

## A Survey of Laboratory Manuals in Physiology

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### Introduction

Laboratory sessions are extremely valuable assets in the teaching of physiology because they elevate the students from passive absorbers of information to active participants in their own learning. "Hands-on" manipulation of instruments and biological material also reinforces basic concepts and develops expertise in physiological methodologies. Successful laboratory experiences can arouse student interest in subject matter developing excitement in the study of life and, ultimately, foster conceptual and manipulative skills.

Potentially, there exist literally hundreds of laboratory experiences which could be conducted on each organ system. However, our academic experiences have indicated that the laboratory offerings in physiology courses are relatively consistent. Temporal, financial, and instrumental limitations can play important roles in limiting the scope of exercises utilized by teaching laboratories in college level physiology. Additionally, tradition dictates that laboratory exercises "work" and are within the expertise of the students' instrumental, animal handling, and surgical skills. The purpose of this survey is to document the breadth and extent of occurrence of subjects and methodologies in published physiology laboratory manuals for college courses.

### Methods

Nine human physiology and eleven general physiology laboratory manuals were reviewed for this study (Appendix). Grouping of the manuals into these headings was directly related to the purpose of the manuals as stated by the authors in the "Forward" sections of the texts. Without exception, human physiology manuals were designed for one term courses for preclinical or physical education students while general physiology manuals were intended for upperclassmen majoring in life sciences. Selection of manuals was based on their inclusion in the latest edition of *Books in Print* and availability from the publishers. Although this selection procedure cannot be considered either random or complete, we do believe they are recent and representative of the laboratory schemes utilized by many physiology laboratories.

All manuals were read in their entirety and each exercise was categorized into one of the major topic and subtopic headings for Human (Table 1) and General (Table 2) Physiology. We developed topic areas which were based primarily upon organ systems. These criteria for topic breakdown proved to be judicious since laboratory units as they appeared in the manuals rarely involved more than one organ system. Subtopics were developed on the basis of which methodologies were utilized under each topic heading. Since there existed considerable variety in the depth of coverage in the topic areas, the numbers of subtopics were not consistent within or among manual types.

Laboratory exercises were also assigned to one of three categories of "independent student involvement." The categories were:

- 1—Students were carefully directed by the manual in both data gathering and interpretation.

TABLE 1. *Percentage of Human Physiology laboratory manuals including exercises in each topic and subtopic.*

Topic Subtopic	% Manuals With:		Topic Subtopic	% Manuals With:	
	Topic	Subtopic		Topic	Subtopic
<b>Hematology</b>	100		<b>Respiration</b>	100	
Histology		100	Spirometry		86
Hematocrit		100	Pneumography		57
Blood Type		100	Effect-CO <sub>2</sub>		43
Clot Time		86	Sounds		43
Hb		57	Ciliary Movement		29
Blood pH		29	Calorimetry		29
Sedimentation		29	<b>Cellular Processes</b>	100	
Electrophoresis		14	Osmosis		100
<b>Circulation</b>	100		Enzymes		29
Blood Pressure		100	Cell Respiration		29
Heart Sounds		86	Karyotype		14
EKG		72	Active Transport		14
In Vitro		43	pH Regulation		14
Microcirculation		43	<b>Nutrition</b>	86	
Ergometry		14	In Vitro Digestion		86
<b>Neurophysiology</b>	100		Smooth Muscle		43
Reflexes		100	GIT Sounds		14
Vision		100	<b>Muscle Physiology</b>	86	
Audition		100	Contraction		86
Taste		71	EMG		14
Olfaction		43	<b>Endocrinology</b>	57	
Cutaneous		14	Epinephrine		29
EEG		14	Insulin		29
<b>Renal Physiology</b>	100		Thyroid Hormone		14
Urinalysis		100	Sex Steroids		14
Homeostasis		86	<b>Reproduction</b>	43	
Renal Clearance		14	Antigen Test		14
			Bioassay Test		14
			Fertilization		14

2—Students were required to manipulate and interpret data.

3—Students developed at least portions of the experimental design.

We quickly found that one must be extremely careful not to associate a hierarchy of thought processes with this scheme. Many areas covered by the manuals can only be effectively covered by the category 1 mode (e.g., histology of blood cells) while some areas readily invite the student to participate in experimental design (e.g., effects of various parameters on ventilation in rats). However, many experiments can be molded to neatly fit any of the three categories at the discretion of the authors. For example, a laboratory on peripheral blood pressure could involve a description of technique and measurement of blood pressures (category 1), measurement, comparison and interpretation of blood pressures taken under variable conditions (category 2), or the student could be required to design an experiment to demonstrate what factors effect peripheral blood pressure (category 3).

TABLE 2. *Percentage of General Physiology laboratory manuals including exercises in each topic and subtopic.*

Topic Subtopic	% Manuals With:		Topic Subtopic	% Manuals With:	
	Topic	Subtopic		Topic	Subtopic
Circulation	100		Hematology	89	
Cardiac Cycle		100	Blood Type		89
EKG		100	Hb		89
Blood Pressure		89	Hematocrit		78
Exercise		56	Clot Time		78
Microcirculation		56	Histology		78
Heart Sounds		44	Sedimentation		33
Direct Blood Pressure		33	Respiration	78	
Pleismography		33	Rate and Volume		78
Blood Volume		11	Respiration Drive		55
Comparative Systems		11	Endocrinology	67	
Neurophysiology	100		Thyroid Hormone		56
Reflex		78	Sex Steroids		56
Transmission		67	Hormonal Bioassay		33
Reception		56	Epinephrine		22
EEG		22	Insulin		22
CNS Physiology		11	Nutrition	55	
Renal Physiology	89		Digestion		44
Urinalysis		78	Absorption		22
Tubular Filtration		33	Motility		11
Hormonal Control		22	Metabolism	55	
Muscle Physiology	100		Calorimetry		55
Skeletal		100	Thermoregulation		22
Smooth		55	Enzymes		22
EMG		22			

### Results and Discussion

Six of the ten major topics in human physiology were represented in all of the manuals examined and two other topics (nutrition and muscle physiology) were present in all but one manual (Table 1). Endocrinology and reproduction were the only human physiology topics covered by less than half of the manuals reviewed. The homogeneous nature of human physiology manuals transcended not only topic areas, but also subtopics as well. Nine laboratory exercises (histology, hematocrit, blood type, blood pressure, reflexes, vision, audition, urinalysis, osmosis) were present in all human physiology manuals. Eight of these exercises have direct clinical applications and all nine are relatively inexpensive, easy to carry out, have a high success rate, and are illustrative of important physiological phenomena. Additionally, eight of these exercises utilize the human organism as the experimental subject which possesses obvious advantages, not the least of which is stimulating student interest in the functional properties of their own bodies. Other exercises found in a majority of human physiology manuals also involved relatively inexpensive instrumentation and clinical observations. These included blood clot time, heart sounds, taste reception, renal homeostasis, and spirometry. *In vitro* digestion and frog skeletal muscle contraction were the only two experiments which did not utilize human subjects but were present in most

of the manuals observed. These experiments are, however, inexpensive and illustrative of physiological principals which would be impossible to conduct on human subjects. Those experiments infrequently observed in the manuals involved expensive equipment acquisitions (electrophoretic apparatus, ergometer, physiological recorder, and calorimeter), more extensive animal care and handling (microcirculation, ciliary movement, cell respiration, sex steroids and pregnancy bioassay) or required complex and tedious methodologies, (observation of *in vitro* circulation, CO<sub>2</sub> measurement, karyotype production, accurate pH measurement and tedious bioassays). It is somewhat surprising that such experiments as hemoglobin determination, sedimentation rate, blood pH, olfaction, renal clearance, and respiratory sounds were not more widely distributed since they meet the major criteria of those found in all human physiology manuals (i.e., human subjects, little equipment, clinical application). Perhaps tradition and conformity are reflected in the manual authors' experiment selection within temporal constraints relative to limited student laboratory time. Human physiology manuals were largely restricted to human subjects, involved clinical data gathering (with clinical applications), were pedagogical in presentation, required a minimum of bioinstrumentation and were fairly standardized among all manuals. This must be considered a logical approach to laboratory instruction in human physiology since such courses generally involve underclassmen who are bound for clinical careers. Additionally, human physiology class sizes may be larger than general physiology courses necessitating financial frugality.

Laboratory experiments in general physiology manuals fit into nine major topic areas (Table 2). The topics cellular processes and reproduction were not present in general physiology manuals and the area metabolism was added. Experiments and subjects covered in general physiology manuals were much more heterogenous than those in human physiology manuals. This is exemplified by the fact that subtopics categories were highly diversified and only three of the major topic areas were present in all general physiology manuals (circulation, neurophysiology and muscle physiology). The experiments common to all general physiology manuals (cardiac cycle, EKG, and skeletal muscle contraction) are all time tried experiments with a high level of success and clearly represent basic physiological phenomena. Probably for the same reasons as in human physiology manuals, the most commonly used experiments were the most inexpensive and utilized human subjects. However, there was a much greater tendency to utilize more sophisticated instrumentation (physiological recording systems with pleysmograph, EEG, EMG capability) than was the case in human physiology manuals. Additionally, there were more *in situ* investigations (direct blood pressure, blood volume, CNS physiology, tubular filtration, hormonal control, smooth muscle contraction, endocrinology, absorption, gastric motility, and calorimetry) which require animal maintenance and handling skills. In accordance with the theme of general physiology courses, these manuals also tended to offer a more varied array of experimental subjects (Table 3) although humans were again the most commonly utilized subject within five of the major topic areas.

Most human physiology experiments fit category 1 of independent student involvement while general physiology manuals exhibited a predominance of student involvement fitting categories 2 and 3 (Table 4). These results are consistent with the assertion that human physiology manuals tend to be clinically oriented where precision in technique is stressed and data are compared to previously determined ranges and averages. General physiology experiments involved much more data interpretation by the student, presumably to more completely develop an appreciation of the use of scientific method and design. Category 3 experiments

TABLE 3. *Percentage of General Physiology laboratory manuals using each experimental animal for each major topic area.*

Topic	Utilizing					
	Humans	Other Mammals	Reptiles	Amphibians	Fish	Invertebrates
Circulation	100	67	100	100	0	11
Endocrinology	11	56	0	0	0	0
Hematology	89	0	0	0	0	0
Metabolism	44	22	0	11	11	0
Muscle Physiology	22	44	0	100	0	0
Neurophysiology	78	22	0	78	0	0
Nutrition	0	33	0	0	0	11
Renal Physiology	55	22	0	22	22	11
Respiration	78	0	0	0	0	0

which involve the student directly in experimental design were totally lacking in human physiology manuals and surprisingly scarce in general physiology manuals (only two manuals included any category 3 experiments at all). Undoubtedly, category 3 experiments necessitate a reduction in the quantity of data collection and in the breadth of experimentation since student time is required in developing experimental design. The inclusion of at least one category 3 experiment would, however, present the student in physiology with first hand experience with the process of scientific method.

### Appendix

#### Human Physiology

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7. MCCLINTIC, J. R. 1976. *Human Anatomy and Physiology. A Laboratory Manual*. J. Wiley and Sons Inc. New York, NY 281 p.

TABLE 4. *Percentage of all laboratory exercises in each category of independent student involvement for human Physiology and General Physiology laboratory manuals (see text for description of categories 1, 2, and 3).*

Manual Type	Category		
	1	2	3
Human Physiology	61.2	38.8	0.0
General Physiology	40.9	57.4	1.7

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