Date: May 24, 1959

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Institution: Oklahoma State University

Location: Stillwater, Oklahoma

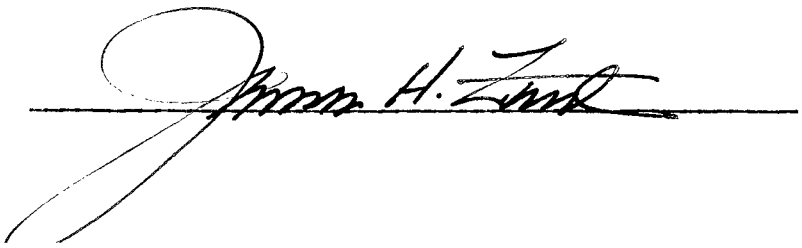
Title of Study: DISSECTION TECHNIQUES FOR HIGH SCHOOL BIOLOGY TEACHERS

Number of Pages in Study: 46 Candidate for Degree of Master of Arts

Major Field: Natural Science

Nature of Study: Many high school biology teachers fail to offer their students any individual laboratory activities. One phase of activities which can be effectively administered, but is often avoided by high school biology teachers, is the dissection of preserved animal specimens. This report deals with various problems which appear while conducting dissection activities. Items such as: obtaining preserved specimens; dissection equipment; facilities required for dissection; motivation of students; and, dissection procedures are discussed. Also included are dissection plans, orderly step-by-step procedures, for the earthworm, frog, grasshopper, and the fetal pig.

Use of the Study: It is desired that the concepts developed and the dissection plans included in this report will be of value to secondary biology teachers who do not include dissection activities in their biology classes. Also that some teachers who are not satisified with the methods they currently employ may be assisted by the dissection techniques discribed.

ADVISER'S APPROVAL 

DISSECTION TECHNIQUES FOR HIGH

SCHOOL BIOLOGY TEACHERS

1958-1959

by

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Bachelor of Science

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1954

Submitted to the faculty of the Graduate School of the Oklahoma State University in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE
May, 1959

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SCHOOL BIOLOGY TEACHERS

Report Approved:

Report Adviser

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ACKNOWLEDGEMENTS

The writer wishes to express his sincere appreciation and gratitude for the assistance and many valuable suggestions given him by Drs. Imy Vincent Holt, Roy Winfield Jones, and Bryan P. Glass, in the planning and writing of this report.

Indebtedness is acknowledged to my wife, Jane Nelson, who rendered invaluable aid as typist.

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CHAPTER I

INTRODUCTION

Statement of the Problem. There is a tendency among biology teachers in secondary schools to neglect one of the most important methods of education - learning by doing. That is, many teachers fail to offer their students any individual laboratory activities.

One phase of activities which can effectively be administered but is often avoided by secondary biology teachers is the dissection of animal specimens. Frequently these dissection activities are omitted from the biology course because the teachers are deficient in training and their thoughts are vague about how an orderly dissection scheme could be administered. They also avoid dissection activities because students traditionally display aversion toward the practice of dissecting preserved specimens.

This study was made for the purpose of solving some of the problems associated with the execution of dissection activities. However, some complications perennially persist. It is the hope of the writer that ideas discussed in this study may alleviate the efforts of secondary biology teachers in finding their best solution to these problems.

No presumption is made that the techniques discussed in this report are the best ones for a high school biology teacher to utilize. Neither is implication intended that preserved animal specimens are superior to dissect than freshly killed or anaesthetized specimens. The animal types

which are emphasized were selected with the writers prerogative.

Methods Used in Partial Solution to the Problem. It is believed by the writer that, if orderly dissection plans were made available to secondary biology teachers, they would be more likely to include dissection activities in their biology course.

In searching for a type of dissection procedure deemed desireable by the writer, several high school biology laboratory manuals and text books were observed. All sources gave mention of dissection activities, but none of the sources discribed orderly step-by-step plans which could be effectively utilized.

The following categories of literature were studied to find additional information pertaining to the topic: text books on science education; college biology, particularly anatomy, text books and laboratory manuals; periodic literature; audio-visual reference materials; catalogs and literature provided by biological supply houses; and dissection plans used in various high schools. Recall of the writers experience in conducting dissection activities and opinions received from practicing high school biology teachers were correlated with the literature in the production of this report and the included dissection plans.

Use of the Study. It is the hope of the writer that the concepts developed and the dissection plans included in this report will be of value to secondary teachers who do not include dissection activities in their biology classes. Some teachers who are not satisfied with the dissection methods they currently employ may be assisted by the techniques discribed. Through the use of these methods, a high school biology in-

structor may be able to emphasize more effectively the structural and functional characteristics of animals.

CHAPTER II

IS DISSECTION IN SECONDARY BIOLOGY A WORTHWHILE ACTIVITY?

The study of anatomy, gross and microscopic, is the foundation for most other phases of biology; classification, physiology, embryology, and ecology rest upon a basis of structure.[1] However, there seems to be two schools of thought in the matter of dissecting preserved specimens in the high school biology course. There are some secondary biology teachers who require minute and careful studies of the anatomy of worms, frogs, crayfish, and other organisms. They also require memorization of the names of bones, muscles and other parts of the body. Again there are those teachers who suggest little or no dissection - where learning proceeds on textbook drawings as being the sole exposure to animal structure. Between these two extremes are teachers who have taken several courses in comparative anatomy and who are strengthened in the tradition of memorizing many terms; and on the other hand the teacher who never had much actual laboratory work with a dissecting kit, and is therefore afraid to tackle any "dismembering" with groups of high school pupils.[2]

Most students will join the ranks of the average citizen upon the completion of their high school career. It would seem to be a waste of time to make detailed studies of anatomy. The logical procedure is to

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1. Francis E. Lloyd and Maurice A. Bigelow, The Teaching of Biology in the Secondary School (New York, 1909), p. 268.
2. Donald S. Lacroix, "To Cut or Not to Cut!," American Biology Teacher, XI (1949), pp. 169-170.

give the students an opportunity to dissect several types of organisms and allow them to observe the development of digestive systems, respiratory apparatus, excretory and reproductive organs, skeletal structures and circulatory devices, without having to memorize too many terms.

Care should be taken that the anatomy studies are not elevated to the extent that they would tend to replace similar activities performed in college zoology. There is little need for the average high school student to persue the topics in such minute detail. Complex vocabulary should be kept at a minimum, and when possible, common names should be substituted for scientific. However, maximum comprehension involves the development of vocabulary, and in order to be meaningful, it is necessary that the students memorize certain scientific names. Often in anatomy the scientific name of a structure is also the common name. Most of these technical names are of Latin or Greek derivation. The use of these names by the student is facilitated if they are told the roots from which the names evolved. Through learning the derivation of the scientific names, the students will have increased their repertory of word roots and in this way their entire vocabulary will have increased.

Observing and stressing anatomical structures is important when laying a basis for understanding body functions. Students should be able to identify gross organs and relate them to a body activity.[3] The human is the organism with which all students are most familar. Throughout their formal education they are taught the structure and function of the human body, but under no conditions are they actually able to delve in-

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3. Lee R. Yothers, "An Identification Aid When Dissecting Frogs." School Science and Mathematics, XLVII (1947), p. 421.

side the protective layer of skin in the human. The heart, stomach, pancreas, liver, etc., are thoroughly discussed and the major functions of these familar organs are well understood. The nearest thing available for the students to use to visualize the relationship of these structures are the two dimensional diagrams and charts included in textbooks, and perhaps their past exposure to several well chosen films and filmstrips.

Dissecting animal specimens will allow the high school student to recognize more vividly the intricate composition of living things, and to relate the structures and functions of the lower organisms with the human. The green gland of the crayfish, Malpighian tubules of the grasshopper and the nephrostome of the earthworm are not similar in structure with the human kidney, however the activities they perform are comparable. The kidney of the frog and fetal pig are structurally similar to that of the human, and the students can get a lasting image of this structure by making these observations in the lower forms of animals. Personal experience provides the best basis for learning any subject. One may study alone, but one usually works more efficiently and progresses more rapidly when guided by a teacher with previous training and experience in the subject matter. Many facts, ideas, and conclusions may be learned from lectures or by reading, but this is "secondhand" information in the words of some speaker or writer. By contrast, laboratory study affords opportunity to obtain knowledge "firsthand" from personal observations, Laboratory study constitutes training in scientific observations, which requires care and precision.[4]

Dissection activities also afford an opportunity for the secondary

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4. Tracy I. Stoer, Laboratory Manual for General Zoology (York, Pa., 1944), p. 5.

students to closely scrutinize the external features of the specimens. Modifications such as the point of attachment of the frog tongue, setae of the earthworm, horizontal action of the grasshopper mandibles, tympanic membranes of the forg and grasshopper, and many more interesting features would likely never be recognized by the student if he were not given the opportunity to dissect these animals.

A specimen gives the pupil actual first hand experience and this means direct personal contact with the item. Usually the more direct the experience is the more educative it is. This direct experience can be direct only if and when the pupil himself sees, feels, handles, operates, and in other ways actually works with the item.[5] "Direct, purposeful experience is in reality the basis of all effective learning."[6]

Biology is a life science, and no function in the universe is quite as complex as life itself. Each living animal is a highly precisioned mass of protoplasm, admittedly including the simplest protozoans and the apex of advancement, the human. Some students fail to realize that such things as the insect or earthworm are complex, self-sustaining organisms which carry out all life functions. They do not realize the close structural similarity between the frog, pig, and the human. The primary reason for this oversight is that students have never been exposed to the intricate compostition of living things. If through the activity of dissection the students can become aware of the Creators genius in constructing living things, and the simple interrelationship of animals in an evolutionary sequence, the time spent in dissection would not be wasted.

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5. Harry C. McKnown and Alvin B. Roberts, Audio-Visual Aids to Instruction (New York, 1940), p. 56
6. Ibid.

"Anatomy is absolutely an essential part in any elementary course in the science of biology, and there is no other way of beginning except by giving considerable attention to structural facts as the basis for determining functions, studying life histories, or interpreting environmental relations."[7]

It is the writer's opinion that dissection should be included in a secondary biology course, if for no other reason, to assist the students in recognizing the complexity, yet regularity of living things, and through this medium, learn to appreciate nature more fully.

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7. Lloyd and Bigelow, P. 268.

CHAPTER III

PROBLEMS INCURED IN PRESENTING DISSECTION ACTIVITIES IN HIGH SCHOOL BIOLOGY CLASSES

Methods of Presentation. Different methods of topic presentation are employed by various teachers of secondary biology. Perhaps the most commonly used form is the textbook-recitation method. This has elicited a strong following particularly with inexperienced teachers because it is an easy way to teach, it gives a superficial showing of scholarly attainment, it is possible to cover large amounts of subject matter in a relatively short period of time, it gives the teacher less to do in planning and preparing, and it offers a feeling of security by a reliance upon the supposed authority of the author.[8] The general practice in this method is where the teacher makes assignments of several pages in the textbook periodically for the pupils to study, and then during the class period, discusses the important concepts included in the assignment.

Dissection activities can easily fit into this type of program. At sometime during the term, representatives of the animal kingdom are studied. When reference is made to the physical structure of these animals, time can be set aside for the purposeful dissection of representative animals to supplement the textual materials. This affords an opportunity for the students and teacher alike to benefit from the diviation from the

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8. David F. Miller and Glenn W. Blaydes, Methods and Materials for Teaching Biological Sciences (New York, 1938), p. 42.

methodical textbook-recitation procedure. This break in the routine greatly stimulates the students to look for knowledge elsewhere than within their textbook.

The lecture-demonstration method is another teaching technique which is less commonly employed. Periodically the instructor demonstrates various biological concepts to the class which supplement the textual materials. This method has an advantage in high schools because the teacher has usually had training in performing laboratory experiments and less time is lost than would be if the less dexterous students performed the experiments individually. This method is less expensive because it necessitates only one set of equipment and supplies. If the students would do the experiments individually, each student or small group of students would require separate equipment.

The obvious disadvantage in using this method is that the students would have difficulty in seeing the demonstrations performed. It would be nearly impossible for a large group of students to see and learn from observing a teacher dissect a specimen. Perhaps the only effective way this method could be used for teaching a large class would be through the use of closed-circuit television, and even if this teaching device were available, the students would miss the important direct contact with the specimens.

The laboratory method of presentation provides each student or small group of students with material and equipment for carrying out their own study. Most teachers look upon the provision of laboratory work as a great advantage.[9] In some situations, classes are scheduled so that the

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9. Miller and Blaydes, p. 43.

students have a double class period for laboratory work twice each week, and the other three single periods each week are spent in discussions of biological principles. There are distinct advantages inherent in the laboratory method even when applied to single periods and in rooms not designed primarily as laboratories. Some of the advantages of this method are: 1. It usually implies learning by doing; 2. The students have the opportunity of handling the materials and thus have direct experience with the materials; 3. The students learn to follow directions; 4. The students perform experiments, record observations and results, and draw conclusions, whether written or oral; and 5. The student learns to handle apparatus and does individual thinking, if the course is properly developed. There are, of course, objectional features pertaining to this method. The most prominant are: the cost of individual equipment is prohibitive; and it is more wasteful of time because students are unskilled workers. It is usually thought that the advantages exceed the disadvantages.[10]

Regardless of the method of presentation, dissection activities can conveniently fit in with the program. The activities would already be included in the laboratory method. In the lecture-demonstration method, student performed dissections would be substituted for the teacher demonstration. This would remove the main criticism of the lecture-demonstration method. The addition of dissection activities in the textbook-recitation method would be progression toward the laboratory method and away from complete reliance in the text authority.

Facilities Required for Dissection. Unfortunately many secondary schools do not provide separate laboratory space for biology study. How-

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10. Miller and Blaydes, pp. 43-44.

ever, special classroom facilities are not essential for dissection activities. A very common arrangement is the combined classroom-laboratory situation in which any individual work performed by the students is done at the same desks or tables they use during the regular class work. Dissection does not require extensive equipment or individual laboratory area. This can be done even at the individual desks or tables provided in many classrooms.

Probably the only essential laboratory equipment required for dissections at the secondary school level is the specimen, a small scissors, a razor blade, and some paper towels. Laboratory kits are more permanent fixtures within the school and are fairly inexpensive. The usual laboratory kit for elementary work consists of a case for the instruments, fine pointed scissors, teasing needles, forceps and scalpel. The scalpel is far more convenient to manipulate than a razor blade. The use of special dissection tools make the students more "surgically" minded and consequently they do more careful and accurate work in their dissection. The dissections can be performed on paper towels or news papers, but dissection pans are helpful in that they support the specimen during the dissection. These pans include a waxy material into which pins may be inserted to further support the specimen. Special dissection pins are available, but ordinary household straight pins are sufficiently effective. The pins should be inserted obliquely through the specimen and into the waxy material in the bottom of the pan. There are three reasons for this. First, when inserted obliquely, the pins are braced against any tension set up in the specimen and will not easily be pulled out. Second, the specimen does not have a tendency to "creep" up the pins and change position. Third, the pins are out of the way of the hand and instruments,

thus permitting free access for working on the specimen.[11] In dissecting larger specimens such as the fetal pig, it is helpful to tie the specimen in place. This can be done by making a slip knot in the center of a cord and fastening this knot to one fore leg, and the other cord in the same way to one hind leg. The cords are then passed under the dissection pan and secured by a bow knot to the opposite legs. The bow knot can be adjusted to provide additional spreading if desired.

Dissection pans can be purchased from nearly all science supply houses at a cost of about $2.00 each. They can be constructed less expensively by obtaining a rectangular cake pan about 1 inch deep from a five-and-ten-cent store. Melt equal quantities of beeswax and paraffin over a low fire. Pour this mixture into the cake pan to a depth not to exceed 3/8 inches. When the wax has hardened the dissection pan is ready for use.[12] The writer has found these pans to be effective, but the wax mixture may fall out of the pan when the pan is inverted. This problem can be remedied by soldering a piece of metal to form a triangle in to corners of the pan about 1/4 inch from the bottom.

A primary requisite of good dissection is good materials. Specimens that are imperfectly preserved, with organs and tissuses in various stages of disentegration obviously are unfit for dissecting purposes. It is also desireable that the specimens be properly straightened and extended for convenience in pinning out or fastening in the position in which they will be dissected. Specimens of this quality can most conveniently be obtained by purchasing them from biological supply houses. Specimens obtained from these sources are more uniform in size and are expertly pre-

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11. Miller and Blaydes, p. 277.

served. The best quality and largest specimens are not essential for high school, however the difference in cost is nominal. Earthworms, frogs, and large lubber grasshoppers can be purchased at a cost of about $ .60 for each student, or a cost of $ .30 per pupil if the students dissect in pairs. Embalmed fetal pigs are somewhat more expensive. Plain embalmed fetal pigs, 8 to 11 inches in length, cost about $15.00 per dozen, or about $ .60 per pupil when they work in pairs. Fetal pigs which are doubly injected with latex so that the circulatory system can be more easily studied, cost about twice as much as the plain embalmed fetal pigs. The technique of dissection is so difficult for beginning students that it should be limited to simple problems, and dissection of more delicate structures should be left to advanced classes.[12] Since dissection of the circulatory system requires a great deal of care and precision, this activity could be eliminated from the dissection exercises, and the plain embalmed specimens would be just as useful. The cost per pupil, then, for the grasshopper, earthworm, frog, and the plain embalmed fetal pig would be about $ .90.

Fetal pigs are readily available in large quantities from meat packing houses. The fetal pigs are removed from slaughtered sows. They can be purchased from this source with or without cost depending on the attitude of the butcher. The pigs can be kept under refrigeration for several days prior to the time they will be used. If they are kept for a greater length of time, they should be preserved. They can be easily preserved by opening up the peritoneum enough to expose the internal organs, than by thoroughly washing the animal, and immersing them in a

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12. Alfred C. Kinsey, Methods in Biology (Chicago, 1937), p. 115.

TABLE I

COMPARATIVE COST OF BIOLOGICAL SPECIMENS
FROM THREE BIOLOGICAL SUPPLY HOUSES

	TURTOX	CAROLINA	WARD'S
PIG EMBRYOS*			
11-13 inches		$24.00/doz.	
8-11 inches	$25.00/doz.	18.00/doz.	$12.00/doz.
5-7 inches	20.00/doz.	9.00/doz.	7.50/doz.
FROGS**			
3-4 inches	5.50/doz.	5.00/doz.	3.95/doz.
$2\frac{1}{2}$-3 inches	4.25/doz.	3.75/doz.	2.75/doz.
$1\frac{1}{2}$-$2\frac{1}{2}$ inches	3.75/doz.	2.00/doz.	
GRASSHOPPERS***			
2-3 inches	1.90/doz.	1.75/doz.	1.40/doz.
EARTHWORMS****			
9-12 inches	2.00/doz.	1.75/doz.	1.25/doz.
7-9 inches	1.60/doz.	1.40/doz.	
TOTAL COST FOR MEDIUM SIZED SPECIMENS	33.15/doz.	23.25/doz.	17.40/doz.
COST PER PUPIL: TWO PUPILS PER SPECIMEN	1.38	.97	.73

*Sus scrofa, preserved by embalming.
**Rana pipiens, preserved in formaline solution.
***Romalea microptera, preserved in alcohol.
****Lumbricus terrestris, preserved in alcohol.

1. Turtox General Biological Supply House, Inc., Catalog No. 60, 1955. 8200 South Hoyne Avenue, Chicago, Illinois.
2. Carolina Biological Supply Co., Catalog No., 39, 1958. Elon College, North Carolina.
3. Ward's Natual Science Establishment, Inc., Catalog No. 478, 1957. P.O. Box 24, Beechwood Station Rochester 9, New York

10% formaldehyde solution.

Prolonged work with large specimens preserved in this fashion is somewhat undesireable for the high school pupils. It is better if the specimens can be embalmed.[13] Further information concerning the preservation of zoological specimens is discussed in the Turtox Service Leaflet Number 2.[14]

Motivation of Students. Every teacher of biology with a class of students taking the subject for the first time finds certain members of either sex who have a natural or feigned aversion for handling laboratory specimens. Such students receive little sympathy from the teacher. The first day "screams" are just a conventional tribute to feminity with no real emotion behind them.[15] Perhaps the best thing to do about the preliminary complaints is to ignore them. Interest in the specimen and in the subject soon submerges any aversion on the part of the student.

The student himself should proceed with his dissection with an exploring spirit - here is something new of which he has a limited knowledge- and he should be determined to learn for himself the structure, mechanism and functions of the specimen before him. However, if a strong dislike toward dissection persists with some of the students, those who are able may start and soon the others will not be able to restrain because of their aroused interest. Let natural curiosity take its course.[16]

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13. Miller and Blaydes, p. 187.

14. A complete selection of service leaflets are avilable to biology teachers, without charge, from the Turtox General Biological Supply House, Inc. Turtox General Biological Supply House, Inc., Catalog No. 57 (Chicago, 1955), p. 715.

15. Doris H. Hawse, "Ooh! Worms!," Science Education, XLI (1957), pp. 436-439.

16. Lacroix, p. 170.

Some of the with-drawal can be overcome if the students realize the nature of the preservatives. The instructor should explain that formaldehyde, alcohol, and embalming fluids are actually anticeptics necessarily used to prevent the specimen from decomposing. Students can be made to realize that the specimen are actually cleaner than they were when alive, at least as far as harmful parasites are concerned. Also the characteristic odors they detect, and often abhor, are not typical of the specimen but actually are the vapors of the preservatives. Often it is these vapors that are more distasteful to the student than is the direct handling of the specimen. The instructor can greatly reduce the odors of alcohol or formaldehyde by running cold tap water over the specimens for several hours before the time for dissection. After being rinsed, the specimens may be soaked in dilute ammonium hydroxide solution. This should not be done to embalmed specimens.

If the students previously know what structures they will be searching for, they become quite eager to witness the structures with their own eyes. For this reason a somewhat detailed laboratory procedure outline could be made available to the student several days before the dissection activity.

Conducive factors in good laboratory work are orderliness and cleanliness. The students should have available paper towels upon which they may wipe their hands during the dissection. Time and facilities should be provided so that the students can thoroughly wash their hands after the dissection period. Cleanliness of the dissection instruments and the disposal of dissected parts or specimens no longer needed help keep the students in the proper frame of mind for good work. Continual insistance on

on cleanliness in all dissections will do much to counteract any squeamishness among students.[17]

17. Kinsey, p. 196.

CHAPTER IV

DISSECTION PROCEDURE

In order to derive the maximum benefit from dissections, there are several activities which may be included. Students should know what to look for in the animal before they commence to dissect it. An effective method to accomplish this end is to require the students to make predissection drawings of the animal. Usually high school biology text books include line drawings of the animals. Important structures are labeled on the diagrams. If the student reproduces these line drawings neatly, and properly labels the structures, he will develop fundamental concepts regarding the size, shape, and the relative locations of the structures. The writer has required the students to perform this activity. To insure that the drawings would be adequately made, the drawings were graded and grades recorded with the same magnitude as a daily quiz.

The instructor may choose to require that the students learn more about the features of the specimens than are discussed in the high school text book. Dissection plans, orderly step by step procedures, may be duplicated by the instructor and made available to the students several days prior to the dissection activity. The students should thoroughly study these plans and have the procedure well in mind before they attempt to dissect. The dissection plans may be retained by the students and made a part of the student's biology notebook.

The formal method of laboratory presentation is perhaps the most

effective for students inexperienced in laboratory dissection techniques. In this method, introductory comments are made by the instructor, including general remarks about the work for the period. The instructor stresses what the students should look for, adds necessary precautions, and gives directions. The students proceed to follow the directions in the dissection plan, make observations, drawings, and answer questions on the work as it continues.[18]

For economy in time, cost of specimens and dissection equipment, it may be advisable to have the students work in pairs, assisting each other with the dissection. Since high school students are inexperienced in laboratory practices, they are able to work more effectively by helping each other with the dissection skills, and thus provide a maximum of opportunity for observations.

It may be more meaningful for the students if the instructor emphasizes the functional aspects of the structures the students identify. Also, as the instructor circulates among the students during the dissection period, he may affirm the structures the students locate to be sure they do not make erroneous identifications.

Students of high school age are occasionally prone to "horse play." Foolish gestures on the part of one student with the preserved specimen can destroy all the efforts the instructor invested in motivating the class. If the students are kept busy continuously during the dissection period they may not have time for any adverse actions.

The actual dissection should not be the end of the dissection activities. Several days following the dissection, the students should be

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18. Hawse, pp. 436-437.

given a laboratory examination on the materials covered. A very effective testing device involves the use of the actual dissected specimens, indicating the structures for identification. Several specimens may be used, each placed in a separate dissection pan and distributed within the classroom so that the students can move from one station to the next while taking the test. A structure can be adequately marked for identification by attaching a number to it. This number corresponds to a test question number. The students should number their test papers prior to taking the examination. When they identify a structure, they can write the name of the structure on their paper along the side of the number which corresponds to the number assigned to the structure. The structures can be indicated by a thread tied around it or by a pin sticking into or through it. Body openings can be indicated by a pin sticking through the opening. Attached to the string or pin is a small numbered card. As well as identifying the various structures by name, the students should also be responsible for indicating the primary functions of the structures. Several essay questions could be incorporated in the laboratory examination. Line drawings of specimens similar to those given in the text may also be included in a unit test which summarizes all the dissection activities.

During the dissection it is a valuable exercise for the students to draw parts of the specimen as they see them. The making of original drawings requires careful attention to details, hence this is helpful in learning. It is also excellent training in the preparation of scientific records. Dissection requires that the specimen be taken apart in an orderly fashion, to determine the structure and arrangement of its component parts. It requires neat and careful work. The dissection should consist of separating and exposing the parts of an animal body with as little dam-

age to the specimen as possible. Cutting and removal of parts should be done only as directed, and only after the parts are correctly identified. In some cases a specimen may be used during more than one laboratory exercise, and it is essential that none of the animal parts be molested unless so directed. If the students realize that they must draw the dissected specimen, they will take more care during the dissection and be more prone to follow directions.

In making laboratory drawings, the students should give attention to the following:

1. Observe and study the laboratory material as carefully as possible, then draw what is seen.
2. Draw directly from the specimen, and use outside references only as guides in identifying structures.
3. Arrange separate figures on a sheet of clean paper in a neat fashion.
4. Make each figure large enough to show all details clearly.
5. Make the drawings simple and clear, mainly in outline, and somewhat diagrammatic.
6. Use a sharp hard pencil (3H or 4H) and avoid sketchy lines.
7. Mark out lightly the extreme length and width to be occupied by the figure. Draw a faint longitudinal axis as a temporary guide in the placement of parts. Then outline the figure lightly. Estimate the proportionate size of some component parts in relation to the entire specimen, and mark these on the area outlined for the drawing. Draw the major features, fill in the details, and strengthen lines where necessary. Finally erase any unneeded marks.
8. Leave space, preferably at the right of the figure, for the labels. Label every part in each figure unless otherwise directed. Rule a fine line from each part horizontally to its label, and print or write each label neatly. Do not cross the lead lines.
9. Under each drawing give the figure title.[19]

Guide questions pertaining to the specimen may also be included in the dissection exercise. These questions should be answered by the student on a separate sheet of paper. These answers and the laboratory drawings may be included in the student's biology note book.

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19. Storer, pp. 6-7.

CHAPTER V

DISSECTION PLANS

The following pages include dissection plans and supplementary study materials on the earthworm, grasshopper, frog, and fetal pig. These plans are in a form that could be used as guides for individual students, if they could be reproduced and duplicated. The plans were designed with the intent that the subject matter would be challanging for the average high school student, but not so detailed that their comprehension would be surpassed.

Some instructors may prefer to use freshly killed or anesthetized animals for dissection. These dissection plans could be used without modification for the earthworm and the grasshopper, because the exercises are designed to be completed in one laboratory period. However, the dissection of the frog is designed to occupy two laboratory periods, and the fetal pig dissection five periods. If specimens are retained for an extended period of time, they should be preserved.

Freshly collected earthworms may be prepared for class dissection by placing them in pans of water, and with a dropping arrangement allow ethyl alcohol to drop into the water. They can be anesthetized in about an hour by adding sufficient alcohol to the water to make a ten per cent solution. Properly anesthetized, the worms may be laid out in a long pan and covered with a solution of five per cent formalin, which will both kill and harden the specimens. They may then be preserved in a fresh

solution of five per cent formalin.[20]

Grasshoppers have a heavy chitinous exoskeleton which is difficult for preservatives to penetrate. If they are to be preserved for dissection, they must be injected with preservative. If they are to be preserved for external study only, it is sufficient to drop the living specimens into the preservative. Enough solution will be swallowed and taken in through the spiracles to give a fairly satisfactory preservation. The following preparation has been found to be most satisfactory in insect preservation:

CARL'S SOLUTION

Alcohol, 95% .....170 c.c.
Formalin ..... 60 c.c.
Glacial acetic acid ..... 20 c.c.
Water .....280 c.c.
Omit the acetic acid until just before using.[21]

Frogs are quickly killed by immersion in 80% alcohol. After death the body cavity should be injected with 5% formalin, the animal hardened in the same solution, and then stored in fresh 5% formalin.[22]

Since fetal pigs are much larger animals they are more difficult to completely preserve. If freshly obtained, they can be preserved adequately by opening their body cavity and immersing them in a 10% formaldehyde solution.

The selection of these particular specimens for dissection purposes was arbitrary. Different representatives may in many instances be more available and serviceable.

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20. Morris M. Wells, The Collection and Preservation of Animal Forms (Chicago, 1932), pp. 28-29.
21. Ibid., p. 35.
22. Ibid., p. 52.

EARTHWORM STUDY

The earthworm is a representative of the Phylum ANNELIDA. Members of this phylum are all worms, most of which have the body divided into a series of similar ring-like segments. The large earthworm (Lumbricus terrestris) of eastern United States is used for dissection. They live in moist loamy soil and burrow extensively. At night they come to or onto the ground to surface feed, mainly on decaying vegetation. They may be collected most easily at night, with the aid of a flashlight, especially after a rain.

The following material will give you further understanding about the physical structure and the body functions of the earthworm.

1. RESPIRATION. The earthworm uses its delicate moist skin as a respiratory organ; the oxygen enters there to reach the blood, and carbon dioxide leaves at the same place. This need for thin wet skin makes drying fatal to the animal, and determines when it can travel, and where it occures. It has a nonliving, very thin cuticle over its live outer cells. Covering the cuticle is a thin layer of mucous which is secreated by glands in its epidermis.

2. NUTRITION. The earthworm eats dead plant material. It eats a burrow through the soil, taking in dirt at the mouth and using the bits of organic material that are scattered among the mineral fragments of the soil. The food is sucked in at the mouth by a very muscular pharynx. It passes through an esophagus to a crop where it is stored, moistened, and softened. It then passes to a muscular gizzard that grinds it, using the bits of sand that are regularly present instead of teeth. The food then passes through a long intestine for absorption, and to increase the absorptive area, lengthwise folds called the typhlosole hangs down into the opening of the intestine from above.

3. EXCRETION. The earthworm is divided into about two hundred segments by partitions called septa. Every segment except the first two and last one contain its own pair of ciled excretory tubes called nephridia. Each nephridium works like a sweat gland or a kidney tubule, giving off a sort of urine which is expelled to the outside through openings called the nephridiopores.

4. CIRCULATION. The earthworm has a complicated circulatory system, based upon a true blood contained in vessels. There is even haemoglobin present, but in solution, not in corpuscles as in our blood. The basic plan of circulation is a longitudinal dorsal and ventral blood vessel. These two vessels are connected in each segment by a circular ring vessel. The left and right arches of these rings in segments 7,8,9, 10, and 11, are somewhat inlarged and serve as aortic arches and function as hearts. These aortic arches pump the blood from the dorsal to the ventral blood vessel. From the ventral vessel some blood goes into capillaries around the intestine to pick up digested food, and some to capillaries in the skin to get oxygen. Then the blood goes into the dorsal vessel and back to the aortic arches.

5. SKELETON. The earthworm has in each segment eight skeletal structures called setae. They project like little bristles. The setae have muscular attachments which allow them to be extended or withdrawn, and in this way they assist the earthworm in locomotion by providing traction with the soil. The earthworm has no ridged skeleton, however,

the cuticle gives the body some form and support.

6. MUSCLES. The earthworm has a series of belts of circular muscle right under its epidermis, and strands of longitudinal muscles inside these belts. When the circular muscles contract, the diameter of the body decreases, and the worm elongates. When the longitudinal muscles contract, the worm becomes shorter and thicker again. The worm travels as a result of his alternate contraction and elongation, and aided by the extension of its setae.

7. NERVES. The earthworm has no well developed sense organs, but the entire body surface is sensitive to irritation. Its surface can "taste" food, and be repelled by harmful chemicals, dryness, excess light, and other injuries. There is a main trunk nerve down the ventral side of the body cavity, called the ventral nerve cord, with branching nerve ganglia in each segment. In the third segment, there is a ring around the pharynx connecting the nerve cord with the head ganglion, which is sometimes called the brain of the animal.

8. REPRODUCTION. The earthworm is monoecious, i.e., it contains both male and female reproductive organs. Segments 10 and 11 are male and produce sperm in the testis. Segment number 13 has left and right ovaries. Two worms, any two, are necessary for sexual reproduction. The two copulate and each deposits sperm in the other's seminal receptacle. Around segments 30 to 33 is a sort of girdle called the clitellum. About once a year it comes loose and slips off the front end of the animal. As it passes the openings from the ovaries and from seminal receptacles, it squeezes out and picks up eggs produced by itself, and sperm from the worm that did the inseminating. The eggs are fertilized and they may either immediately develope into new worms, or remain dormant over winter and develope when the temperature is again favorable.

9. EXTERNAL FEATURES. If you closely examine an earthworm you will immediately note the rings or segments. The extremities seem to resemble each other, but the end which usually goes ahead, and is also darker, is the anterior end. There is no distinct head nor any definite sense organs present. The somewhat crescent-shaped opening in the anterior end is the mouth opening. The vertical slit at the posterior end is the anus, the terminal opening of the intestines. The dorsal surface, the upper surface, can be identifies by the dark longitudinal line which is really the dorsal blood vessel. The under surface is called the ventral surface.

EARTHWORM DISSECTION

Equipment: Dissection pan, lab kit, 12 pins, hand lens, 2 paper towels, and the earthworm.

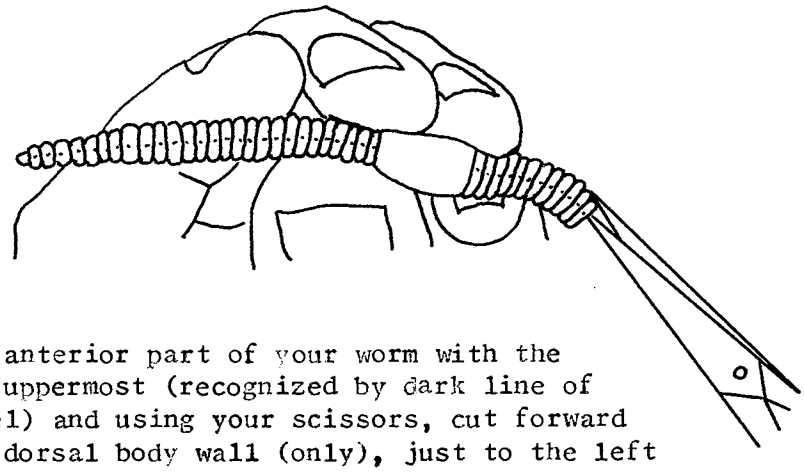
1. EXTERNAL FEATURES. Examine an entire earthworm and identify:

Anterior end
Mouth (in anterior end) crescent shaped
Lobe over the mouth
Posterior end
Anus (vertical slit)
Dorsal surface (darker, with median line of dorsal vessel)
Ventral surface (slightly flattened)
Segments (ring-like divisions of the body)
Clitellum (smooth swelling over several anterior segments)

Setae (tiny spines on segments)
Oviducts (2 small openings, ventral on segment XIV)
Sperm ducts (2 vertical slits ventral on segment XV)
Kidney pores (2 per segment, very small, latero-ventral)

Count the segments in your specimen (a) anterior to the clitellum, (b) in the clitellum, and (c) behind the clitellum. Do not count the lobe over the mouth.

2. INTERNAL FEATURES. Cut the specimen in half about one inch posterior to the girdle. Keep all parts of the worm until the exercise is completed.



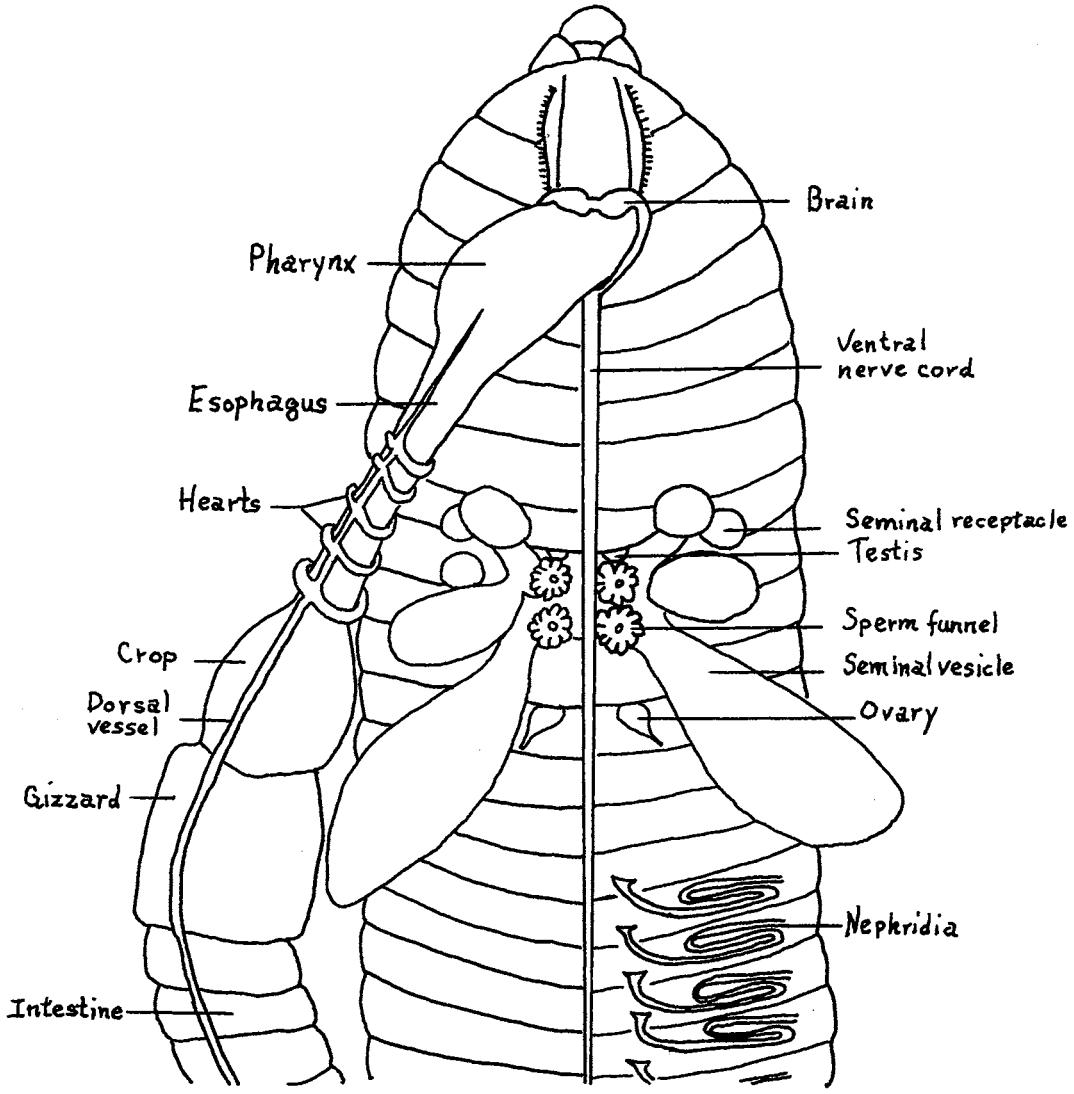
Holding the anterior part of your worm with the dorsal side uppermost (recognized by dark line of dorsal vessel) and using your scissors, cut forward through the dorsal body wall (only), just to the left of the mid-dorsal line to about segment IV. Keep the point of the lower scissors blade from damaging internal organs.

Pin down the specimen by the posterior end, with the worm in the center of the dissecting pan. Beginning posteriorly grasp the cut edges of the body wall with the forceps, and use a dissecting needle to release the thin transverse septa from their attachments to the digestive tract. Keep the blackish dorsal vessel uppermost. Loosen the tissue equally on both sides. As the body wall is spread, fasten it down with pins, inserted obliquely outward. Carefully cut and spread segments IV to I. Your instructor will moisten the worm with water.

Locate the following organs:

Pharynx (swollen, with external muscle fibers, III to V)
Esophagus (slender, partially hidden, VII to XIV)
Crop (large, thin walled, spherical, XV to XVI)
Gizzard (large, thick muscular walls, XVII to XVIII)
Head ganglion (2 small white lobes, dorsal in III)
Nerve cord (whitish band on ventral wall of body cavity)
Nephridia (1 pair in each segment, small white coiled tubes, on the sides of body wall and towards the ventral)
Dorsal vessel (middle, over digestive tract, dark in color)
Intestines (from segment XIX and posterior)
Aortic arches (on the side of the esophagus, partly hidden under thick tissue, VII to XI)

3. Clean your lab dissection tools. Remove pins from worm and wrap the worm in a paper towel. Discard. Rinse dissection pan in water carefully, and blot dry. Check lab kits to be sure all the tools are in place. Return the equipment to its proper locality.



GRASSHOPPER STUDY

The grasshopper is a representative of the Phylum ARTHROPODA. This major group includes the crustaceans, spiders, centipedes, millipedes, and the insects, the class in which the grasshopper belongs. Collectively the Arthropods comprise the majority of all known animals. In the insect class alone there are 650,000 known species. Typically the body is segmented and comprised of head, thorax, and abdomen. It bears jointed appendages and its body is enclosed in a more or less hardened exoskeleton. The body contains many specialized muscles and has well developed sense organs. These enable many arthropods to be quite active and exhibit quick response to stimuli. All but the crustaceans are predominantly terrestrial.

The following material will give you further understanding about the grasshopper's physical structure and body functions.

1. RESPIRATION. In insects respiration occurs by means of tubes called trachea that take the air from openings through the body wall called spiracles, and release it from other spiracles. Usually each abdominal segment has a pair of spiracles, and so do some thoracic segments. It may be noted that this method of respiration is inefficient because four parts of useless nitrogen are transported for each part of useful oxygen. Insects succeed well only so long as no part of the body is very far from the exterior; no insects are or can possibly be very large for this reason.

2. NUTRITION. Nearly anything in the world, from wood to blood, that is eaten by anything else is also eaten by one or more kinds of insect. The individual insect sometimes has an amazingly monotonous diet, such as only cabbage or potato plants. The grasshopper is less particular in its diet and will eat nearly anything. Most of the plants that the grasshopper desires to eat are also directly or indirectly important for our food. As is true with many organisms, their common nutritional desires compete with man. For this reason they are termed pests. The food enters the grasshoppers mouth between two mandibles which chew horizontally. Salivary glands open into the mouth. From the mouth the food goes through a slender esophagus into a large crop. Between the crop and the stomach are six double finger-shaped structures called the gastric caeca. These are important in that they provide extra area for absorption. Beyond the stomach is the intestines, rectum, and the terminal opening, the anus.

3. EXCRETION. In insects, this process is carried on by malphighian tubules that empty into the intestines.

4. CIRCULATION. The heart of the grasshopper is all ventricle. It lies along the dorsal part of the body cavity and squirts blood at the head. The blood works its way back to the abdomen where it re-enters the heart through many little openings. Recall the trachea not the blood is responsible for carrying oxygen through out the body.

5. SKELETON. As previously mentioned the insect has an exoskeleton. This is made of a tough, slightly flexible material. Growth occurs only by molting or sheding their skin. A new skeleton develops within a few hours.

6. MUSCLES. The muscles in insects are very efficient. They are attached to the exoskeleton in a way to provide excellent leverage.

7. NERVES. This system in the insects is the best of all animals' except a few of the very highest classes. There are good sense organs: smell in the antennae; taste in the palps, the finger-like structures which surround the mouth; touch all over the body especially in the antennae; and hearing by the ears which are strangely located above the jumping legs in the abdominal region. The eyes are of two types. There are three simple eyes, one above each antennae and the third between the antennae. These are thought to be in focus for close-up view. There are two compound eyes, one on each side of the head. The compound eyes are composed of many lenses and are throught to be in focus for distant objects. Although the eyes of a grasshopper can record outlines nearly as well as human eyes, they have no devices for changing focus. There is a ventral nerve cord made up of clusters of nerves. The cluster in the head is the largest and is therefore sometimes called the brain.

8. REPRODUCTION. This process in insects is so efficient that they remain numerous in spite of physiological handicaps and severe persecution. The sexes are seperate. Sperm is deposited in the female and soon after many eggs are deposited. Some insects, including the grasshopper, emerge from the egg as an immature form called a nymph that resembles the adult except in size. They then go through a series of molts, each time increasing in size until they become adults. This is called incomplete metamorphosis (change in form). Other insects, including the beetle and butterfly, emerge from the egg in a worm-like stage, and are then termed larvae. The larvae of some insects are given common names such as grubs, caterpillars, maggots, army worms, etc. The larvae eventually forms a cocoon about itself and is then called a pupa. It finally emerges as the adult and thereafter grows no more. This process is called complete metamorphosis.

GRASSHOPPER DISSECTION

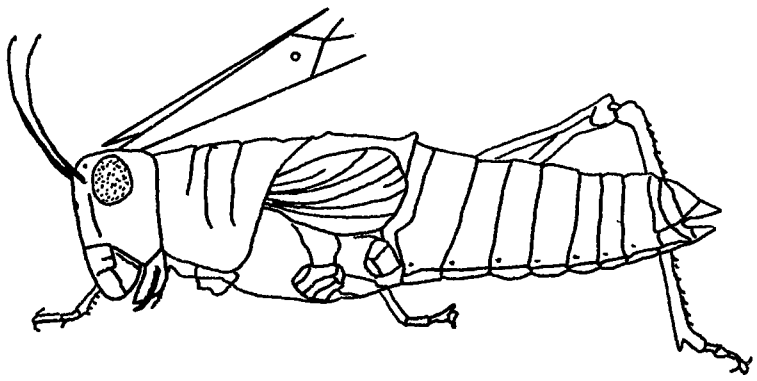
Equipment: Dissection pan, lab kit, hand lens, 2 paper towels, microscope, microscope slide and cover glass, and the grasshopper.

1. EXTERNAL FEATURES. Examine an entire grasshopper and identify the parts of the body:

Head Region	Abdomen
Antennae (2, slender)	Segments (number ?)
Compound eyes (2, large, lateral)	Spiracles (small openings on sides of segments; note the two spiracles on the thorax)
Simple eyes (3, small between compound eyes)	Ear (2, lateral on first abdomenal segment)
Mouth parts (ventral). Note the way they function.	Ovipositor (on female, of 4 spurs, posterior)
Thorax	Anus (small opening, posterior)
Legs (3 pairs)	
Wings (2 pairs)	

With your forceps, carefully remove the three legs from the left side, using care to bring away the base segment of each. Locate on each: Femur (large, upper leg); Tibia (slender, barbed, middle leg); Tarsus (foot region); and Claws (lateral).

2. INTERNAL FEATURES. With scissors, and beginning at the tip of the abdomen, make a lengthwise cut in the body covering slightly to the left of the middorsal line and along the entire length of the grasshopper. Cut over the top of the head and down, between the antennae, to the mouth. Make a similar cut ventrally and also up the front of the head. Keep the inner scissors point just inside the body covering to avoid damaging the internal organs.



Carefully lift and dissect off the body covering of the left side. Keep as much as possible of the internal organs in place in the right side of the body covering. Note the many muscles, especially those in the thorax connecting to the legs and wings. Also note the large tracheal vessels which adhere to the inside of the spiracles. Recall that the body covering that you have removed is the exoskeleton of the insect.

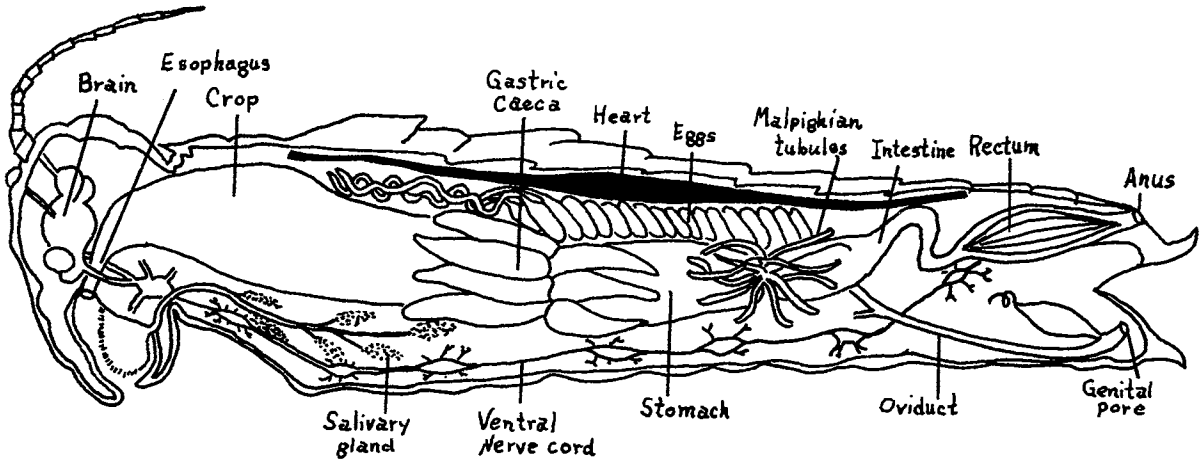
If the specimen is a mature female, the interior spaces may be filled largely with slender eggs in the ovaries.
Remove such of the lateral muscles and tracheae as necessary without injuring other organs. Your instructor will flood the specimen with water to aid in distinguishing the organs.

Locate the following organs:

Mouth (between mandibles)
Salivary glands (slender, whitish, ventral to crop)
Esophagus (slender, short, in head)
Crop (large, thin-walled in the thorax)
Gizzard (short, thickwalled)
Gastric caeca (6, double, finger-like, on sides of stomach)
Stomach
Malpighian tubules (many, hair-like, function as excretory organs)
Intestine (tapered, in abdomen)
Rectum (swollen, near end of the abdomen)
Anus (terminal opening of the digestive system)
Heart (region, dorsal in abdomen)

The nervous system in the grasshopper occupies the head and ventral floor of the thorax and abdomen. Identify:

Brain (3 lobes, with nerves to the three simple and two compound eyes)
Ventral nerve cord (double, lengthwise, with clusters of nerves at various locations)



FROG STUDY

The frog is a representative of the Phylum CHORDATA, Subphylum VERTEBRATA. The Class to which the frog belongs is the Amphibia which means dual life. This Class name indicates that most of the species live partly in water and partly on land. Other common Amphibians are the toads and salamanders. The larvae of the Amphibians, usually called tadpoles, are always aquatic and breathe by means of gills. Lungs are developed in most species. The adults, even when they spend their entire existence in the water, breathe air. In some salamanders, both gills and lungs are found in the adult. In nearly all cases their eggs are laid in water so that even the toads, which leave the water for a part of their lives, return to it in the breeding season.

The Amphibians are cold blooded animals, that is, their body assumes the temperature of the environment rather than maintaining a constant body temperature. In regions where the temperature in winter goes below freezing the Amphibia burrow into the mud at the bottom of ponds where they hibernate in a dormant condition awaiting the coming of warmer weather.

The following material will give you further understanding about the frog's physical structure and body functions.

1. RESPIRATION. The frog's blood receives oxygen and gives up carbon dioxide through its skin, the lining of its mouth, and its lungs. The frog's skin is abundantly supplied with blood vessels and is kept moist with mucus from glands in the skin. Oxygen from the air or water surrounding the frog passes through the cells of the epidermis and of the walls of the capillaries into the blood stream. Carbon dioxide diffuses from the blood through the same structures. The frog lacks a diaphragm muscle, so another device is necessary to force air into its lungs. The frog accomplishes this by gulping a mouth full of air, closing its nostrils with its tongue, and moving upward the floor of its mouth, which forces the air through the glottis, past the larynx or voice box, and into the lungs. When a frog "croaks", air is forced through the larynx between stretched vocal cords. These vibrate and cause the sound.

2. NUTRITION. While the tadpole is strictly a vegetarian, the adult frog feeds on insects and other small animals. It catches insects by flipping out its tongue, which is attached at the front of the mouth. The frog has teeth on its upper jaw, maxillary teeth, and on the roof of its mouth, vomerine teeth. It does not chew its food but swallows it whole, using its teeth only to seize the food. The food passes from the mouth, through the tubular esophagus, and into the stomach. The stomach bulges out on the left side and gradually tapers to the pylorus, a valvular structure which can control the passage of food into the intestines. The intestines consist of a long, coiled small intestine, and the much larger large intestine. The solid waste materials pass from the large intestine into a region called the cloaca which is a common receptacle for intestinal wastes, and sperm or eggs produced from the sex organs. Posterior to the cloaca is the terminal opening, the anus. The frog has two important digestive organs; the liver, a dark red-brown structure which is located anterior to the stomach; and the pancreas, a yellow-white organ which is orientated between the stomach and the first coil of the small intestine. The gall bladder, a reservoir for bile produced by the liver, is a green sac-like structure found between the lobes of the liver. The stomach,

small intestine, and large intestine are attached to the dorsal body wall along the line of the back bone by a transparent tissue called the mesentery. In this mesentery run the blood vessels and nerves to the various parts of the digestive tract.

3. EXCRETION. The kidneys of the frog are two reddish, flat, oval bodies lying against the dorsal body wall about midway between the ends of the abdominal cavity. They are covered on their ventral side by the peritoneum, a transparent continuous tissue which completely encloses the body cavity. From the side of each kidney runs a tube called the ureter which opens into the cloaca. The urinary bladder, a white sac-like structure, is an outgrowth from the ventral side of the cloaca and is not connected with the ureters.

4. CIRCULATION. The frog has a completely closed circulatory system consisting of arteries connected to veins by capillaries. A muscular heart pumps the blood through these vessels. The heart consists of left and right auricles and a ventricle. The right auricle receives blood from the body, and the left auricle receives blood from the lungs. The ventricle pumps part of the blood to the lungs where carbon dioxide is exchanged for oxygen, and part of the blood to the body. The heart is enclosed in a delicate membrane, the pericardial sac. The spleen in the frog is a small, spherical, dark-colored body in the mesentery not far from the stomach. It acts as a reservoir in which blood may be stored to be released into the circulation when needed.

5. SKELETON. The internal supporting framework of the frog's body is an endoskeleton consisting largely of cartilage and bone. The main parts of the skeletal system is the cranium, the vertebral column, and the bones of the appendages.

6. MUSCLES. The muscles of the hind limbs of the frog are common to many persons who eat them as frogs legs.

7. NERVES. The nervous system of vertebrates is more complex than that of any other animals. It comprises a central nervous system consisting of the brain and spinal cord, and the body nerves. The spinal cord is a thick tube directly connected with the brain. It passes through the bones of the vertebral column. The large eyes of the frog protrude from either side of the head and look sidewise so that their vision covers entirely different fields. The upper eyelid is capable of only slight movement, but the lower eyelid can be drawn up to cover the remainder of the exposed part of the eye. The lower eyelid is composed of two parts, a lower eyelid proper, which forms the thicker lower portion and a nictitating membrane, a thinner and more transparent upper portion. The external ear of the frog is apparent as the eardrum or tympanic membrane. It consists of a tightly stretched membrane on the side of the head posterior to the eye.

8. REPRODUCTION. The testes of the frog are two small, white, sausage-shaped bodies which lie in the body cavity one on the ventral side of each kidney. Sperm pass through small tubules connecting the testes with the ureter, through the ureters to the cloaca and to the exterior. Ovaries of the frog lie in the abdominal cavity ventral to the kidneys, corresponding in number and location with the testes. At the beginning of the breeding season they are large irregular masses which almost completely fill the body cavity, and the innumerable small black and white eggs which they contain give the organ a speckled appearance. Eggs pass from the ovaries through oviducts, and into the cloaca. From this point they pass to the exterior.

FROG DISSECTION

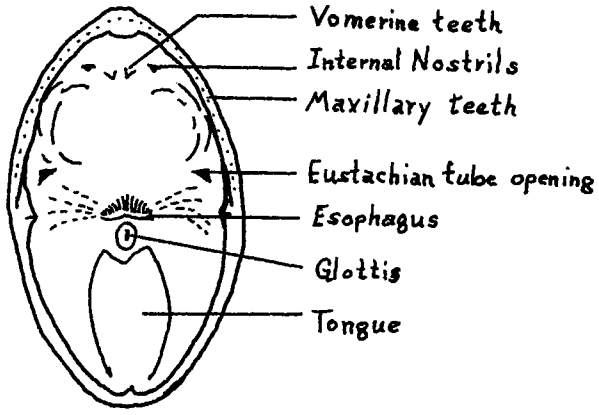
Day 1: covers outline no. 1-4. Day 2: covers outline no. 5.

Equipment: Dissection pan, lab kit, hand lens, 12 pins, two paper towels, microscope, microscope slide and cover glass, and the frog.

1. EXTERNAL FEATURES. Examine an entire frog and identify the following structures:
   - Head (to behind eardrum)
   - Trunk (remainder of body)
   - Mouth
   - Anus (opens dorsally at end of body)
   - Fore limb (upper arm, forearm, had, wrist, 4 digits)
   - Hind limb (thigh, lower leg, ankle, foot, 5 digits, webs)
   - Nostrils (2, on snout)
   - Eye, each with
     - Upper eyelid (fleshy)
     - Lower eyelid (narrow)
     - Nictitating membrane (large thin eyelid, inside others)
   - Tympanic membranes (eardrums, behind eyes)

   The innermost digit of each hand in males is enlarged.

2. MOUTH CAVITY. Open the frog's mouth widely by bending the lower jaw far back. With your scissors, cut the muscles at the corners of the mouth. Wash out any mucus present. Find the Following:
   - Maxillary teeth (on upper jaw, many, like sandpaper)
   - Internal nostrils (2, anterior openings, connected to external nostrils)
   - Vomerine teeth (2 small patches, between internal nostrils)
   - Eustachian tube openings (2 at corners of mouth; each connects to cavity of middle ear under eardrum)
   - Tongue
   - Pharynx (posterior part of the cavity, behind the tongue)
   - Glottis (lengthwise slit in ventral wall of pharynx)
   - Esophagus (posterior to pharynx)



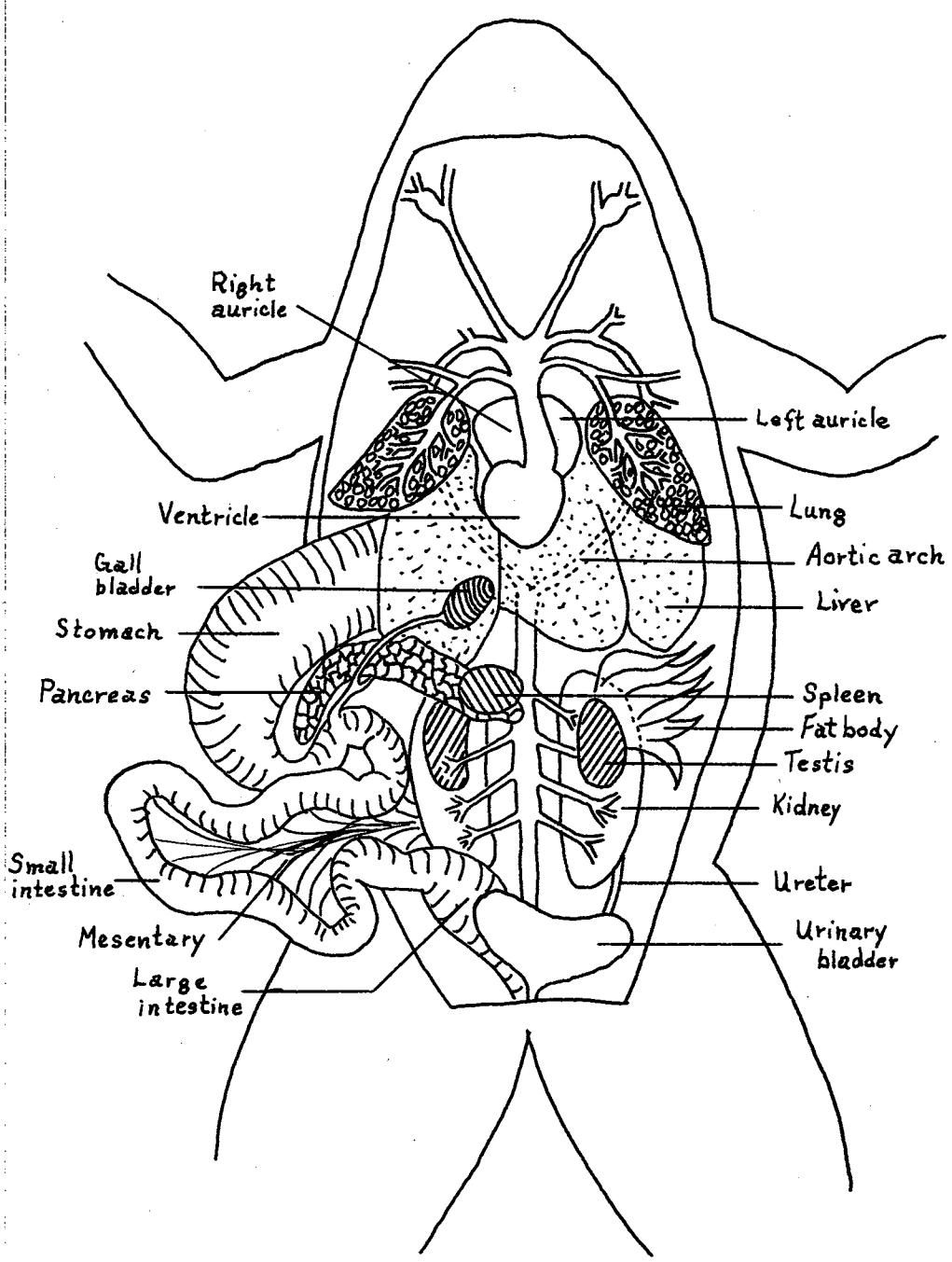
3. MUSCLES OF THE THIGH. Place the frog on its back with its hind limbs pointing away from you. With your scissors cut through the skin, from the point where the hind limb connects with the trunk, to the knee. Cut the skin around the hind limb between it and the trunk. Free the skin from the underlying muscles. Note that the muscles exist in bundles. With the dull side of the scaple, seperate the muscle bundles and note the white colored thigh bone. Note how the muscles are attached to the bones of the thigh and the knee.
4. SKIN OF THE FROG. Note the skin coloration differs on the upper and under surface of the frog. With your scissers, cut out a pigmented section of the skin from the leg of the frog. Mount on a slide with

the inner side up. Examine under low power. Note the many blood vessels and the pigment cells.

5. INTERNAL FEATURES. Lift and continue cutting the skin across the trunk just anterior to the hind legs. Hold up the cut edge and slit the skin anteriorly up to the chin. Keep the lower edge of the scissors close up beneath the skin. Cut the skin free from the entire ventral surface of the head and trunk. Note the abdominal muscles beneath the skin. Cut the muscle across just anterior to the hind legs. Cut the muscles of the abdominal wall on each side of the ventral blood vessel, from the hind legs to the head. (Be careful not to injure any of the organs below the muscle.) This leaves a narrow strip of muscle with the abdominal vein inside. Cut this strip anteriorly, then carefully dissect it free from the vein back to the posterior end. Cut through the shoulder girdle with your scissors. With your thumbs, grasp the cut ends of the bones and gently force them apart. Pin the shoulders to the dissection pan. Free and pin down the abdominal muscles. Locate the following structures:

*Ovaries and eggs (very prominant in the female only)
Liver (large, firm, reddish-brown, 3 lobes)
Heart (reddish, conical, muscular
Pericardium (delicate membrane enclosing the heart)
Auricles (2, upper parts of the heart)
Ventricle (lower, largest part of the heart)
Gall bladder (thin, spherical sac, greenish, between middle and right lobes of the liver)
Stomach (long, whitish, along left side, dorsal to liver)
Small Intestine (yellowish, slender, irregularly coiled)
Peritoneum (transparent tissue, encloses body cavity, separates the kidneys from the digestive organs)
Testes (2, in male, bean-shaped pink or yellow, at antero-ventral ends of kidneys)
Pancreas (irregular flattish tissue, yellowish white, between stomach and first fold of the small intestine)
Mesentery (transparent tissue, supports small intestine)
Large intestine (dark, larger extension posterior to the small intestine)
Cloaca (region posterior to large intestine, dark)
Urinary bladder (attached to cloaca, ventral)
Spleen (small, spherical, dark reddish, posterior to stomach)
Lungs (2, dorsal to liver, soft, thin walled)
Fat bodies (2 soft, finger-like lobes, yellowish, attached to kidneys)
Kidneys (2, elongated, dark brown on dorsal wall of body cavity)

*If you have a female frog, with your fingers, carefully grasp the egg masses and remove them from the frog. If you are careful, all of them may be removed in two clusters.


Right auricle
Left auricle
Ventricle
Lung
Gall bladder
Aortic arch
Liver
Stomach
Pancreas
Spleen
Fat body
Testis
Kidney
Small intestine
Ureter
Mesentary
Urinary bladder
Large intestine

FETAL PIG STUDY AND DISSECTION

Day	Covers Outline No.
1	I - V
2	VI
3	VII
4	IX - X
5	XI - XII

I. The fetal pig is removed from the mother in late stages of development. The young pig is attached to the wall of the uterus of the mother by the umbilical cord. After birth the severed cord becomes shriveled and the resulting scar is known as the navel.

II. Preliminary examination of the pig and external features.

A. Position of parts of the body.
Anterior (pertaining to head)
Posterior (pertaining to tail)
Dorsal (pertaining to back)
Ventral (pertaining to belly)
Lateral (pertaining to sides)
Medial (pertaining to midline)

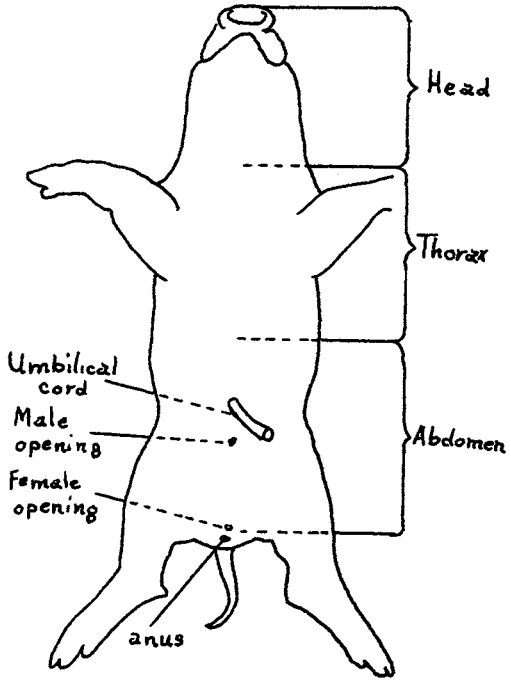


Fig. 1

B. Body divisions. The body of fetal pig is divided into three general regions - head, thorax, and abdomen.

How do the relative sizes of these regions compare with the adult pig?

The thorax, or chest region, extends from the posterior end of the neck to the last rib.

What part of the skeletal system supports the thorax?

The abdomen contains the main parts of the digestive tract, and the urogenital (excretory + reproductive system). Notice the umbilical cord arising from the ventral portion of the abdomen. At the posterior end of the body, just under the tail is the anus, the opening through which solid waste products are expelled. If you have a female pig, the urogenital opening is located just ventral to the anus. If you have a male pig, the urogenital opening is located just posterior to the umbilical cord. The scrotum, the sac which contains the testis, can be identified in the male as to swellings at the posterior end of the body.

The appendages include the fore and hind limbs of the pig. Notice that the first toe of each appendage is missing and the second and fifth toes are reduced in size. The pig walks on the tip of his third and fourth toe - somewhat of a ballet dancer.

The head region is the entire anterior portion of the pig. Located on the head are the ears, the eyes with upper and lower lids and a small mass of tissue in the corner of the eye called the

nictitating membrane. The pig has a fairly large mouth, and two nostrils rimmed with tough connective tissue.

III. Brief demonstration showing major incisions and techniques.

IV. Major incisions and preliminary dissection.

A. With your scissors, make an incision from the umbilical cord to the hair of the chin. (Fig. 2; cut A)

B. Make an incision across the abdomen and through the skin and muscle from the umbilical cord to the animals left side. (Fig. 2; cut B) Strip the skin and muscle away exposing the peritoneum. The peritoneum is a thin, transparent membrane that completely encloses the organs of the abdominal cavity.

C. Cut through the length of the sternum, the breast bone. Do not cut farther. (Fig. 3; cut C)

D. Make an incision across the abdomen and through the skin and muscle exposing more of the peritoneum toward the anterior. (Fig. 3; cut D)

E. Note the sex of your pig.

1. If it is a male (♂), make an incision $\frac{1}{4}$ inch to the left of the midline from the umbilical cord to the left side of the scrotum. Cut only through the skin and muscle. Since the position of the testes varies, depending on the age of the pig, care must be used in this dissection. (Fig. 2; cut E♂) Continue the incision to the anus. Pull down the flap of skin and muscle exposing the peritoneum to the left side. The instructor will cut through the pelvic bone for you.

2. If it is a female (♀), make an incision through the skin and muscle $\frac{1}{4}$ inch to the left of the midline from the umbilical cord to the urogenital opening, similar to the male dissection. (Fig. 2; cut E♀) Pull down the flap of skin and muscle on the left side exposing the peritoneum. Do not strip the right side. The instructor will cut through the pelvic bone.

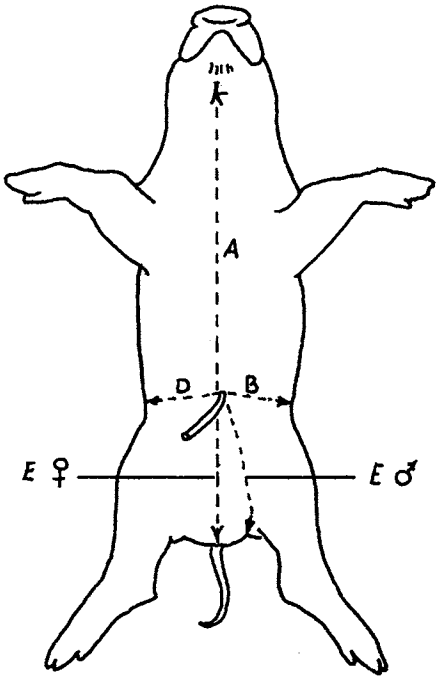


Fig. 2

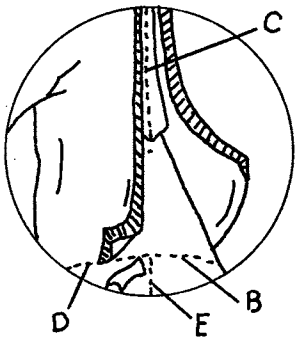


Fig. 3

V. Preparation for preservation:
   A. Open up the peritoneum enough to expose the organs within, being careful not to cut the umbilical vein, leading from the umbilical cord to the liver. Through this vein comes food and oxygen from the mother to the embryo pig.
   B. Wash the pig thoroughly.
   C. Place the pig in formaldehyde for preservation (1 part formaldehyde to four parts water).

VI. General anatomy of the thoracic and abdominal cavities.
   A. Thoracic cavity. Place your finger through the opening in the thoracic cavity and note the smooth lining. This lining is the pleura. It forms a sac around the lungs. Locate the following organs:
      * 1. Right and left lungs. These are reddish, spongy organs and in the pig are small and collapsed because they have never been inflated.
      * 2. Heart. This is a reddish, cone-shaped organ. It is enclosed in transparent membrane, the pericardium. The heart lies between and in front of the lungs.
      * 3. Diaphragm. This is a muscular sheet that separates the abdominal cavity from the thoracic cavity. During respiration it moves up and down aiding in filling the lungs. Free the diaphragm on both sides as demonstrated by cutting through it close to its line of attachment to the ribs.
   B. Abdominal cavity. This cavity lies below the diaphragm and contains other organs. Most of these organs were enclosed in the peritoneum when the dissection was started. Locate the following organs within the abdominal cavity.
      * 1. Liver. This is a large, five-lobed red organ just below the diaphragm and to the right in the abdominal cavity. Note that the umbilical vein, carrying food to the embryo from the mother, is attached to the liver. The liver has many functions. Among the most important of these are the storage of glycogen and the secretion of bile which aids in digestion of fats.
      * 2. Gall Bladder. A small greenish sac on the under side of the liver. It may be seen by raising the liver. Trace the tiny duct leading from the gall bladder to the duodenum. This is the bile duct. Bile is made in the liver, stored in the gall bladder and is released as needed into the small intestine.
      * 3. Stomach. This is a whitish organ to the left in the abdominal cavity and partly covered by the liver. The stomach secretes digestive juices, partly digests proteins and stores food temporarily until it is released into the small intestine.
      * 4. Spleen. The spleen is a thin red organ wrapped around the left surface of the stomcah. Its function has not been clearly defined. It is part of the circulatory system and can store large quantities of blood. It has been removed in man with few ill effects.
      * 5. Pancreas. A gland below the lower margin of the stomach. It is a long, irregular, grayish gland and quite soft. Look carefully and do not destroy it. The pancreas secretes a

digestive juice containing three enzymes that aid in the digestion of carbohydrates, proteins and fats. This secretion is carried to the duodenum by a very tiny duct. The pancreas also manufactures the hormone insulin which is secreted directly into the blood stream. Diebetes is an organic disease caused by insufficient secretion of insulin.

* 6. Small intestine. This is a coiled tube that begins at the lower end of the stomach. Note the extreme length that provides for adequate digestion and absorption of food. The walls of the small intestine secrete a digestive juice that aids in the digestion of carbohydrates, proteins and fats. It is the organ where most of the food is absorbed into the blood stream. The first part of the small intestine is the duodenum.

* 7. Large intestine. This is a coiled mass rather tightly bound together in the lower left abdominal cavity and continuing from the small intestine. The large intestine carries undigested food toward the rectum.

* 8. Caecum. This is a part of the large intestine which is a blind pouch at the point where the small intestine joins the large intestine. Although the pig has none, this is the approximate location of the appendix in man.

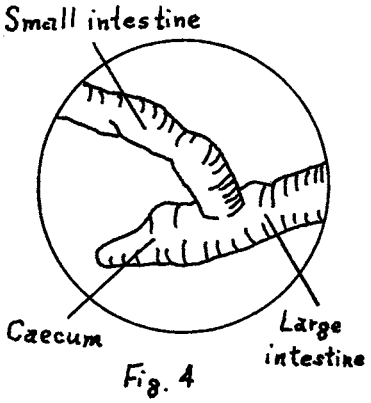


Fig. 4

* 9. Mesenteries. Membranes that support the intestines from the back abdominal wall. The blood vessels in the mesenteries carry digested food.

* 10. Rectum. The extreme end of the digestive tube which lies at the back of the abdominal cavity under and below the intestinal coils. Here wastes are collected and stored until they are excreted through the anus, the lower opening of the digestive tube.

* 11. Kidneys. A pair of bean-shaped, reddish organs at the back of the abdominal cavity. These organs remove urine, liquid wastes, from the blood stream. These organs lie behind the peritoneum.

* 12. Urinary bladder. A single organ attached in the fetal animal to the umbilical cord. Urine secreted by the kidneys is carried to the urinary bladder by two small tubes, the ureters. Urine is stored in the urinary bladder until released through a tube, the urethra. Trace the two ureters from the kidneys to the bladder, and the urethra from the bladder to the urogenital opening.

* 13. Gonads. The reproductive glands producing sex cells and hormones.

a. Testes. These are the male reproductive organs: A pair of grayish colored organs located below and outside of the abdominal cavity. They are contained in a protective sac, the scrotum, in a fully developed fetus. Sperm, the male reproductive cells, are produced by this organ.

b. Ovaries. These are the reproductive organs of the female: Small, paired organs located in the lower part of the abdominal cavity, one on either side below the kidneys. Ova, the female reproductive cells, are produced by this organ.

VII. Sketch the contents of the thoracic and abdominal cavities.

A. Make a full page drawing of the dissected pig.

B. As directed by the instructor, arrange and spread out the organs in the dissected animal so that each organ, or at least a part of each organ, marked with an (*) is visible and can be shown on the drawing. Label each organ marked with an (*) in the above sketch.

C. When the drawing has been completed, remove the liver and gall bladder. Then cut the stomach at the diaphragm and the large intestines at the rectum. Take hold of the entire intestinal tract, lift up, and remove by cutting the supporting membranes. Wrap the removed organs and discard as directed.

VIII. Dissection of the neck region.

A. Gently free the tissues from the sternum. Be careful not to cut any of the large blood vessels leading from the heart. Identify:

1. Thyroid gland. A small, oval, red gland which lies on top of the trachea or windpipe. Like the pancreas it secretes a hormone, thyroxin, into the blood stream. This substance controls the growth rate and also the rate at which an animal oxidizes food. Such glands as the thyroid that secrete hormones directly into the blood stream are called endocrine glands.
2. Trachea or windpipe. A long tube in the front of the esophagus. The walls of the trachea are composed of partial rings of cartilage which keep the air passage opened.
3. Larynx or "voice box". A rounded, short, hard structure connected to the upper end of the trachea. Air on its way from the lungs passes through the larynx and in so doing passes over the vocal cords causing them to vibrate and produce sound.
4. Carotid arteries. Extend up the side of the neck, one on each side. They supply blood to the head.
5. The vagus nerves. Large nerves found with the carotid arteries in a common sheath. Trace the nerve to the diaphragm.
6. Thymus gland (see IX. A. 1.)

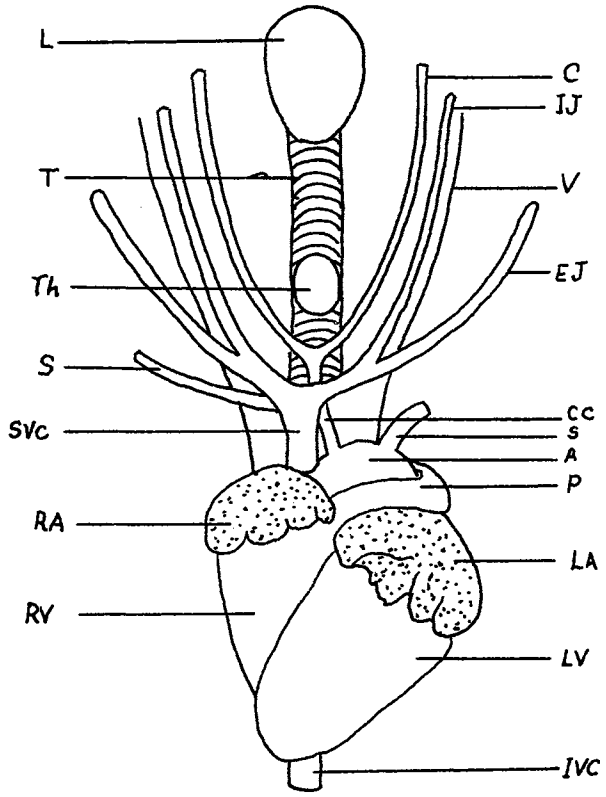
IX. Observation of the heart and major blood vessels.

A. Locate the following structures:

1. Thymus gland. An irregular mass in front of and above the heart. This is another endocrine gland, but its function is not clearly understood. The gland disappears in adulthood. The thymus gland of the calf is sold as a food delicacy known as "sweetbread."
2. Pericardium. This is the membrane which surrounds the heart. Dissect away the pericardium, the thymus gland, and other loose tissue around the hear.

B. Draw and label the heart, major blood vessels, and the structures identifies in the neck region. (Figs. 5 and 6).

Fig. 5



KEYS TO FIGS. 5 AND 6

A---Aorta
C---Carotid artery
CC--Common carotid
D---Ductus arteriosus
EJ--External jugular vein
IJ--Internal jugular vein
IVC-Inferior vena cava
L---Larynx
LA--Left auricle
LV--Left ventricle
P---Pulmonary artery
RA--Right auricle
RV--Right ventricle
S---Subclavian artery
SVC-Superior vena cava
T---Trachea
Th--Thyroid
V---Vagus nerve

Fig. 6

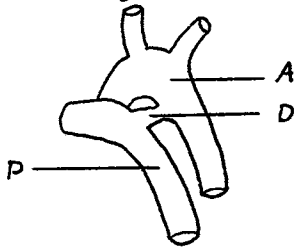


Fig. 6 (Showing the ductus arteriosus. This is a short tube between the pulmonary artery and the aorta in the fetal pig. A few days after birth, the ductus arteriosus closes.)

X. Jaw incision (See Fig. 7)

A. Cut through the left jaw bone at the corner of the mouth. (Demonstration.) Bend the lower jaw bone back until the back of the throat is exposed. Locate the following:

1. Epiglottis. A pointed fold of tissue that forms a lid over the opening of the larynx. Bend it down to see how it works.
2. Pharynx. This is the throat region, a common passage for both food and air.
3. Esophagus. A tube that lies behind the trachea. It takes food to the stomach.

Fig. 7

XI. Removal of the respiratory system.

A. Free the upper end of the larynx from the surrounding tissue and pull it and the trachea downwards and forwards.

B. Follow the trachea downward to where it branches into the bronchi. Notice that one bronchus goes to each lung. Remove the larynx, trachea, bronchi, and lungs as a unit.

C. Draw and label the dissected unit.

XII. Examination of the urogenital system.

A. Be able to identify all of the parts shown in Figs. 8 and 9.

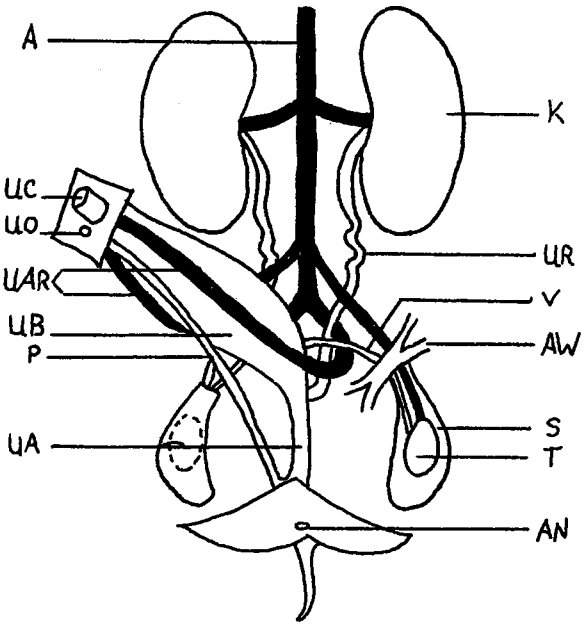
B. Examine both a male and female pig.

C. In the male the position of the testes will vary, depending on the stage of development of the fetus. In the fetal pig the testes are within the body cavity. By the time of birth they will have descended into the scrotum through the inguinal canal. This is a point of weakness in the muscular wall of the male where hernias frequently occur in man.

KEYS TO FIGS. 8 AND 9

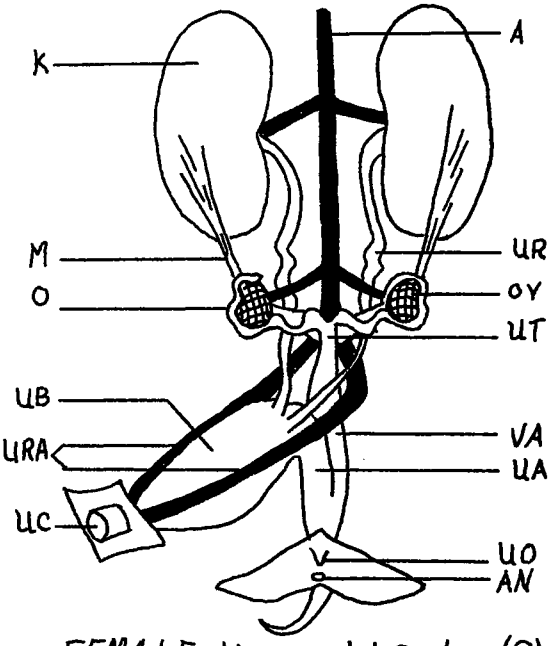
A---Aorta
AN--Anus
AW--Abdominal wall (region of inguinal canal)
K---Kidney
M---Mesentery
O---Oviduct
OV--Ovary
P---Penis
S---Scrotal sac
T---Testis
UA--Urethra
UAR-Umbilical artery
UB--Urinary bladder
UO--Urogenital opening
UC--Umbilical cord
UR--Ureter
UT--Uterus
V---Vas deferens
VA--Vagina

Fig. 8



MALE Urogenital System (♂)

Fig. 9



FEMALE Urogenital System(♀)

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