastham, L. E. S., 97
 Eckstein, B., 19
 Edwards, G. A., 55, 63, 67, 73, 77, 78, 83, 84
 Ewer, R. F., 41
- Farmer, C. J., 67
 Farr, A. L., 35, 47-49, 55-57, 71-73
 Faure, S., 17-19, 29, 39, 79, 86
 Felix, M. D., 99
 Field, J., II, 3, 53, 77, 84, 98
 Folin, O., 67
 Foster, J. M., 35, 47
 Fox, H. M., 39-41, 53, 98
 Frieden, E., 96
 Fruton, J. S., 95, 99
- Gabe, M., 95-97, 99
 Galtsoff, P. S., 97
 Gamble, J. L., Jr., 99
 Gardner, E. M., 42
 Gerard, R. W., 43-45
 Geschwind, N., 35, 100
 Ghiretti, F., 15-17, 37-39, 75, 77, 83
 Ghiretti-Magaldi, A., 15-17, 37-39, 75, 77, 83
 Gilbert, L. I., 96, 97
 Gilmour, D., 65
 Giuditta, A., 37-39, 75, 77, 83
 Glaister, D., 29
 Goodman, J. W., 35
 Gorbman, A., 99
 Gordon, E. E., 9
 Graham, K., 57, 77, 84
 Grasse, P. P., 97
 Grebe, R. M., 99
 Green, D. E., 95, 96, 99
 Greenstein, J. P., 3
 Gumbman, M., 81, 95
 Guttman, R., 43, 80, 87
- Hammen, C. S., 81, 95
 Handford, S. W., 27, 49
 Hanström, B., 97, 99
 Harmer, S. F., 97
 Hartline, H. K., 43-45
 Hartree, E. F., 5, 82
 Harvey, G. T., 67, 76
 Harvey, W. R., 57, 73, 82, 83, 86, 96

- Hatefi, Y., 95, 96, 99
Heilbrunn, L. V., 99
Higashi, S., 23-25, 76, 77, 83
Hogeboom, G. H., 95, 98, 99
Hopkins, H. S., 23, 27, 31-33, 49, 76-79, 83, 84, 86
Horecker, B. L., 96
Horie, Y., 55
Hoskins, D. D., 55
Humphrey, G. F., 33
Hyman, L. H., 97

Ito, T., 55
Ishikawa, S., 55

Järnefelt, J., 95, 96, 99
Jodrey, L. H., 23, 76
Johnson, M. L., 43

Kabat, E. A., 59-63
Kalckar, H. M., 15
Kaplan, N. O., 95, 96, 98, 99
Karlson, P., 97
Kawai, K., 21-25, 29-31, 75-77, 79, 83, 86
Keilin, D., 5, 82, 96, 99
Kerkut, G. A., 19, 77, 83
Kerly, M., 29
Kermack, W. O., 49, 77, 83
Keynes, R. D., 1
Kilby, B. A., 71
King, E. J., 95, 96, 99
Kleinholz, L. H., 95, 97
Knowles, F. G. W., 95, 99
Koller, G., 95, 97, 99
Korschelt, E., 95
Kramer, S., 63, 71
Krebs, H. A., 3, 81, 95, 97, 99
Krishnan, G., 47, 78, 80, 84, 85
Krumbach, T., 97
Kubišta, V., 69, 73, 78-80, 84, 86, 87
Kuff, E. L., 95, 98, 99
Kükenthal, W., 97
Kun, E., 19
Kuntz, E., 85
Kurfess, J. J., 96
Kurland, C. G., 82, 83

Lankester, R., 97
Lardy, H., 96
Laser, H., 11, 82
Laverack, M. S., 19, 77, 83
Lazarow, A., 35, 95, 96

Lees, A. D., 96
Lees, H., 49, 77, 83
Lehninger, A. L., 95, 96, 99
Lewis, S. E., 57, 78, 81, 86, 96
Lichtenstein, R., 17, 27-31, 39, 73
Lilienthal, J. L., Jr., 96
Lindeman, V. F., 45
Lipmann, F., 96, 99
Long, C., 95, 96, 99
Loomis, W. F., 96, 99
Lowry, O. H., 35, 47-49, 55-57, 71-73
Ludwig, D., 69
Lundegårdh, H., 96, 98
Lutz, E., 21
Lutz, F. E., 97

Ma, T. S., 67, 71-73
McGilvery, R. W., 97
MacGinitie, G. E., 97
MacGinitie, N., 97
Machado, A. L., 37
McShan, W. H., 63
Maroney, S. P., Jr., 23, 75
Martin, A. W., 97, 99
Mayer, M. M., 59-63
Mercer, E. H., 95
Meyerhof, O., 15, 33, 37, 45, 51
Milne, L. J., 97
Miner, G. W. C., 98
Mirsky, A. E., 98
Morrison, M., 96, 99
Morrison, P. E., 67
Morton, J. E., 97
Moser, J. C., 69
Myrbäck, K., 96

Nachmansohn, D., 37
Naisse, J., 97, 99
Nathanson, N., 17, 27-31, 39, 73
Navez, A. E., 76
Needham, J. G., 97
Nelson, W. L., 71
Neville, E., 71
Newburgh, R. W., 55
Nicol, J. A. C., 97
Nomura, S., 31
Novikoff, A. B., 95, 96, 98-100
Nowinski, W. W., 95, 96, 98-100

O'Brien, B. R. A., 41-43, 79, 87
Okamura, N., 21, 76
Osborne, P. J., 81, 95

- Pablo, I. S., 81, 96
 Palade, G. E., 95, 96, 98-100
 Passano, L. M., 85, 95
 Pennak, R. W., 97
 Pérez-González, M. D., 55, 63, 67, 73, 77, 78, 83, 84
 Peters, D., 96, 99
 Pieh, S., 29, 45, 79, 86
 Pitelka, F. A., 97
 Potter, V. R., 96
 Potts, F. A., 97
 Prosser, C. L., 97, 99

 Raabe, M., 96, 97
 Randall, R. J., 35, 47-49, 55-57, 71-73
 Rees, K. R., 19, 63, 75
 Reif, A. E., 96
 Renaud, L., 85
 Richards, A. G., 67, 71-73, 78, 84, 86
 Richards, O. W., 96
 Ricketts, E. F., 97
 Riggs, B. C., 1, 98
 Robbie, W. A., 3, 9-11, 25, 33, 53, 73, 75, 76, 81, 82, 96-99
 Roberts, J. L., 51
 Roberts, N. R., 35
 Roeder, K. D., 97
 Rolander, B., 17, 27-31, 39, 73
 Ronkin, R. R., 75
 Rosebrough, N. J., 35, 47-49, 55-57, 71-73
 Rotta, A., 65
 Rouiller, C., 99

 Sacktor, B., 65-69, 78, 81, 84, 96, 99
 Saez, F. A., 95, 96, 98-100
 Sallach, H. J., 97
 Samuels, A., 63, 77, 80, 84
 Sanborn, R. C., 57
 Saunders, J. T., 97
 Scharrer, B., 95-97, 99
 Scharrer, E., 97, 99
 Scheer, B. T., 45, 49-51, 80, 85, 95, 97, 99
 Scheer, M. A. R., 45, 49-51, 80, 85
 Schlegel, V., 63
 Schlieper, C., 29
 Schmitt, F. O., 35, 100
 Schneider, W. C., 3, 82, 95, 96, 98, 99
 Schneideman, H. A., 82, 83, 86, 96, 97
 Scholander, P. F., 35, 55, 63, 67, 73, 98
 Schulz, W., 15, 33, 37, 45, 51
 Schwabe, C. W., 45, 49-51, 80, 85
 Sedgwick, A., 97

 Selby, C. C., 96, 99, 100
 Shanes, A. M., 49, 79, 86
 Shapiro, H., 45, 77, 80, 83, 87
 Shappirio, D. G., 5, 59-63, 76, 78, 79, 81-83, 86, 96
 Shipley, A. E., 97
 Siekevitz, P., 95, 98, 99
 Simmonds, S., 95, 99
 Sizer, I. W., 96
 Sjöstrand, F. S., 96, 99, 100
 Skinner, D. M., 47, 78, 84, 85
 Slater, E. C., 57, 78, 81, 86, 96, 99
 Smith, R. I., 97
 Sperry, W. M., 95, 96, 99
 Spiegel, M., 9
 Spiegelman, S., 37
 Stadie, W. C., 1, 98
 Stannard, J. N., 65, 96
 Stauffer, J. F., 98
 Stazione Zoologica di Napoli, 97, 99
 Steinbach, H. B., 37
 Sumner, J. B., 96

 Taggart, J. V., 95, 96, 99
 Tahmisian, T. N., 65, 77, 84
 Tappel, A. L., 81, 95, 96
 Thomas, G. M., 69, 78, 84
 Thunberg, T., 23, 27, 31-33, 98
 Tosi, L., 15-17, 83
 Travis, D. F., 85
 Turner, C. D., 95-97, 99

 Umbreit, W. W., 98
 Utz, G., 21

 Van der Kloot, W., 98
 Vernberg, F. J., 45-53, 77, 83, 84
 Villet, C. A., 9, 17, 27-31, 39, 73
 Vincentiis, M. de, 37

 Wadkins, C. L., 99
 Wallach, D. F., 35, 98
 Warburg, O., 1, 98
 Ward, H. B., 97
 Watanabe, M. I., 71, 78, 99
 Waterman, T. H., 95, 99
 Webb, E. C., 96
 Weesner, F. M., 97
 Weichselbaum, T. E., 55
 Weinbach, E. C., 21
 Welch, P. S., 97
 Weller, H., 75

- Welsh, J. H., 95, 97, 99
 Wennesland, R., 51, 98
 Wernstedt, C., 23
 Weymouth, F. W., 53, 77, 84
 Whipple, G. C., 97
 Wigglesworth, V. B., 96, 97
 Wilbur, K. M., 23, 75, 76
 Williams, C. M., 5, 57-63, 71, 76, 78, 81-83, 86, 96, 97, 99
 Williams, G. R., 95, 96, 99
 Wilson, D. P., 97
 Wilson, E. B., 95
 Wingfield, C. A., 53, 98
 Winterstein, H., 43, 99
 Wolpers, C., 96, 99
 Wolvekamp, H. P., 99
 Wood, J. D., 49, 77, 83
 Yonge, C. M., 97
 Young, R. G., 55-57, 71-73, 78, 84
 Zamecnik, P. C., 95, 98, 100
 Zuazaga, G., 67, 71-73

SUBJECT INDEX

- abbreviations, 89
 abdomen, of American cockroach, 69, 79, 87
 abdominal muscle, dorsal extensor. See dorsal extensor abdominal muscle
 absorbancy, 91
 accessory glands, 91; of American cockroach, 67
 adductor muscle, 91; effect of age, 27, 78; effect of hydrogen cyanide, 29; effect of salinity, 29, 79, 86; effect of season, 21, 27; gray, 33; of ark shell, 31; of Australian rock oyster, 33; of fresh water mussel, 21-25, 77; of pearl oyster, 31; of pen shell, 33; of quahog, 27-29, 78, 79, 86; of Virginia oyster, 23, 78; red, 29; white, 31-33
 adult, developing, epithelium, 59-63, 78; of *Cecropia* moth, 59-63, 78; wing, 59-63, 78
 age, effect of. See under effect
 air, 13, 21, 29-31, 39-41, 73
 albumen gland. See albuminous gland
 albuminous gland, 91; of pond snail, 21; of vineyard snail, 19
 alcohol, 69
 American cockroach, abdomen, 69, 79, 87; accessory gland, 67, 91; brain, 67-69; coxal muscle, 67, 91; effect of age, 67-71, 78, 86; effect of antimycin A, 67, 76, 91; effect of sex, 65-71, 77, 78, 84; effect of stage, 69-71, 78, 86; fat body, 67-71, 78, 92; flight muscle, 67, 78; gradient along body, 69, 79, 87; gut, 67-69, 78, 84; heart, 67; leg muscle, 65-71, 77, 78, 86; Malpighian tubules, 67-69, 93; muscle, 67-69, 78, 86; nerve cord, 67-69; nymph, 69-71, 78, 86, 93; respiratory quotient, 65, 93; testes, 67; thorax, 69, 78, 79, 87; wing muscle, 69-71, 78, 86
 American lobster, claw nerves, 47-49; effect of cyanide, 76; leg nerves, 47-49; ventral nerve cord, 47
 anemone, sea. See sea anemone
 antimycin A, 61, 67, 76, 91; 96
 apparatus, biochemical and biophysical. See continuous flow respirometer, fluorometric measurement, polarograph, spectrophotometer
 apparatus, manometric. See manometer; also Barcroft, differential, Fenn, Thunberg, and Warburg manometers
 apparatus, volumetric. See differential volumeter, microvolumeter, Scholander-Wennesland microrespirometer, volumeter, volumetric microrespirometer
 ark shell, posterior adductor muscle, 31, 91
 arthropods, effect of age, 84; effect of sex, 83, 84; effect of stage, 84; increase in size, 84; molt cycle, 78, 84, 85, 93. See also crabs, crustaceans, insects
 artificial sea water, 15, 29, 33, 45, 49-51
 ascarid, horse. See horse ascarid
 ascarid, pig. See pig ascarid
 ascorbate, 17, 57, 67, 71, 91
 ascorbic acid, 33, 39, 63
 Australian rock oyster, adductor muscle, 33, 91
 axons, giant. See giant axons
 axoplasm, 91
 azide, 82, 83, 96
 Baldwin's phosphate solution, 17-19
 Barcroft manometer (Barcroft respirometer), 3, 5, 6, 41-43, 47, 91, 98
 bee, honey. See honeybee

- beetle, water scavenger. See water scavenger beetle
- Belar-phosphate buffer, 65
- Belar's solution, 63
- bicarbonate, 15, 33, 37, 51
- biochemical and biophysical apparatus. See continuous flow respirometer, polarograph, spectrophotometer
- biochemical and biophysical methods. See biochemical and biophysical apparatus, fluorometric measurement
- biochemistry, references, 95
- biology, general, references, in crustaceans, 95; in insects, 96; in invertebrates, 97
- black blow fly, cytochrome oxidase, 78, 91; effect of age, 71, 78; muscle, 71, 78
- blow fly, black. See black blow fly
- blue crab, claw nerve, 45; effect of sex, 45, 77; gill, 45, 77; leg nerve, 45; midgut gland, 45, 77, 93
- blue worm, body wall, 43, 79; gradient along body, 43, 79, 86, 87; succinoxidase, 79, 86, 87, 94
- bluebottle fly, effect of age, 57, 78, 86; flight muscle, 57, 78, 86; α -ketoglutaric oxidase, 78, 86
- body wall. See body wall muscle
- body wall muscle, effect of gas phase, 41-43; effect of suspending media, 13; gradient along body, 41-43, 79; of blue worm, 43, 79; of earthworm, 43; of feather-duster worm, 41; of horse ascarid, 13; of manure worm, 41, 79; of sabellid, 41; of vineyard snail, 19; succinoxidase, 79, 94
- brachyuran, 91
- brackish water, 45
- brain, effect of sex, 69; of American cockroach, 67-69; of striped shore crab, 51. See also cerebral ganglion, forebrain, head ganglion, supraesophageal ganglion
- branchial gland, effect of gas phase, 39; of octopus, 39
- branchial tree, of sea cucumber, 73, 82, 91
- brandling. See manure worm
- buccal mass, 91
- buccal mass muscle, of sea hare, 15-17, 83; of vineyard snail, 19
- bug, giant water. See giant water bug
- Burgundy snail. See vineyard snail
- carbon monoxide, 21, 29-31, 37, 41-43, 75, 82, 83, 96
- cardiac ganglion, of horseshoe crab, 43
- catalase, 11-13, 82, 91
- Cecropia moth, developing adult, 59-63, 78, 82; effect of antimycin A, 61, 76, 91; effect of injury, 82, 83; effect of malonate, 57; effect of stage, 59-63, 78, 82; epithelium, 59-63, 78, 82; heart, 82; larva, 57, 93; midgut, 57; pupa, 5, 57-63, 78, 82, 83, 93; wing, 57-63, 78, 82
- cell fractions. See fractions
- cell structure, references, 95. See also sub-cellular morphology
- cell suspension, 3, 4, 11-13. See also suspension
- centrifugation, density gradient, 98
- centrifugation, differential, 98
- centrifugation, ultra, 98
- cerebral ganglion, of vineyard snail, 19, 77. See also brain, forebrain, head ganglion, supraesophageal ganglion
- chemical methods, 5, 6. See also micro-Winkler, tetrazolium, and Winkler methods
- chloride solution, isotonic. See isotonic chloride solution
- citrate, 15, 23, 49, 55, 65
- citric acid cycle, 81, 82, 91; references, 95
- clam, gill, 27; muscle, 27
- clam, soft-shelled. See soft-shelled clam
- claw nerve, effect of ionic concentration 49, 79, 86; of American lobster, 47-49; of blue crab, 45; of horseshoe crab, 43; of spider crab, 49, 79, 86
- clitellate, 91
- clitellum, 41, 91
- cockroach, American. See American cockroach
- cockroach, German. See German cockroach
- cockroach, Madeira. See Madeira cockroach
- codling moth, effect of sex, 57, 77; fat body, 57, 77, 92; larva, 57, 77, 93; muscle, 57, 77; respiratory quotient, 57, 93
- collagenous, 91
- columella muscle, of vineyard snail, 19, 91
- comparative respiratory rates, 76-78, 83
- concentration, effect of ionic. See under effect
- conch, muscle, 17
- continuous flow respirometer, 35
- control of growth, references, 95, 96
- control of metamorphosis, references, 96
- control of molting, references, 95
- corpora allata, 91. See also effect of removal
- coxal muscle, 91; effect of antimycin A, 67, 76;

- effect of sex, 67; of American cockroach, 67;
of giant water bug, 55; of South American
locust, 73; of water scavenger beetle, 63
- crab, blue. See blue crab
- crab, fiddler. See fiddler crab
- crab, ghost. See ghost crab
- crab, green. See green crab
- crab, hermit. See hermit crab
- crab, horseshoe. See horseshoe crab
- crab, kelp. See kelp crab
- crab, marsh. See marsh crab
- crab, mud. See mud crab
- crab, purple land. See purple land crab
- crab, spider. See spider crab
- crab, stone. See stone crab
- crab, striped shore. See striped shore crab
- crabs, comparative respiratory rates, 77, 83;
effect of eyestalk removal, 45, 47, 80, 84, 85;
effect of sex, 77, 83, 84; gill, 77, 83, 84;
midgut gland, 77, 83, 84, 93; molt cycle,
47, 78, 84, 85
- crayfish, nerve, 45
- cricket, greenhouse stone. See greenhouse
stone cricket
- cricket, house. See house cricket
- cricket, Japanese stone. See greenhouse
stone cricket
- crown. See tentacles
- crustaceans, effect of eyestalk extract, 45, 51,
80, 92; effect of eyestalk removal, 45-51,
80, 85; effect of sinus gland extract, 84;
increase in size, 84; molt cycle, 47, 78, 84,
85, 93; molt-inhibiting hormone, 85;
references, 95
- cucumber, sea. See sea cucumber
- cuttlefish, effect of ionic concentration, 39,
79, 86; effect of suspending medium, 39;
nerve, 39, 79, 86
- cyanide, 55, 75, 76, 81-83, 96
- cyanide, hydrogen. See hydrogen cyanide
- cyanide, potassium. See potassium cyanide
- cyanide-insensitive respiration, 47, 78, 80, 84
- cytochrome c, 15-23, 33-51, 55-73, 82, 83, 91
- cytochrome oxidase, 75, 78, 81-83, 91
- cytochrome system (electron transport system),
5, 75, 81, 82, 91
- cytochromes, references, 95, 96
- dart, sac, of vineyard snail, 19, 92
- data, respiratory, 99
- DDT, 69
- dehydrogenases, 92
- density gradient centrifugation, 98
- dented garden snail, effect of ionic concen-
tration, 39, 79, 86; heart, 17, 79, 86
- desert locust, fat body, 71, 92
- dialysis, 92
- diapause, 92; in *Cecropia* moth, 5, 57-63
- dichlorodiphenyltrichloroethane (DDT), 69
- differential centrifugation, 98
- differential locust, hind femur, 65, 92;
muscle, 65; respiratory quotient, 65, 93
- differential manometer, 3, 5, 6, 15, 33, 37,
45, 51, 57, 92
- differential volumeter, 27-29, 43-45, 65
- digestive diverticula, 92. See midgut gland
- 2, 4-dinitrophenol (DNP), 13, 23, 75, 82,
83, 92
- diphosphopyridine nucleotide (DPN), 19, 92
- diphosphopyridine nucleotide, reduced
(DPNH), 15-17, 59-61, 71
- distilled water, 13, 55
- diverticula, digestive. See midgut gland
- DNP, 13, 23, 75, 82, 83, 89, 92
- dorsal extensor abdominal muscle, effect of
latitude, 53; effect of temperature, 53;
in prawn, 53; in pink shrimp, 53
- DPN, 19, 89, 92
- DPNH, 15-17, 59-61, 71, 89
- earthworm, body wall, 43; clitellum, 91;
effect of gas phase, 43; ventral nerve
cord, 43; respiratory quotient, 43, 93
- ecdysis, 78, 84, 85, 92
- edible land snail, little. See little edible
land snail
- edible land snail, white-lipped. See white-
lipped edible land snail
- edible mussel, effect of suspending medium,
29; effect of temperature, 29; gill, 29;
retractor muscle of foot, 29, 93
- EDTA, 55, 89, 92
- effect of age, 84; in American cockroach,
67, 71, 78, 86; in arthropods, 84; in
black blow fly, 71, 78; in bluebottle fly,
57, 78, 86; in pelecypod mollusks, 84;
in Portuguese oyster, 25, 78, 84; in
quahog, 27, 78, 84; in Virginia oyster,
78, 84; on adductor muscle, 78, 91; on
flight muscle, 57, 78, 86; on gill, 25-27,
78; on leg muscle, 67-71, 78, 86; on
mantle, 25-27, 78, 93; on midgut

- gland, 25, 78, 93; on muscle, 25-27, 57, 67-71, 78, 86; on wing muscle, 69-71, 78, 86
- effect of environment, 86
- effect of eyestalk extract, in green crab, 45, 80, 85; in shrimp, 51, 80, 85; on muscle, 45, 51, 80
- effect of eyestalk removal, 84, 85; in green crab, 45-47, 80, 85; in lobster, 49, 80, 85; in purple land crab, 85; in shrimp, 51, 80, 85; on muscle, 45-49, 80, 85
- effect of gas phase, in earthworm, 43; in feather-duster worm, 41; in greenhouse stone cricket, 73; in mussel, 29; in octopus, 37-39; in oyster, 21; in pearl oyster, 31; on body wall, 41-43; on branchial gland, 39; on femur, 73; on gill, 21, 29-31, 39; on heart, 21, 39; on kidney, 39; on mantle, 21, 31; on midgut gland, 31, 39; on optic ganglion, 39; on salivary gland, 37-39
- effect of injury, in greenhouse stone cricket, 73, 80, 86; in pupa, 82, 83, 86; on femur, 73, 80, 86; on leg muscle, 73, 80, 86
- effect of insulin, in red oyster sponge, 9
- effect of ionic concentration, in cuttlefish, 39, 79, 86; in dented garden snail, 17, 79, 86; in mussel, 29, 79, 86; in spider crab, 49, 79, 86; on heart, 17, 29, 79, 86; on nerve, 39, 49, 79, 86
- effect of latitude, in pink shrimp, 53; on dorsal extensor abdominal muscle, 53
- effect of metabolic inhibitors, 81-83; in American cockroach, 67, 76; in American lobster, 76; in *Cecropia* moth, 57, 61, 76, 82, 83; in fresh-water mussel, 76; in jellyfish, 82; in mussel, 29, 75; in nematodes, 82; in octopus, 37, 75; in oyster, 21, 75, 76; in pearl oyster, 31, 75, 76; in pig ascarid, 13, 75; in Portuguese man-of-war, 76; in purple gorgonian, 76; in purple sea fan, 76; in quahog, 27-29, 76; in sea anemone, 75; in sea cucumber, 82; in sea hare, 15; in silkworm, 55; in spiny lobster, 76; in sponge, 75, 81; in squid, 76; in tree oyster, 76; in trematode, 82; in vineyard snail, 75; in Virginia oyster, 23, 75, 76; on adductor muscle, 29, 76; on branchial tree, 82; on eye, 76; on gill, 21, 27-31, 75, 76; on gizzard, 15; on heart, 21, 76, 82; on mantle, 21-23, 29-31, 75, 76; on midgut, 55-57; on midgut gland, 31, 75, 76; on muscle, 13, 29, 67, 75, 76, 82; on nerve, 76; on nerve cord, 76; on salivary gland, 37, 75; on subumbrella, 82; on tentacles, 76; on wing epithelium, 61, 76, 82
- effect of removal of corpora allata, in Madeira cockroach, 63, 80; on thoracic muscle, 80
- effect of salinity, in green crab, 45, 79, 86; in quahog, 27-29, 79, 86; on adductor muscle, 29, 79, 86; on gill, 27, 45, 79, 86; on mantle, 29, 79, 86
- effect of season, in fresh-water mussel, 21; in pearl oyster, 31, 79; in pelecypod mollusks, 86; in quahog, 27, 78, 79; on adductor muscle, 21, 27, 78, 79; on gill, 27, 31, 79; on mantle, 27, 79
- effect of sex, 83, 84; in American cockroach, 65-71, 77, 78, 84; in blue crab, 45, 77; in codling moth, 57, 77; in fiddler crab, 53, 77; in fleshfly, 71, 78; in ghost crab, 51, 77; in kelp crab, 53, 77; in larva, 57, 77; in Madeira cockroach, 63, 77, 84; in mealworm, 73, 78; in mud crab, 53, 77; in nymph, 71, 78; in red-jointed fiddler crab, 53, 77; in spider crab, 49, 77; in stone crab, 51, 77; on brain, 69; on coxal muscle, 67, 77, 78; on fat body, 57, 69-71, 77, 78; on flight muscle, 67, 73, 77, 78; on foregut, 69, 83; on gill, 45, 49, 77, 83, 84; on hindgut, 69; on leg muscle, 67, 71-73, 77, 78; on Malpighian tubules, 69; on metathorax, 69, 78; on midgut, 69; on midgut gland, 45, 49, 77, 83, 84; on muscle, 57, 65-73, 77, 78, 84; on nerve cord, 69; on thoracic muscle, 71, 77, 78, 84; on wing muscle, 69-71
- effect of stage, 84, 85; in American cockroach, 69-71, 86; in *Cecropia* moth, 59-63, 78; in green crab, 47, 78, 84; in purple land crab, 47, 78, 84; on epithelium, 59-63, 78; on integumentary tissue, 47, 78, 84; on leg muscle, 69, 71, 86; on metathorax, 69; on muscle, 47, 69-71, 78, 84, 86; on wing, 59-63, 78; on wing muscle, 69-71, 86
- effect of surgery, in green crab, 45-47, 80; in greenhouse stone cricket, 73, 80, 86; in lobster, 49, 80; in Madeira cockroach, 63, 80; in shrimp, 51, 80; on leg, 73, 80, 86; on muscle, 45-49, 73, 80, 86

- effect of suspending medium, in cuttlefish, 39; in dented garden snail, 17; in edible mussel, 29; in green crab, 45; in horse ascarid, 13; in mussel, 29; in octopus, 33, 37; in silkworm, 55; in spider crab, 49-51; on body wall muscle, 13; on gill, 29, 45; on heart, 17, 29; on midgut, 55; on nerve, 33, 37-39, 49-51; on stellate ganglion, 33
- effect of temperature, in Australian rock oyster, 33; in edible mussel, 29; in horseshoe crab, 43, 79, 80; in pink shrimp, 53; in prawn, 53; in quahog, 27; on gill, 27; on muscle, 29, 53, 63; on optic nerve, 43, 79, 80
- electron microscopy, references, 96
- electron transport system, 5, 75, 81, 82, 92; references, 96
- endogenous respiration, 9-57, 63-73, 76, 78-84, 86, 92
- endoplasmic reticulum, 92
- environment, effect of, 86
- enzymes, references, 96
- epithelium, effect of stage, 59-63, 78; of *Cecropia* moth, 59-63, 78; of developing adult, 59-63, 78; of pearl oyster, 31; of pupa, 59-63, 78, 93; of wing, 59-63, 78
- esophagus, of vineyard snail, 19
- estivation, effect on midgut gland, 19; in Jerusalem land snail, 19
- ethanol, 11, 13
- ethylenediaminetetraacetic acid (EDTA; versene), 55, 92
- extensor abdominal muscle, dorsal. See dorsal extensor abdominal muscle
- extinction coefficient, 92
- extract, 47, 80, 85, 92
- extract, eyestalk, 80, 85, 92. See also under effect
- extract, sinus gland, 85
- eye, of horseshoe crab, 45; of octopus, 37; of squid, 33
- eyestalk extract, 80, 85, 92. See also under effect
- eyestalk removal, effect of. See under effect
- fan, purple sea. See purple sea fan
- fat body, 92; effect of sex, 57, 69-71, 77, 78; of American cockroach, 67-71, 78; of codling moth, 57, 77; of desert locust, 71; of German cockroach, 55; of house cricket, 55; of larva, 57, 73, 77, 93; of mealworm, 73; of nymph, 55, 71, 78, 93; of wax moth, 57; respiratory quotient, 57, 93
- feather-duster worm, body wall, 41; tentacles, 39
- female duct, of vineyard snail, 19
- femur, 92; effect of injury, 73, 80, 86; effect of surgery, 73, 80, 86; of greenhouse stone cricket, 73, 80, 86
- Fenn manometer (Fenn respirometer), 3, 5, 6, 45, 55-57, 73, 92, 98
- fiddler crab, effect of sex, 53, 77; gill, 53, 77; midgut gland, 53, 77, 93
- fiddler crab, red-jointed. See red-jointed fiddler crab
- fin nerve, of squid, 35
- fire sponge, 9; effect of cyanide, 75
- flavoproteins, 92
- fleshfly, effect of sex, 71, 78; flight muscle, 71, 78; thoracic muscle, 71, 78
- flight muscle, 83; effect of age, 57, 78, 86; effect of sex, 67, 71-73, 77, 78; of American cockroach, 67, 77, 78; of bluebottle fly, 57, 78, 86; of fleshfly, 71; of giant water bug, 55, 77; of honeybee, 55; of mealworm, 73, 78; of mud dauber wasp, 71; of South American locust, 73, 77; of water scavenger beetle, 63, 77. See also thoracic muscle, wing muscle
- fluid, perienteric, 13, 93
- fluorescence, 92
- fluorometric measurement, 35
- fly, black blow. See black blow fly
- fly, bluebottle. See bluebottle fly
- fly, flesh. See fleshfly
- fly, house. See house fly
- foot, 83; fore, 19; middle, 19; rear, 19; of pearl oyster, 31, 77; of vineyard snail, 19, 77
- forebrain, of horseshoe crab, 45, 77
- foregut, effect of sex, 69; of American cockroach, 67-69, 77; of horseshoe crab, 45, 77
- fraction, nuclear, 3, 4, 47
- fraction, particulate, 3, 4, 13, 21, 65, 83, 93, 98
- fraction, soluble, 65
- fractions, 3; references 95
- fragments of organ or tissue, 3, 4, 43
- fresh-water mussel, adductor muscle, 23-25, 77, 91; effect of cyanide, 76; effect of season, 21; gill, 23-25, 77; heart, 23-25, 77; mantle, 23-25, 77, 93; posterior adductor muscle, 21, 91
- fructose, 47, 78, 80
- fumarate, 15, 49, 55, 65
- ganglion, cardiac, 43; cerebral, 19, 45, 77;

- head, 37; of horseshoe crab, 43-45, 83; of octopus, 33, 37, 77, 83; of squid, 35-37; of striped shore crab, 51; of vineyard snail, 19, 77, 83; optic, 37, 77; pedal, 19; stellate, 33-35. See also brain, forebrain
- garden snail, dented. See dented garden snail
- gas phase. See air, carbon monoxide, nitrogen, oxygen; also under effect
- general biology, references, in crustaceans, 95; in insects, 96; in invertebrates, 97
- German cockroach, fat body, 55, 92; nymph, 55, 93
- ghost crab, effect of sex, 51, 77; gill, 51, 77; midgut gland, 51, 77, 93
- giant axons, 92; of squid, 1, 35
- giant nerve fibers. See giant axons
- giant water bug, coxal muscle, 55, 77, 91; flight muscle, 55, 77; leg muscle, 55, 77
- gill, 83; effect of age, 25-27, 78; effect of cyanide, 76; effect of gas phase, 21, 29-31, 39; effect of salinity, 27, 45, 79, 86; effect of season, 27, 31, 78, 79; effect of sex, 45, 49, 51, 53, 77; effect of suspending medium, 29, 45; epithelium, 23; inhibition by carbon monoxide, 29-31; inhibition by hydrogen cyanide, 27; light-reversible inhibition by carbon monoxide, 21; of blue crab, 45, 77; of clam, 27; of edible mussel, 29; of fiddler crab, 53, 77; of fresh-water mussel, 23-25, 77; of ghost crab, 51, 77; of green crab, 45, 79, 86; of hermit crab, 47, 77; of marsh crab, 53, 77; of mud crab, 53, 77; of mussel, 23, 29; of octopus, 39, 77; of oyster, 21, 77; of pearl oyster, 31, 77; of Portuguese oyster, 25, 77, 78; of quahog, 25, 77-79, 86; of red-jointed fiddler crab, 53, 77; of scallop, 31; of soft-shelled clam, 29; of spider crab, 49, 77; of squid, 33; of stone crab, 51, 77; of tree oyster, 25; pallial margin, 31
- gizzard, 92; effect of potassium cyanide, 15; of sea hare, 15, 83
- gland, accessory, 67, 91; after estivation, 19; albuminous, 19-21, 91; branchial, 39; during estivation, 19; effect of age, 25; effect of cyanide, 76; effect of gas phase, 37-39; effect of sex, 45, 49-53; inhibition by carbon monoxide, 31; light-reversible inhibition by carbon monoxide, 37; midgut, 17-19, 31, 37-39, 45-53; of American cockroach, 67; of fiddler crab, 53; of ghost crab, 51; of hermit crab, 47; of Jerusalem land snail, 19; of kelp crab, 53; of lobster, 49; of marsh crab, 53; of mud crab, 53; of octopus, 37-39; of pearl oyster, 31; of pond snail, 21; of Portuguese oyster, 25; of red-jointed fiddler crab, 53; of sea hare, 17; of spider crab, 49; of spiny lobster, 53; of stone crab, 51; of vineyard snail, 17-19; salivary, 37-39
- glossary, 91-94
- glucose, 9, 13, 17, 27, 31, 37-39, 65, 73
- gonad, of pearl oyster, 31
- gorgonian, purple. See purple gorgonian
- gradient of respiratory rate, along long axis of body, 41-43, 69, 79, 86, 87; along nerve, 43-45, 79, 80, 87; effect of temperature, 43, 79, 80, 87; in American cockroach, 69, 79, 87; in blue worm, 43, 79, 86, 87; in horseshoe crab, 43-45, 79, 80, 87; in manure worm, 41, 79, 86
- grasshopper, red-legged. See red-legged grasshopper
- greater wax moth, fat body, 57, 92; larva, 57, 93
- green crab, during molt cycle, 47, 78, 84, 85, 93; effect of eyestalk extract, 45, 80, 85, 92; effect of eyestalk removal, 45-47, 80, 85; effect of salinity, 45, 79, 86; effect of sinus gland extract, 85; effect of suspending medium, 45; gill, 45, 79, 86; muscle, 45-47, 78, 80, 84, 85
- greenhouse stone cricket, effect of injury, 73, 80, 86; effect of surgery, 73, 80, 86; femur, 73, 80, 86, 92; leg muscle, 73, 80, 86
- growth, 84; control of, references, 95, 96
- gut, of American cockroach, 67; of horseshoe crab, 45. See also foregut, midgut, hindgut, intestine
- hare, sea. See sea hare
- H₂CN, 27-29, 89
- head ganglion, of squid, 37
- heart, effect of gas phase, 21, 39; effect of ionic concentration, 17, 29, 79, 86; effect of suspending media, 17, 29; light-reversible inhibition by carbon monoxide, 21; of American cockroach, 67; of *Cecropia* pupa, 82; of dented garden snail, 17, 79, 86; of fresh-water mussel, 23-25, 77; of horseshoe crab, 45; of little edible land snail, 17; of mussel, 29, 79, 86; of octopus, 39, 77; of oyster, 21, 31, 77; of squid, 37; of vineyard snail, 17; of white-lipped edible land snail, 19
- hemimetabolous, 92
- hepatopancreas, 92. See midgut gland

- hermit crab, gill, 47, 77; midgut gland, 47, 77, 93
- hexoses, 65
- hibernation, effect on midgut gland, 19; in vineyard snail, 19
- hind femur, 92; in differential locust, 65; in red-legged locust, 65; muscle, 65
- hindgut, effect of sex, 69; of American cockroach, 67, 69
- holometabolous, 92
- homogenate, 3, 4, 11-13, 17-19, 23, 33-35, 41-51, 55-73, 82, 85, 93, 98
- honeybee, flight muscle, 55
- hormone, molt-inhibiting, 85
- hormones, references, in crustaceans, 95; in insects, 97; in invertebrates, 97
- horse ascarid, body wall muscle, 13; effect of suspending medium, 13
- horseshoe crab, 83; cardiac ganglion, 43; claw nerve, 43; effect of temperature, 43, 79, 80; eye, 45; forebrain, 45, 77; foregut, 45, 77; gradient along a nerve, 43-45, 79, 80, 87; heart, 45; muscle, 45, 77; optic nerve, 43, 77, 79, 80, 87
- house cricket, fat body, 55, 92; nymph, 55, 93
- house fly, muscle, 65
- hydrogen cyanide, 27-29
- hydrogen peroxide, 11-13
- hydroquinone, 17, 93. See also quinol
- inhibition, light-reversible (photoreversible), 21, 37
- inhibitors, metabolic, 3; references, 96. See also antimycin A, carbon monoxide, cyanide, 2, 4-dinitrophenol, hydrogen cyanide, malonate, potassium cyanide; also under effect
- injury, effect of. See under effect
- insects, comparative respiratory rates, 76, 77, 83; effect of age, 78, 84, 86; effect of sex, 76-78, 83, 84; effect of stage, 78, 84, 86; flight muscle, 77, 78, 83, 86; leg muscle, 77, 78, 83, 86; references, 96, 97
- insulin, effect of. See under effect
- integumentary tissue, during molt cycle, 47, 78, 84; of purple land crab, 47, 78, 84
- intermediary metabolism, references, 97
- intermolt cycle. See molt cycle
- intestine, of sea cucumber, 73. See also gut
- invertebrates, references, 97, 98
- ionic concentration, effect of. See under effect
- iso* Citrate, 23, 35, 55, 71
- isotonic chloride solution, 17-19, 29, 39, 45, 55
- Japanese stone cricket. See greenhouse stone cricket
- jellyfish, tentacles, 11; umbrella, 11, 94
- Jerusalem land snail, estivation, 19; midgut gland, 19, 93
- KCN, 15, 47, 59-61, 67-71, 89
- kelp crab, effect of sex, 53, 77; midgut gland, 53, 77, 93
- α -ketoglutarate, 19, 49, 55-57, 65, 71-73, 81
- α -ketoglutaric dehydrogenase, 81
- α -ketoglutaric oxidase, effect of age, 78, 86; in bluebottle fly, 78, 86; in flight muscle, 78, 86
- kidney, effect of gas phase, 39; of octopus, 39; of vineyard snail, 19
- Krebs cycle (citric acid cycle), 81, 82, 91, 93
- land crab, purple. See purple land crab
- land snail, Jerusalem. See Jerusalem land snail
- land snail, little edible. See little edible land snail
- land snail, white-lipped edible. See white-lipped edible land snail
- larva, 93; effect of sex, 57; fat body, 57, 73, midgut, 55-57; muscle, 57; of *Cecropia* moth, 57; of codling moth, 57; of mealworm, 73; of silkworm, 55; of wax moth, 57
- latitude, effect of. See under effect
- leech, smooth muscle, 43
- leg muscle, 83; effect of age, 67-71, 78, 86; effect of cyanide, 76; effect of injury, 73, 80, 86; effect of sex, 67-73, 77, 78; effect of stage, 69-71, 78, 86; effect of surgery, 73, 80, 86; of American cockroach, 65-71, 77, 78, 86; of coxa, 55, 63, 67, 73, 77, 78; of femur, 73, 80, 86; of giant water bug, 55, 77; of green crab, 85; of greenhouse stone cricket, 73; of mealworm, 73, 78; of nymph, 71, 78, 86; of South American locust, 73, 77; of spiny lobster, 53; of striped shore crab, 51; of water scavenger beetle, 63, 77; respiratory quotient, 65, 93
- leg nerve, effect of cyanide, 76; effect of suspending medium, 51; of American lobster, 47-49; of blue crab, 45; of spider crab, 51; of spiny lobster, 53
- life cycle, variation during. See effect of stage
- light-reversible inhibition by carbon monoxide, 21, 37

- little edible land snail, heart, 17
- liver, 93. See midgut gland
- lobster, effect of eyestalk removal, 49, 80, 85; midgut gland, 49, 77, 93; muscle, 49, 77, 80, 85
- lobster, American. See American lobster
- locust, desert. See desert locust
- locust, differential. See differential locust
- locust, migratory. See migratory locust
- locust, South American. See South American locust
- Madeira cockroach, effect of removal of corpora allata, 63, 80; effect of sex, 63, 77, 84; thoracic muscle, 63, 77, 80, 84
- malate, 15, 19, 23, 35, 49, 55, 65, 71
- malonate, 15, 57, 67, 81, 93
- Malpighian tubules, 93; effect of sex, 69; of American cockroach, 67, 69
- manometer, 3, 5, 6, 17-19, 39, 55, 63. See also Barcroft, differential, Fenn, Thunberg, and Warburg manometers
- manometric apparatus. See manometer
- manometric methods. See manometer
- mantle, 93; central zone, 23, 29; edge, 23, 25; effect of age, 25-27, 78; effect of cyanide, 76; effect of 2, 4-dinitrophenol, 23; effect of gas phase, 21, 39; effect of salinity, 29, 86; effect of season, 27, 79; epithelium, 31 inhibition by carbon monoxide, 31; inhibition by hydrogen cyanide, 29; light-reversible inhibition by carbon monoxide, 21; lobe, 23, 25; marginal zone, 23; muscle, 31, 39; of fresh-water mussel, 23-25, 77; of octopus, 39, 77, 83; of oyster, 21, 77; of Portuguese oyster, 25, 77, 78; of quahog, 27-29, 77-79, 86; of scallop, 31; of vineyard snail, 19; of Virginia oyster, 23; pallial zone, 23
- mantle nerve, effect of suspending medium, 33, 37; giant nerve fibers, 35; of octopus, 33, 37; of squid, 35
- manure worm, body wall, 41, 79; gradient along body, 41, 79, 86; succinoxidase, 79, 94; viscera, 41, 79
- marsh crab, gill, 53, 77; midgut gland, 53, 77, 93
- mealworm, yellow. See yellow mealworm
- medium, suspending, 3. See also artificial sea water, Baldwin's phosphate solution, Belar-phosphate buffer, Belar's solution, distilled water, isotonic chloride solution, physiological saline solution, Ringer's solution, sucrose, Wilder and Smith saline; also under effect
- mesothorax, of American cockroach, 69, 79
- metabolic inhibitors, 3; references, 96. See also antimycin A, carbon monoxide, cyanide, 2, 4-dinitrophenol, hydrogen cyanide, malonate, potassium cyanide; also under effect
- metabolism, intermediary, references, 97
- metamorphosis, control of, references, 96
- metathorax, effect of sex, 69, 78; effect of stage, 69; of American cockroach, 69, 78, 79; of nymph, 69, 93
- methods, biochemical and biophysical. See continuous flow respirometer, fluorometric measurement, polarograph, spectrophotometer
- methods, chemical, 5, 6. See also micro-Winkler, tetrazolium, and Winkler methods
- methods, manometric, references, 98. See manometer
- methods, volumetric. See differential volumeter, microvolumeter, Scholander-Wennesland microrespirometer, volumeter, volumetric microrespirometer
- methylene blue, 11-13, 82, 85
- microrespirometer, 43. See also micro-volumeter, Scholander-Wennesland microrespirometer, Thunberg microrespirometer, volumetric microrespirometer
- microsomes, 3, 4, 93; references, 98
- micro-volumeter, 3, 5, 6, 35. See also volumeter, volumetric microrespirometer
- micro-Winkler method, 3, 5, 6, 21, 31, 39, 98
- midgut, effect of malonate, 57, 93; effect of sex, 69; effect of suspending medium, 55; of American cockroach, 67-69; of *Cecropia* moth, 57; of larva, 55-57, 93; of silkworm, 55; of vineyard snail, 19
- midgut gland, 83, 85, 93; after estivation, 19; after hibernation, 19; during estivation, 19; during hibernation, 19; effect of age, 25, 78; effect of cyanide, 76; effect of gas phase, 39; effect of sex, 45, 49-53, 77; inhibition by carbon monoxide, 31; of blue crab, 45, 77; of fiddler crab, 53, 77; of ghost crab, 51, 77; of hermit crab, 47, 77; of Jerusalem land snail, 19; of kelp crab, 53, 77; of lobster, 49, 77; of marsh crab, 53, 77; of mud crab, 53, 77; of octopus, 37-39, 77; of pearl oyster, 31, 77, 78; of Portuguese oyster, 25, 77; of red-jointed fiddler crab, 53, 77; of sea hare, 17, 83; of spider crab, 49, 77; of spiny lobster, 53; of stone crab,

- 51, 77; of vineyard snail, 17-19, 77
- migratory locust, muscle, 63
- mince, 3, 4, 37, 41-43
- mitochondria, 3, 4, 19-21, 35, 47-49, 55-57, 71-73, 85, 93; references, 99
- mollusks, pelecypod. See pelecypod mollusks
- molt, 93
- molt cycle, 84, 85; changes in integumentary tissue during, 47, 78, 84; muscle during, 47, 78, 84; in green crab, 47, 78, 84; in purple land crab, 47, 78, 84
- molt-inhibiting hormone, 85
- molting, control of, references, 95, 96
- morphology, subcellular, references, 99, 100
- moth, *Cecropia*. See *Cecropia* moth
- moth, codling. See codling moth
- moth, *Polyphemus*. See *Polyphemus* moth
- moth, wax. See wax moth
- moths, saturniid. See saturniid moths
- mud crab, effect of sex, 53, 77; gill, 53, 77; midgut gland, 53, 77, 93
- mud dauber wasp, flight muscle, 71
- muscle, adductor, 21, 23-27, 31-33, 77-79, 86, 91; coxal, 55, 63, 67, 73, 77, 78, 91; during molt cycle, 47, 78, 84; effect of age, 25-27, 57, 67-71, 78, 86; effect of antimycin A, 67, 76, 91; effect of cyanide, 76; effect of 2, 4-dinitrophenol, 13, 75, 92; effect of eye-stalk extract, 45, 51, 80, 85, 92; effect of eyestalk removal, 45-51, 80, 85; effect of gas phase, 21, 39, 41-43; effect of hydrogen cyanide, 29; effect of injury, 73, 80, 86; effect of ionic concentration, 17, 29; effect of latitude, 53; effect of potassium cyanide, 15; effect of removal of *corpura allata*, 63, 91; effect of salinity, 29, 79, 86; effect of season, 21, 27, 79; effect of sex, 63-73, 77, 78; effect of stage, 69-71, 78, 86; effect of surgery, 45-47, 63, 73, 80, 85, 86; effect of suspending medium, 11-13, 17, 29; effect of temperature, 53; flight, 55-57, 63, 67, 71-73, 77, 78, 86; gray, 23, 31-33; light-reversible inhibition by carbon monoxide, 21; of American cockroach, 65-69, 77, 78, 86; of ark shell, 31; of Australian rock oyster, 33; of black blowfly, 71, 78; of blue worm, 43, 79; of bluebottle fly, 57, 78, 86; of body wall, 13, 19, 41-43, 79; of buccal mass, 15-19, 91; of clam, 27; of codling moth, 57, 77; of columella, 19, 91; of conch, 17; of dented garden snail, 17; of differential locust, 65; of earthworm, 43; of edible mussel, 29; of femur, 73, 80, 86, 92; of fleshfly, 71, 78; of foot, 19, 31, 77; of fresh-water mussel, 21-25, 77; of giant water bug, 55, 77; of gizzard, 15, 92; of green crab, 45, 80, 84; of greenhouse stone cricket, 73, 80, 86; of heart, 17-25, 29, 31, 77; of hind femur, 65, 92; of honeybee, 55; of horse ascarid, 13; of horseshoe crab, 45, 77; of house fly, 65; of leech, 43; of leg, 51-55, 63-69, 73, 77, 78, 86; of little edible land snail, 17; of lobster, 49, 77, 80; of Madeira cockroach, 63, 77, 80; of mantle, 31, 39, 77, 93; of manure worm, 41, 79; of mealworm, 73, 77; of migratory locust, 63; of mud dauber wasp, 71; of mussel, 29; of nematodes, 82; of nymph, 71, 78, 86, 93; of octopus, 39, 77, 83; of oyster, 21, 31, 77; of parchment worm, 39; of pearl oyster, 31, 77; of pen shell, 33; of pig ascarid, 11-13; of pink shrimp, 53; of Portuguese oyster, 25, 77, 78; of prawn, 53; of quahog, 27-29, 77-79, 86; of red-legged grasshopper, 65; of scallop, 31; of sea cucumber, 73; of sea hare, 15-17; of shrimp, 51, 53, 80; of South American locust, 73, 77; of spiny lobster, 53; of squid, 35; of striped shore crab, 51; of thorax, 63, 71, 77, 78, 80; of trematode, 82; of vineyard snail, 17-19, 77; of Virginia oyster, 23, 78; of water scavenger beetle, 63, 77; of white-lipped edible land snail, 19; of wing, 69-71, 86; pink, 69-71, 86; red, 27-31; respiratory quotient, 57, 65, 93; retractor of foot, 29, 33, 93; smooth, 23-25, 43; striated, 23-25; white, 17, 21-23, 27, 31-33, 69; yellow, 21
- mussel, effect of 2, 4-dinitrophenol, 75; effect of gas phase, 29; effect of ionic concentration, 29, 79, 86; effect of suspending medium, 29; gill, 23, 29, 75; heart, 29, 79, 86; inhibition by carbon monoxide, 29; respiratory quotient, 23, 93
- mussel, edible. See edible mussel
- mussel, fresh-water. See fresh-water mussel
- nematode, 82
- nerve, effect of cyanide, 76; effect of ionic concentration, 39, 79, 86; effect of sex, 69; effect of suspending medium, 33, 37, 39, 51; effect of temperature, 43, 79, 80; giant axons, 35, 92; of American cockroach, 67-69; of American lobster, 47-49; of blue crab, 45; of claw, 43-49, 79, 86; of crayfish, 45; of cuttlefish, 39, 79, 86; of earthworm, 43; of fin, 35; of horseshoe crab, 43-45, 79, 80, 87;

- of leg, 45-53; of mantle, 33, 37, 93, of octopus, 33, 37, of sea hare, 15; of spider crab, 49-51, 79, 86; of spiny lobster, 53; of squid, 35; optic, 43-45, 79, 80, 87; ventral nerve cord, 43, 47, 67, 69
- neuroendocrine systems, references, 99; in crustaceans, 95; in insects, 97; in invertebrates, 97
- neurohormones, references, 99. See also hormones
- neurosecretion, references, 99
- neurosecretory systems, references, 99
- night crawler. See earthworm
- nitrogen, 21, 37, 43
- nitrogen determination, 21, 55, 59-63, 67, 71-73
- nuclear fraction, 3, 4, 47
- nymph, 93; effect of sex, 71; fat body, 55, 71, 92; leg muscle, 71, 86; metathorax, 69; of American cockroach, 69-71, 86; of German cockroach, 55; of house cricket, 55; wing muscle, 71, 86
- octopus, 83; branchial gland, 39; effect of gas phase, 37-39; effect of suspending medium, 33, 37; eye, 37; gill, 39, 77; heart, 39, 77; kidney, 39; light-reversible inhibition by carbon monoxide, 37; mantle, 39, 93; mantle muscle, 39, 77, 83; mantle nerve, 33, 37; midgut gland, 37-39, 77, 93; optic ganglion, 37-39, 77; salivary gland, 37-39; stellate ganglion, 33; tentacles, 39, 83
- optic ganglion, effect of gas phase, 39; of octopus, 37-39, 77
- optic nerve, effect of temperature, 43, 79, 80; gradient along nerve, 79, 80, 87; of horseshoe crab, 43-45, 77, 79, 80, 87
- orange, sea. See sea orange
- optical density, 93
- organ, whole, 1, 3, 4, 15-25, 29-39, 43-53, 57, 65, 69, 73
- oxaloacetate, 82
- oxidase, terminal, 81-83
- oxidative phosphorylation, 93; references, 99
- oxygen, 13, 21, 29-31, 37-39, 43-45, 73, 82-84, 87, 91
- oxygen cathode, 35
- oyster, effect of cyanide, 76; effect of gas phase, 21, 75; gill, 21, 77; heart, 21, 31, 77; light-reversible inhibition by carbon monoxide, 21, 75; mantle, 21, 77, 93
- oyster, Australian rock. See Australian rock oyster
- oyster, pearl. See pearl oyster
- oyster, Portuguese. See Portuguese oyster
- oyster, tree. See tree oyster
- oyster, Virginia. See Virginia oyster
- pallial, 93
- pallial nerve. See mantle nerve
- parchment worm, muscle, 39
- particle preparation, 15-17, 83
- particle suspension, 17, 39
- particulate fraction, 3, 4, 13, 21, 65, 83, 93, 98
- parts of organ or tissue, 1, 3, 4, 29, 31
- peacock worm. See feather-duster worm
- pearl oyster, adductor muscle, 31, 91; effect of cyanide, 76; effect of 2, 4-dinitrophenol, 75; effect of gas phase, 31; effect of season, 31, 79; epithelium, 31; foot muscle, 31, 77; gill, 31, 77, 79; gonad, 31; inhibition by carbon monoxide, 31; midgut gland, 31, 77, 93
- pedal ganglion, of vineyard snail, 19
- pedal retractor, 93; effect of temperature, 29; of edible mussel, 29; of pen shell, 33
- pelecypod mollusks, effect of age, 78, 84; effect of season, 86
- pen shell, pedal retractor muscle, 33, 93; posterior adductor muscle, 33, 91
- perienteric, 93
- perienteric fluid, of pig ascarid, 13
- peroxidase, 82
- petit-gris. See dented garden snail
- phase, gas. See air, carbon monoxide, oxygen; also under effect
- phenol, 9
- p-phenylenediamine, 17, 39, 49, 55, 93
- phosphate solution, Baldwin's. See Baldwin's phosphate solution
- phosphorylation, oxidative, 93; references, 99
- phosphorylation quotient. See P/O ratio
- photoreversible inhibition, 21, 37
- physiological saline solution, 13
- physiology, references, comparative, 99; general, 99; in crustaceans, 95; in insects, 97; in invertebrates, 97
- pieces of organ or tissue, 1, 3, 4, 21-33, 43-45
- pig ascarid, effect of 2, 4-dinitrophenol, 13, 75; muscle, 11-13; perienteric fluid, 13
- pink shrimp, dorsal extensor abdominal muscle, 53; effect of latitude, 53; effect of temperature, 53
- P/O ratio, 13, 21, 49, 57, 63, 89, 93

- polarograph, 5, 6, 21, 43, 93, 98
- Polyphemus moth, pupa, 73, 93; wing, 73
- pond snail, albuminous gland, 21, 91
- Portuguese man-of-war, effect of cyanide, 76; tentacles, 11
- Portuguese oyster, effect of age, 25, 78, 84; gill, 25, 77, 78; mantle, 25, 77, 78, 93; midgut gland, 25, 77, 78, 93; muscle, 25, 77, 78
- potassium cyanide (KCN), 15, 47, 59-61, 67-71
- prawn, dorsal extensor abdominal muscle, 53; effect of temperature, 53. See also shrimp
- preparation, particle, 15-17, 83
- protein determination, 35, 47-49, 55-57, 69-73
- prothorax, of American cockroach, 69, 79
- pupa, 93; effect of injury, 82, 83, 86; epithelium, 59-63, 78, 82; heart, 82; of Cecropia moth, 5, 57-63, 78, 82, 83; of Polyphemus moth, 73; wing, 57-63, 73, 78, 82
- purple gorgonian, 11; effect of cyanide, 76
- purple land crab, during molt cycle, 47, 78, 84; effect of eyestalk removal, 85; integumentary tissue, 47, 78, 84
- purple sea fan, branches, 11; effect of cyanide, 76
- pyruvate, 9, 13, 37, 65
- quahog, adductor muscle, 27-29, 77-79, 86, 91; effect of age, 27, 78, 84; effect of cyanide, 27-29, 76; effect of salinity, 27-29, 79, 86; effect of season, 78, 79; effect of temperature, 27; gill, 27, 77-79, 86; mantle, 27-29, 77-79, 86, 93; respiratory quotient, 27, 93
- quinol, 39, 93. See also hydroquinone
- radula, 93
- rates, comparative respiratory, 76-78, 83
- ratio, P/O, 13, 21, 49, 57, 63, 89, 93
- red-jointed fiddler crab, effect of sex, 53, 77; gill, 53, 77; midgut gland, 53, 77, 93
- red-legged grasshopper, hind femur, 65, 92; muscle, 65
- red oyster sponge, effect of insulin, 9
- references, 95-100
- respiration, cyanide-insensitive, 47, 78, 80, 84; respiration, endogenous, 9-57, 63-73, 76, 78-84, 86, 92
- respiratory data, 99
- respiratory enzymes, references, 96
- respiratory quotient, 93; of American cockroach, 65; of codling moth, 57; of differential locust, 65; of earthworm, 43; of fat body, 57, 92; of larva, 57, 93; of muscle, 57, 65; of mussel, 23; of quahog, 27
- respiratory rates, comparative, 76-78, 83
- respiratory tree, 91
- retractor muscle of foot, 93; See pedal retractor
- Ringer's solution, 45
- R.Q. See respiratory quotient
- sabellid worm. See feather-duster worm
- sac, dart, of vineyard snail, 19
- saline solution, physiological, 13
- salinity, effect of. See under effect
- salivary gland, effect of gas phase, 37-39, 75; light-reversible inhibition by carbon monoxide, 37, 75; of octopus, 37-39
- sarcoplasm, 65
- sarcosomes, 57, 63, 71, 81, 93. See also mitochondria
- saturniid moths, 83
- scallop, adductor muscle, 31, 91; gill, 31; mantle muscle, 31, 93
- Scholander-Wennesland micro-respirometer, 51
- sea anemone, effect of cyanide, 76; tentacles, 11
- sea cucumber, branchial tree, 73, 91; intestine, 73; muscle, 73
- sea fan, purple. See purple sea fan
- sea hare, buccal mass muscle, 15-17, 83, 91; effect of potassium cyanide, 15; gizzard, 15, 83, 92; midgut gland, 17, 83, 93; muscle, 15-17, 83; nerve, 15
- sea orange, 11; effect of cyanide, 75
- sea water, 21, 27-29, 39, 49; artificial, 15, 29, 33, 45, 49-51
- season, effect of. See under effect
- sections, thin, 1, 3, 4, 27
- sex, effect of. See under effect
- sheets, thin, 1, 3, 4, 17, 27-31, 39, 73
- shell, pen. See pen shell
- shore crab, striped. See striped shore crab
- shrimp, effect of eyestalk extract, 51, 80, 85, 92; effect of eyestalk removal, 51, 80, 85; muscle, 51, 80, 85. See also prawn
- shrimp, pink. See pink shrimp
- silkworm, effect of suspending medium, 55; larva, 55, 93; midgut, 55
- sinus gland extract, 85
- size, effect of. See effect of age
- Slater factor, 93
- slices of organ or tissue, 1, 3, 4, 9-11, 15-19, 27, 31, 37-45, 53, 73, 75, 76, 83, 98
- smooth muscle, of fresh-water mussel, 23-25; of leech, 43

- snail, during activity, 19; during hibernation, 19; heart, 17
- snail, Burgundy. See vineyard snail
- snail, dented garden. See dented garden snail
- snail, Jerusalem. See Jerusalem land snail
- snail, little edible land. See little edible land snail
- snail, pond. See pond snail
- snail, vineyard. See vineyard snail
- snail, white-lipped edible land. See white-lipped edible land snail
- soft-shelled clam, gill, 29
- soluble fraction, 65
- solution, Baldwin's phosphate, 17-19; isotonic chloride, 17-19, 29, 39, 45, 55; physiological saline, 13
- South American locust, coxal muscle, 73, 77, 91; flight muscle, 73, 77; leg muscle, 73, 77
- spectrophotometer, 3, 5, 6, 15-19, 23, 35, 47-49, 59-63, 67-71, 93, 98
- spectroscopy, 5, 82
- spider crab, claw nerve, 49, 79, 86; effect of ionic concentration, 49, 79, 86; effect of sex, 49, 77; effect of suspending medium, 51; gill, 49, 77; leg nerve, 51; midgut gland, 49, 77, 93
- spiny lobster, effect of cyanide, 76; leg muscle, 53; leg nerve, 53; midgut gland, 53, 93
- sponge, 9, 11, 81; effect of cyanide, 75. See also sea orange
- sponge, fire. See fire sponge
- sponge, red oyster. See red oyster sponge
- sponge, stinker. See stinker sponge
- squid, cerebral ganglion, 37; effect of cyanide, 76; eye, 33; fin nerve, 35; giant axons, 1, 35-37, 92; gill, 33; heart, 37; mantle nerve, 35; muscle, 35; stellate ganglion, 35
- stage, effect of. See under effect
- stellar nerve, 94. See mantle nerve
- stellate ganglion, effect of suspending medium, 33; of octopus, 33; of squid, 35
- stinker sponge, 9; effect of cyanide, 75
- stone crab, effect of sex, 51, 77; gill, 51, 77; midgut gland, 51, 77, 93
- stone cricket, greenhouse. See greenhouse stone cricket
- stone cricket, Japanese. See greenhouse stone cricket
- striped shore crab, brain, 51; leg muscle, 51;
- strips of organ or tissue, 3, 4, 21-23
- subcellular morphology, references, 99, 100
- substrates. See under individual name of substrate
- subumbrella, 82, 94
- succinate, 11-13, 19, 23, 33-35, 39-51, 55-59, 63-73, 80
- succinic acid, 41
- succinic dehydrogenase, 81, 82, 92
- succinoxidase, 79, 86, 87, 94
- sucrose, 55
- supernatant, 3, 4, 13, 47
- surgery, effect of. See under effect
- suspending medium, 3. See also artificial sea water, Baldwin's phosphate solution, Belar-phosphate buffer, Belar's solution, distilled water, isotonic chloride solution, physiological saline solution, Ringer's solution, Wilder and Smith saline, sucrose; also under effect
- suspension, 3, 4, 19, 63
- suspension, cell. See cell suspension
- suspension, particle. See particle suspension
- symbols, 89, 90; chemical, 89
- systems, neuroendocrine, references, in crustaceans, 95; in insects, 97; in invertebrates, 97
- teased tissue, 3, 4, 51, 55, 63-67, 73, 84
- temperature, effect of. See under effect
- tentacles, effect of cyanide, 76; of feather-duster worm, 39; of jellyfish, 11; of octopus, 39, 83; of Portuguese man-of-war, 11; of sabellid, 39; of sea anemone, 11
- terminal oxidase, 81-83
- testes, of American cockroach, 67
- tetrazolium method, 19
- thin sections of organ or tissue, 1, 3, 4, 27
- thin sheets of organ or tissue, 1, 3, 4, 17, 27-31, 39, 73
- thoracic muscle, effect of removal of corpora allata, 63, 80, 91; effect of sex, 63, 71, 77, 78; of fleshfly, 71, 78; of Madeira cockroach, 63, 77, 80
- thorax, effect of sex, 69; effect of stage, 69; gradient along body, 69, 79, 87; of American cockroach, 69, 79, 87; of nymph, 69, 93
- Thunberg manometer (Thunberg microrespirometer, Thunberg respirometer), 3, 5, 6, 23, 27, 31-33, 49, 94, 98
- tissue, during molt cycle, 47; integumentary, 47; of purple land crab, 47
- TPN, 89, 94
- tree, branchial. See branchial tree

- tree oyster, effect of cyanide, 76; gill, 25
- trematode, 82
- tricarboxylic acid cycle, 94. See citric acid cycle
- triphosphopyridine nucleotide (TPN), 94
- tyrosinase, 82
- ultracentrifugation, 98
- umbrella of jellyfish, 11, 82, 94
- urea, 15, 33, 37, 51
- ventral nerve cord, effect of cyanide, 76; effect of sex, 69; of American cockroach, 67-69; of American lobster, 47; of earthworm, 43
- versene (ethylenediaminetetraacetic acid; EDTA), 55,
- vineyard snail, 83; albuminous gland, 19, 91; body wall, 19; buccal mass muscle, 19, 91; cerebral ganglion, 19, 77; columella muscle, 19, 91; dart sac, 19, 92; effect of 2, 4-dinitrophenol, 75, 92; esophagus, 19; female duct, 19; foot, 19, 77; heart, 17; hibernation, 19; kidney, 19; mantle, 19, 93; midgut, 19, 77; midgut gland, 17-19, 93; pedal ganglion, 19
- Virginia oyster, adductor muscle of, 23, 78, 91; effect of age, 78, 84; effect of cyanide, 76; effect of dinitrophenol, 23, 75, 92; mantle, 23, 75, 93
- viscera, gradient along body, 41, 79; of manure worm, 41, 79; succinoxidase, 79, 94
- volumeter, 94, 98. See also differential volumeter, microvolumeter, Scholander-Wennesland microrespirometer, volumetric microrespirometer
- volumetric apparatus. See differential volumeter, Scholander-Wennesland microrespirometer, volumeter, volumetric microrespirometer
- volumetric methods. See volumetric apparatus
- volumetric microrespirometer, 3, 5, 6, 51, 55, 63, 67, 73, 98
- Warburg manometer, 3, 5, 6, 9-33, 37-57, 63-73, 94, 98
- wasp, mud dauber. See mud dauber wasp
- water, artificial sea, 15, 29, 33, 45, 49-51
- water, brackish, 45
- water, distilled, 13, 55
- water, sea, 21, 27-29, 39, 49
- water bug, giant. See giant water bug
- water scavenger beetle, coxal muscle, 63, 77, 91; flight muscle, 63, 77; leg muscle, 63, 77
- wax moth, greater. See greater wax moth
- white-lipped edible land snail, heart, 19
- whole organ, 1, 3, 4, 15-25, 29-39, 43-53, 57, 65, 69, 73
- Wilder and Smith saline, 55, 63, 67, 73
- wing, effect of age, 69-71, 78; effect of antimycin A, 61, 76, 91; effect of sex, 69-71; effect of stage, 59-63, 69-71, 78, 82; epithelium, 59-63, 78, 82; muscle, 69-71; of American cockroach, 69-71; of Cecropia moth, 57-63, 78; of developing adult, 59-63, 78, 82; of nymph, 71, 93; of Polyphemus moth, 73; of pupa, 57-63, 73, 78, 82, 93
- wing muscle, effect of age, 69-71, 78, 86; effect of sex, 69-71; effect of stage, 69-71, 78, 86; of American cockroach, 69-71, 78, 86; of nymph, 71, 78, 86, 93; pink, 69-71, 86; white, 69-71. See also flight muscle
- Winkler method, 3, 5, 6, 29, 94, 98
- worm, blue. See blue worm
- worm, earth. See earthworm
- worm, feather-duster. See feather-duster worm
- worm, meal. See yellow mealworm
- worm, parchment. See parchment worm
- worm, peacock. See feather-duster worm
- worm, sabellid. See feather-duster worm
- worms, clitellate, 41, 43
- yellow mealworm, effect of sex, 73, 78; fat body, 73, 92; flight muscle, 73, 78; larva, 73, 93; leg muscle, 73, 78
- zones of organ or tissue, 3, 4, 23-25, 45

