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ABSTRACT

This publication of the American Physiological Society provides information about some new classroom experiments and techniques. These are: "Negative Feedback Control in the Blowfly--A Laboratory Exercise," "Demonstration of Various Habitats for Investigating Murine Behavior Patterns," and "Use of Behavioral Objectives and Audio-Visual Tutorial Methods in the Teaching of Physiology." Book reviews are presented, along with the list of free publications available to the subscribers of the newsletter. A list of audiovisual materials is arranged by categories for graduate students, medical students, allied health, and nurses; high school and introductory college; and middle school, elementary and lay audiences. (PS)

THE PHYSIOLOGY TEACHER

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NEGATIVE FEEDBACK CONTROL IN THE BLOWFLY – A LABORATORY EXERCISE

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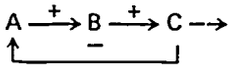
The principle of feedback control operates at nearly all levels of organization in biological systems, from the molecular to the whole animal level and beyond. At all levels it operates on essentially the same basis, namely that the product of a reaction or sequence of events can have an effect on the reaction, as summarized in a simple diagram:



Here the sequence of events will result in a more or less constant level of C, since as C increases, its braking effect on A eventually produces a lower value of C, releasing A partially from inhibition and resulting in a higher level of C, and so on.

Many such feedback loops are difficult to get at, and difficult to demonstrate in a single laboratory period. In the Blowfly, *Phormia regina*, a negative feedback loop exists at the neural level, which functions to control the fly's food intake. It is relatively easy to tamper with the workings of this system and to produce noticeable effects with a minimum of equipment. The feeding behavior of the fly can thus serve as a model system which demonstrates the principle of negative feedback loops in general.

FEEDING PHYSIOLOGY OF THE FLY

The fly has taste receptors both on its tarsi and on the labellar lobes of its proboscis (tubular mouthparts) (Figure 1). These are hair sensillae in wh[illegible] four basal cell bodies send dendrites out through a lumen to a pore near the tip of the hair (a fifth cell in each hair sends a dendrite to the base of the hair, and is a mechanoreceptor); the pore is thought to be open to the outside environment, allowing stimulating solutions to make contact with the receptor membranes of the sensory cells. Each of the four chemosensory cells which sends a dendrite to the pore has a characteristic range of sensitivity: one is sensitive to salts, one to acids, one to water, and one to sugars. A complete review of Blowfly feeding behavior can be found in the chapter by V.G. Dethier, Feeding Behavior of the Blowfly, in *Advances in the Study of Behavior*, Vol.2, edited by Lehrman, Hinde, and Shaw, Academic Press, 1969.

In a food-deprived fly, stimulating one or more of either the tarsal or labellar taste hairs with sugar-water causes the fly to extend its proboscis and suck up the sweet fluid. In a fly which has recently had a meal, stimulating the taste receptors has no effect on behavior even though the primary

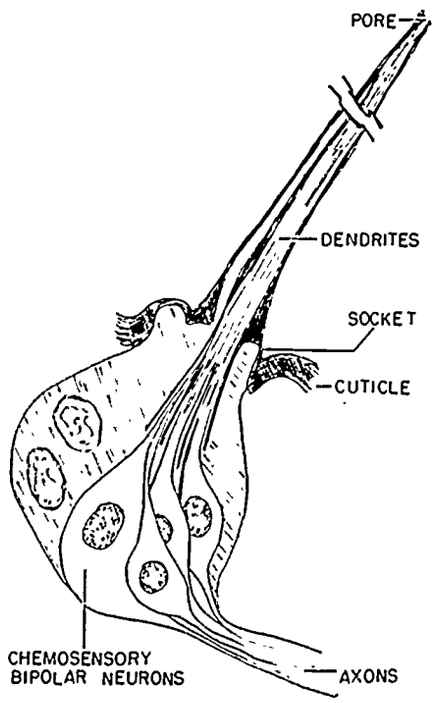


Fig. 1

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receptors still generate nerve impulses–the reflex of extending the proboscis has been inhibited.

This inhibition is due to feedback from internal stretch receptors in the gut wall which signal distention of the gut. The receptors lie in the region of the foregut, through which food passes on its way from the crop. Food is stored in the crop after feeding, passing slowly to the midgut, where it is finally absorbed, the foregut contributes to moving food into the midgut by means of peristalsis. Therefore the fly's central nervous system continues to receive input from its foregut stretch receptors for as long as it has food in its crop. The period of time for which neural input continues is greater for larger meals and for meals of higher caloric value. Due to the nature of the input, the longer the time since a fly's last meal, and therefore the emptier its gut, the more likely it is to take a meal when it comes across food. Hence the existence of a negative feedback loop allows the fly to regulate its food intake at a more or less constant level (Figure 2).

There is also a second set of stretch receptors which lie in branches of the nerves surrounding the crop. These are activated by movement and distention of the crop. The effect of neural input from these receptors upon feeding behavior is similar to that of input from the foregut stretch receptors; an analysis of the interactions between these two sources of inhibitory feedback can be found in Dethier and Gelperin, 1967, Hyperphagia in the Blowfly, *J. Exptl. Biol.*, Vol, 47, pp. 191-200.

The diagram of the foregut receptors' feedback system, with which we will be concerned, is as follows:

As you can see, inhibition is imposed on the input from the tarsal hairs of the legs but not on the input from the labellar hairs of the mouthparts.

There are several ways of affecting the feedback loop so that the fly becomes hyperphagic. One is to completely cut off the flow of information from the foregut receptors by cutting the recurrent nerve, which carries impulses from the foregut stretch receptors to the brain, so that one removes the inhibition close to its source. A film loop is available which shows the operation of cutting the recurrent nerve and pictures its effects on the fly; this procedure and its results, which are striking, are best shown by demonstration or by means of the film loop, "Feeding Behavior of the Blowfly," by Vincent Dethier, Harper and Row film loop cat. # 04-78198, Library of Congress card No. 77-706630.

A second method of tampering with the feedback loop, which we will use, is to bypass the loop by eliminating the first part of the feeding sequence, *i.e.* stimulation of the feet, and feeding the flies by mouth. Inhibition from the stretch receptors then has no effect on the amount a fly will eat, since the inhibition is all directed toward taste input from the feet, and so the flies should become hyperphagic.

EQUIPMENT AND METHODS

The research described above has all been carried out on *Phormia regina*, the black Blowfly. Pupae of this fly should be obtainable from most Entomology departments. If *Phormia* is difficult to obtain it might be possible to observe the same effects on other Blowflies such as *Calliphora* or *Lucilia*, but they should be tested beforehand to make sure that they will respond in the same way as *Phormia* to the manipulations described. Females of *Phormia* will lay eggs on liver, horsemeat, or some equivalent source of protein, provide fresh meat every day until the eggs are laid. The larvae can be raised on dogfood, they should be kept in a container which permits some ventilation but which does not allow the larvae to escape, since the late-instar larvae tend to wander. A Mason jar with a two-part lid, with the liner lid replaced by a square of muslin or cheesecloth, makes an ideal container for both larvae and adults. At normal room temperature, the larvae pupate in about nine days after they hatch; several days before this, some fine sawdust or shavings should be added to the container of dogfood as a pupation medium and the pupae can be separated from the sawdust a couple of days after pupation has taken place. The adult flies emerge four to five days after pupation takes place. They can be maintained on water and sugar cubes, with a source of protein available if eggs are desired.

The adults to be used in the laboratory should be allowed to emerge into clean Mason jars (about 100 pupae per jar) supplied with a wet piece of filter paper as a source of water, and should be two to three days old before being used. They can be immobilized either with CO_2 gas or with cold–cold may be more convenient in a large laboratory.

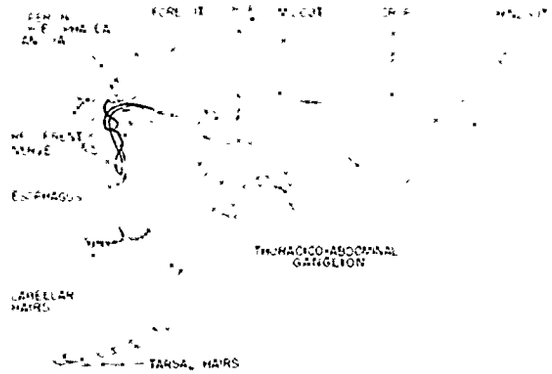

Fig. 2

One can put the jars of flies to be used in a refrigerator for an hour before they are needed, then transfer them to covered glass or plastic containers, twenty or so per container, on ice or in a refrigerator. Students should be cautioned to handle the flies as little as possible and to leave containers in the cold at all times. Ten flies, plus a few extras, will be needed for each team of students.

The following equipment is needed:

For the lab as a whole:

- Two flasks containing a few lumps of dry ice, clearly labelled "control and experimental."* A bag or liner of cheesecloth can be placed in the flask, over the dry ice, to facilitate removal of flies.
- A precision balance capable of weighing accurately in the mg range.
- A beaker of 100% ETOH for use as a killing jar (flies succumb immediately when thrown in).

*These containers are used to collect the flies for weighing at the end of the exercise, and it is very important that control and experimental flies be put in the proper container–mixups have been known to obscure good results in the past.

For each team of students:

10 fly holders (these may be made by sticking a ½" lump of Tackiwax (Cenco) onto one end of an applicator stick).

Two stands for holders, each to accommodate five holders (these are easily made of 1 X 2 lathing cut in a 6" sections, with holes drilled at 1" intervals to fit the applicator sticks).

2 Petri dishes or watch glasses.

1.0 M sucrose — enough of each to give each team a

Distilled water — Petri dish full

THE LABORATORY EXERCISE

Preliminary instructions:

Each team of students will have ten flies, five experimental and five control flies. Label the two fly stands E and C. Label the Petri dishes "sugar" and "water." The ten flies should be mounted on holders—to do so, pick up a fly gently by one wing. Hold it so that its head points toward the top of the applicator stick and its back is against the Tackiwax lump. Working quickly, and still holding it by one wing, stretch the other wing out horizontally and press it firmly into the Tackiwax. Stretch out the first wing and do the same. The entire surface of both wings should be stuck down so that the fly's back is snug against the Tackiwax, or the fly may pull free. If a fly begins to get too active, return it to the cold temporarily. If you injure any of

Fig. 3

its legs in attaching the fly, discard it in the alcohol container and use another fly (Figure 3).

THE EXPERIMENT

1. The first step, when you have ten healthy, securely mounted flies, is to make sure they are not thirsty. Fill one Petri dish (or watch glass) to the brim with distilled water. Take one fly on its holder, and lower it slowly over the water until all its feet just touch the surface. In this position, its proboscis should not be able to reach the water when extended. If the fly extends its proboscis, lower it a little more and let it drink. When it has stopped drinking and its proboscis has been retracted for several seconds, replace it in its stand. Test all ten flies the same way.

2. The next step is to feed the control group, consisting of the five flies in the "control" stand. These will be allowed to feed in the normal manner (starting the feeding sequence by stimulating the feet). Fill the second Petri dish with sugar-water. Lower the control flies one by one over the sugar and allow them to feed, following the same procedure as in (1) above. When all five have fed, test them again, in the same order, to make sure they are really satiated. Several flies will probably feed again the second time. Test all five flies a third time and note their behavior, ignoring *partial* extensions of the proboscis.

3. Finally, test the experimental group. *Before feeding these*, gently press all six legs into the Tackiwax so as to make sure that no leg receptors will touch the sugar-water. Remember that you will want an intact fly at the end of the experiment. Then proceed as with the control group, this time lowering the flies over the sugar-water until the proboscis just touches, and continuing to test each fly in turn until it has stopped feeding; stop after six trials if the fly continues to feed.

4. The last step is to measure the effects of bypassing the negative feedback loop. This will be done by comparing the weights of the flies in the experimental and control groups. Since the differences will be small in absolute terms (an average fly weighs about 25 or 30 mg) all the flies in each group from the whole class will be weighed together. Two flasks containing dry ice should be provided; these will be used to quick-freeze the flies for weighing. Be sure that experimental and control flies are kept separate and are put in the appropriate container.

   Gently free the legs of the experimental flies from the Tackiwax with a pair of forceps. Cut off the flies' wings at their base and drop the flies into the proper flask. They can be weighed after 7-10 minutes in the flasks. Pool the results for the entire class and compare the weights of experimental and control groups.

QUESTIONS FOR STUDENTS

1. How many trials did it take before the control flies stopped feeding? Before the experimental flies stopped feeding?

2. What do you think would happen if a fly were fed a sweet, non-nutritious sugar, given the kind of control it has over intake?

3. What would happen if it were fed a sugar which was nutritious but not very sweet?

4. Discuss briefly an example of negative feedback control at a different level of organization. Can your example be bypassed or opened in the same way as the fly's? What happens?

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USE OF "BEHAVIORAL OBJECTIVES" AND "AUDIO-VISUAL TUTORIAL" METHODS IN THE TEACHING OF PHYSIOLOGY

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My attitudes and methods toward teaching have been revolutionized by two experiences in the last several years. One experience was that of developing a vocational curriculum in medical technology built around "modules of instruction," each based on specified "behavioral objectives"(1). The other experience was a short-course at Purdue University on audio-visual tutorial (AVT) approaches to teaching (2). These teaching approaches are the major current trends in education, although neither has made much impact on the teaching of physiology. With certain modifications, both teaching philosophies have considerable merit and perhaps we teachers of physiology ought to incorporate some of the new ideas into our teaching. Toward that end, I have employed both approaches in a rennovation program for my course in comparative animal physiology.

THE BEHAVIORAL OBJECTIVES APPROACH

Modules of instruction are organized around basic physiological subject areas (muscle, digestion, etc.), integrating conventional lecture and laboratory material. Instructions for learning activities in a given module are presented sequentially, one step at a time, in the behavioral objectives format. The objectives are really performance requirements, stated in terms of physical behavior wherever possible. For instance, rather than direct a student with such vague and abstract terms as "understand," he is told to *do* something that will *demonstrate* his understanding to himself and to me.

Specific exampies of behavioral objectives that I have developed in physiology are available upon request. I have also used this approach in a graduate course on methods of physiological investigation and found that the technique is especially suited for instrument-oriented learning tasks.

THE AUDIO-VISUAL TUTORIAL APPROACH

AVT methods generally require students to study tape-recorded information in individual study carrels. In addition, other learning materials are placed in the carrel and at central demonstration tables. This approach has the principal merits of increasing active involvement in learning and allowing students to progress at their own pace. The AVT program itself is not just a "taped lecture", didactic material is made provocative by asking students questions, requiring them to solve problems, analyze data, debate theories, etc.

One of my modifications of AVT teaching was to have a team of 4 students study together in a carrel. Students were grouped for 2 reasons. 1) many physiological experiments require a team effort and cannot be accomplished by one student, and 2) students should be able to teach each other through explaining complex material in their own terms, quizzing each other, and discussion.

The other major modification was the use of "skeleton" notes in conjunction with tape-recorded material (examples of such notes are available upon request). Past experience with taped instruction, as well as lectures, has taught me that students spend an inordinate amount of time and effort in taking notes. Skeleton notes insure that material is well organized and free the student's time for thinking and discussion, thereby making the student more actively involved in the substance rather than the mechanics of learning. I believe that a controlled experiment which I performed has documented the efficacy of skeleton notes (3).

IMPLEMENTING THE COMBINED APPROACHES

Students are required to sign up for 2-3 study sessions in the laboratory during each week. Students begin with the learning activities for the first behavioral objective and set their own pace of progression. A given objective may require listening to the AVT program and use of skeleton notes. At various stages the group may be instructed to perform an experiment, observe demonstrations, or consult reference material.

The learning activities are generally equivalent to about 2 lectures and one 3-hour laboratory period. The conventional course included 3 lecture hours and 3 laboratory hours per week, in the revised course, the third, unused lecture hour is available for presentation of review slides and for discussion of recent research as it relates to the programmed subject matter. This reinforces the learning experiences and at the same time provides very important academic enrichment.

When a given module is completed by a group, each member is required to demonstrate 80% mastery by specific written examination, if necessary, repeat examinations using different questions are given. To help insure that memories of learning experiences are consolidated, examinations are delayed a day or more.

Student reaction was generally quite favorable, but they did not like group study. Although some groups did function well and those students benefitted from the group interaction, most groups did not work well together. Many conflicts arose from wide variations in student interest, aptitude, perseverance and spirit of cooperativeness. Another problem was the difficulty of finding mutually satisfactory study times. This feedback will require modifications, I might retain the classical 3-hour laboratory period for those behavioral objectives that cannot be accomplished by one man alone, and at the same time replace about 2/3 of the lecture hours with completely individualized, self-paced instruction.

If by now the reader has developed an interest in revising his own course of physiology, I have some suggestions that might help smooth the way. The first item of advice is to go slowly, converting only a few blocks of lecture laboratory material on subjects that are especially convenient. The conversion process takes much more time and effort than one would anticipate, although as the professor gains experience, he becomes more proficient.

Money need not be the obstacle that many people believe. Most physiology laboratories are already equipped with the basic essentials. chemicals, animals, recording devices, etc. Visual aids are produced very cheaply in the form of 8X10 photographs. Carrels can be built by unskilled labor out of plywood and bulletin-board material.

Many institutions provide ways to enlist help from students. Outstanding students can be hired to help build carrels, models, and even to design behavioral objectives and skeleton notes I have used some of the seminar and problems courses of our department to enlist student participation in developing modules Of course, I must provide guidelines, define much of the material to be included, and critique the selection of performance objectives, visual aids, notes, and experiments.

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3. Klemm, W.R. 1973. Efficiency of handout, "skeleton" notes in student learning. *Improving College and Univ. Teaching*. In press. (Scheduled for publication in 1973; text can be provided earlier upon request).

BOOK REVIEWS

Animal Physiology: Principles and Adaptations by Malcolm S. Gordon in collaboration with G.A, Bartholomew, A.D. Grinell, C. Barker Jorgensen, and F.N. White. Macmillan Co., New York and London, 1972. 592 pp. Illustrated. (2nd Ed.) $14.97.

The preface of this book states that it places "Emphasis on function as it is related to the survival of organisms in their natural environment. The book might be called a textbook of ecological physiology." In this effort, the authors have been extremely successful. Not only are physiological and morphological adaptations of various organisms to their environments clearly elucidated but the importance of behavior modifications is continually stressed. The textbook is a truly comparative one with respect to the vertebrates. In the first edition studies of invertebrate functions were somewhat lacking but this situation has been improved in this second edition. To supplement this deficiency, numerous references to invertebrate material are scattered throughout the text. To the comparative physiologist, the addition of several "special cases," such as hypertension in the giraffe, marine amphibians and endothermy in some fish and elasmobranchs, are particularly interesting.

The first three chapters deal with nutrition, energy metabolism and muscle physiology. This is followed by a treatment of the systems dealing with internal regulation including respiration, circulation, osmotic and thermal regulatory mechanisms. The remaining chapters deal with sensory and nervous mechanisms, central coordination and chemical control. Where applicable, organisms are treated with ecological rather than strictly taxonomic groups so that one sees titles referring to "Aquatic Ectotherms," "Terrestrial Ectotherms," etc.

As a student text, this book makes several important contributions. The Introduction is particularly well done. Here the authors provide the reader with a clear and concise review of the different approaches, goals, and philosophies employed in the study of physiology. The extreme complexity of this subject is underlined and the need for the application of numerous research techniques from various disciplines. No less important is the fact that the reader is made aware of the limitations and pitfalls involved in trying to relate laboratory data to natural phenomena. In the light of this awareness, the student can more fully appreciate what is presented in the following chapters. Also included is a section on animal classification, a list of the more widely used review and research journals, and an extensive list of additional readings in physiology and related subjects.

Succeeding chapters are particularly well illustrated with drawings, charts, graphs, and in some cases, electron micrographs. Thus, the student is exposed to the presentation of research data in various forms rather than just the written word. Conveniently, complete references to the data represented in the various figures are included in the figure description. At the end of each chapter an up-to-date list of additional readings is available.

In summary, this work presents a stimulating treatment of an ecological approach to animal physiology and will serve as an outstanding text in this area.

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Grants Administration by William Willner, Perry B. Hendricks, Jr., and National Graduate University, Washington, D.C., 1972. 278 pp. $12.50.

A concise and readable review of Contract and Grant Administration which is well done and covers many points starting from the early origin of the grants system to the present day. The first two chapters contain many references and discuss the individual characteristics of both grants and contracts. The anatomy of a grant is covered, especially with respect to conditions that need to be met to receive and utilize it. The less formal administration of grants is compared to that of contracts.

For the layman, this book is a good introduction into the field of grant and contract administration while covering, with a minimum of excess detail, the area from the inception of the proposal to the finished report. For the experienced administrator, it is a good review of salient points in the field.

The writers, in covering the field of costs, go back to the Blue Book or "Mills formula," and bring you up to date to OMB circular A-21 with which this reviewer had worked in its earliest stages while associated with the Massachusetts Institute of Technology for a number of years. Allowable and unallowable costs; overhead rates and their limitations; cost sharing and many other related items are dealt with. There is broad coverage in grant administration. Reviews are included of such subjects as property management; office organization; relations with the faculty; and assistance given in formulating the original proposals. A good delineation of

the attributes needed to be a successful administrator of grants and contracts is presented.

In summary, it may be stated that the authors' experiences have aided them greatly in putting together a book which covers many necessary details without losing the reader in a myriad of detail and legal jargon and thus losing its full impact. Both the inexperienced and experienced reader should find it very interesting and stimulating, and a helpful aid which should be added to his or her library of reference works.

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11 September 1972

Physiology of Man by L.L. Langley. Van Nostrand Reinhold Co., New York, 1971. 771 pp. (4th Ed.) $10.95.

Physiology of Man by L.L. Langley is a revised edition of a well-established elementary text which has appeared in previous editions by Drs. E. Cheraskin and L.L. Langley. Designed for students with minimal preparation in mathematics, the physical sciences, and anatomy, *Physiology of Man* presents a fairly extensive treatment of the subject. First, there is a brief overview of cell and tissue organization, followed in sequence by several chapters treating nerve, muscle, sensory phenomena, and neural integration; circulation and respiration; nutrition and the function of the digestive system; excretion and regulation of body fluid composition; and the functioning of the endocrine glands. Each chapter concludes with a short summary, followed by a few review questions. There is a good index, but no supplementary references, nor other devices to extend the impact of the material beyond the covers of the book. The illustrations are adequate in number, and the line drawings are simple, clear, and attractive in style. The rare photographs are less satisfactory; they do not add as much to the interest nor to the understanding of detailed structure as might be expected were the reproduction more effective.

Considering the student for whom the book is designed, it has some excellent features as well as certain drawbacks. The style is, for the most part, straight-forward and lucid. Appropriate subtitles and paragraph headings guide the reader forward from page to page. Illustrations from clinical conditions are cited fairly often, in a practice known to arouse student interest. In places, as in the newly added chapter on "Physiological consequence of travel in space and under the sea," the presentation is particularly interesting and informative, with comments on unsolved problems and new approaches in addition to more traditional material. Overall, the discussion is up-to-date.

On the other side of the ledger, the treatment is consistently didactic and somewhat impersonal. This quality of impersonality comes in part from the fact that the contribution of actual people to physiological understanding is barely suggested. Terms such as Dalton's law, the Starling hypothesis, and the Acshheim-Zondek test are indeed used. Despite such references, the reader might gain the impression that physiology arose *de novo*, with no help from Harvey, Beaumont, Cannon and the many other scientists of past and present. A second major reason for the seeming remoteness of the text is its omission of reference to many problems of great concern to students. For instance, approaches to understanding the effects of therapeutic agents, drugs, and toxic materials in the environment are barely hinted at, as in occasional references to the effects of alcohol. Students have many urgent questions which can be clarified by understanding of physiology, but most of these questions receive scant attention in *Physiology of Man*. Finally, throughout the book the uncertainty and change inherent in much of physiological theory is underplayed. Thus, human physiology as described in the text appears more solid, and less challenging and dynamic than it actually is today. Almost never is an attempt made to give the student real understanding of how physiological problems are solved, nor how specialized methods and instruments can serve in the search for solutions. This deficiency is not unique to this book, of course. Rather, it is so characteristic of many elementary texts that it is not surprising that many students believe the study of physiology to be abstract and difficult, as well as remote from their own personal lives.

In summary, *Physiology of Man* may be recommended as a solid, informative book to serve as a basis for the study of physiology by students with marginal preparation in the sciences. The teacher who uses this book will doubtless feel constrained to supply, in addition, opportunities for students to obtain intellectual challenge and an appreciation of human physiology as a dynamic field of human inquiry of direct significance to the individual's life.

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Vertebrate Physiology by William J. McCauley. W.B. Saunders Co., Philadelphia, London, and Toronto, 1971. 422 pp. $9.75.

This excellent textbook for a one-semester undergraduate course in vertebrate physiology was prepared from a series of lectures. The author is successful in integrating the materials of various disciplines of molecular biology and physiology so that the student is presented with a modern-day comprehensive approach to the basic concepts of physiology. It is concisely written in everyday language with appropriate illustrations and cross-indexing throughout the book. A guide to relevant advanced textbooks is found in the supplementary reading section in the back of the book. Definitions and explanations are immediately available in the text in parenthesis to encourage continuity of thought. The comparative approach gives the student an opportunity to learn which functions are common and which are peculiar to a group of animals in response to their physical environment.

The book apparently aims to provide a comprehensive survey of all the areas it covers. Since the subject is too large for adequate discussion in a book so small, the author gives more attention to some areas while skimming others. Like other modern textbooks on physiology, there is minimum emphasis placed on anatomical structures except those necessary for presentation of a functional aspect.

Following an introduction which includes a review of basic processes, there is a brief coverage of the relationship

between structure, location, and function of various cells found to be common in vertebrates. The next five chapters cover respiration and circulation in the classical manner. The topics discussed include the dynamics of blood, a comparative study of the patterns of circulation, the role of respiration and circulation in adaptation to extreme external environmental conditions, and the various transport as well as non-transport functions of blood.

Using the mammalian kidney as the key model, the relationship between function and structure of the excretory system is covered in the eighth chapter. As in most physiology textbooks, the only vertebrate animals examined in any great detail are mammals.

The next three chapters emphasize the relationship between nutrition, digestion, and metabolism of the macromolecules of foodstuffs. Here the student is exposed to the pathways of intermediary metabolism and the utilization of energy.

For the sake of brevity only four chapters are devoted to the surveylike coverage of the nervous system. Unless more research information could be included, a more adequate coverage of neurophysiology is almost impossible.

A single chapter is devoted to the various types of muscles, their functions, the basic concepts of the contractile theory, and a brief discussion of the evolutionary aspect of locomotion. The final chapter on endocrinology is perhaps one of the least developed areas of the book.

It is evident that anyone writing an undergraduate textbook in such a dynamic science as physiology has to decide what is pertinent in terms of the future needs of the student. McCauley has tried to be as comprehensive in his coverage as possible within these limitations.

As a whole, students who were assigned this textbook expressed favorable comments concerning it. They felt that as a text it met their basic needs for a general book covering the comparative aspect of vertebrate physiology on an introductory level.

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EXTRA ISSUE OF THE PHYSIOLOGY TEACHER

As announced in the previous issue (Vol. 1, No. 6, July, 1972) this issue of The Physiology Teacher is an extra issue provided within the first year's subscription.

The reason for the extra issue is to bring the subscription year into a calendar year basis, in line with customary periodical purchasing, and still maintain our quarterly schedule.

Volume II will begin with the January issue. If you have not renewed your subscription and wish to do so, a subscription blank was mailed with the July issue.

DEMONSTRATION OF VARIOUS HABITATS FOR INVESTIGATING MURINE BEHAVIOR PATTERNS

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One of the major social problems that faces our nation today is drug abuse. Drug abuse does not recognize academic or socioeconomic boundaries. It occurs in homes and dormitories as well as in alleys and cellars. One approach to aid better understanding of this problem area would be to provide teachers and students with educational tools and techniques for observing the effects of drugs on biological systems.

A biological system which lends itself to scientific investigation is a grouping of the small common social mammal, the mouse. Mice are inexpensive, easy to maintain and handle, and have a complex set of social interactions and behavioral responses that can be observed and measured. Indeed much of our knowledge about learning, motivation, behavior and drug effects has been derived from research using rodents, the group to which the common house mouse *mus musculus* belongs.

During the past ten years our laboratory has been investigating the social behavior of mice as well as the physiological, psychological, and biochemical correlates of this behavior. It has been shown by numerous investigators that social factors are responsible for many neuro-endocrine response patterns [2,3,7,15,17]. Important variables responsible for a pathological or nonpathological response are the duration of the psychosocial stimulus, individual perception of the social situation, and the repertoire of responses available to cope with the situation. When a social organism is in a situation that is stressful or demands a confrontation, evidence shows that the sympathetic-adrenal medullary and pituitary adrenal cortical defense alerting systems are primarily affected [1,6,9,11]. It is understandable then that animals in different social environments or with different social experiences can have different physiological and psychological responses. For instance, amphetamine is more toxic for newly aggregated than for individually housed mice [10], but the toxicity is reversed in mice that have been housed together for several weeks [18]. Also it has been shown that mice socially deprived by isolation have a decrease in the catecholamine biosynthetic enzymes while mice socially stimulated by mixing without regard to family origin exhibit an increase in these enzymes over control box siblings [1].

One method to allow different social environments to develop is through an appropriately designed system of interconnected cages. Different physical arrangements of cages can elicit specific patterns of behavior.

ENVIRONMENTAL DESIGN

The standard laboratory cage can be used to study dose-response relationships of drugs and obvious changes in behavior can be detected, such as a dramatic alteration in aggressive behavior or the difference between lethal doses in isolated versus grouped animals [18]. However, this restricted environment inhibits the development of many behavioral response patterns and a sibling group immured in a 1-foot by 6-inch box does not exhibit the same response patterns as a group which is free to interact socially in a more complex and "enriched" environment. It has been noted repeatedly that the environment restrictions imposed by many experiments have been as influential in determining the results as have been the experimental manipulations [14,16]. Therefore it is beneficial to examine behavioral responses in an environment that allows freedom of movement, social interaction, and the development of some type of social organization.

ENVIRONMENTAL DESIGN FOR AGGRESSIVE BEHAVIOR

Several different types of complex population cages have been designed which permit a wide spectrum of behavioral responses [4,5,11,13]. Calhoun [4] has studied a variety of designs for Norway rats and has found that specific arrangements can elicit behaviors which lead to the development of "pathological aggregation" and physiological and psychological deterioration of the individual members of such a colony.

Based on this concept, we modified Calhoun's "behavioral sink" design and developed a population cage which contained six peripheral nest boxes interconnected in a wheel fashion with each having access to a center hub area supplied with food and water (Fig. 1). The intent of the

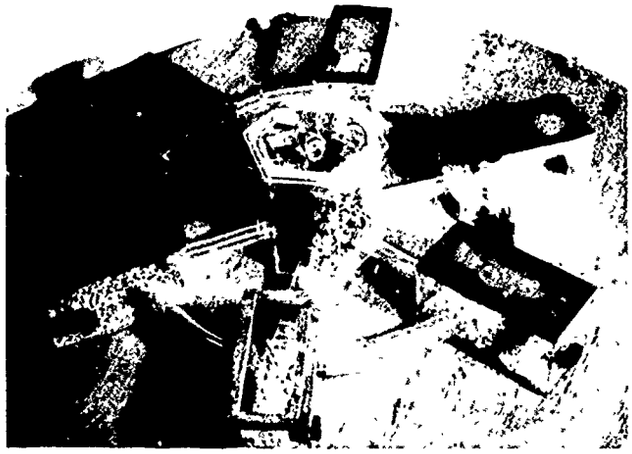

Fig. 1. Population cage designed to elicit aggressive behavior and minimal social organization.

design was to increase aggressive activity by increasing the amount of social interaction via a central feeding area. This design made it difficult for any animal to establish a territory, and, as a result, there was a social disorganization and constant aggression (Fig. 2). This type of cage has been successfully used to produce an increase in mouse aggressive behavior which, when prolonged for 6 months or more, leaves the mice with sustained high blood pressure and pathological changes [12].

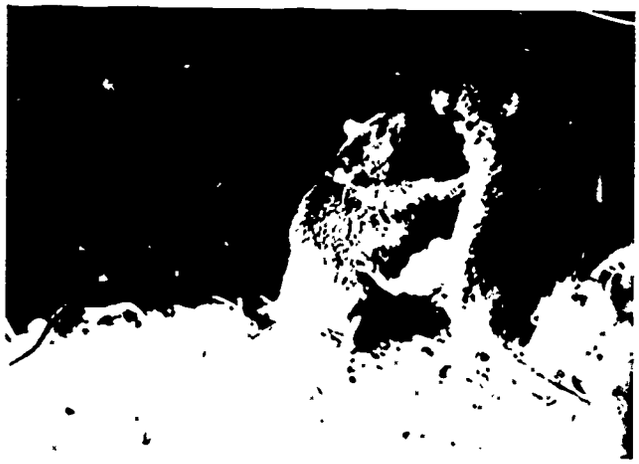

Fig. 2. Aggressive behavior observed in the population cage of Fig. 1.

ENVIRONMENTAL DESIGN FOR TERRITORIAL BEHAVIOR

In order to study territorial behavior and the development of social organization, it is necessary to employ a design which permits the mouse to defend his home environment easily. We chose a modification of that used by Reimer and Petral [13] who studied breeding and territorial behavior in mouse colonies (Fig. 3). It consisted of a series of 8 nest boxes each containing food and water. Each box had a right angle spur which led into a 5-foot-square tubular runway interconnecting all of the next boxes. The system emphasizes the development of territories and social roles because animals could travel around the area without crossing through another animal's territory and the single entrance to each nest box allowed territorial defense. Since social roles were to be studied, it was necessary to observe individuals as well as the entire colony. Therefore, gates were located at the entrance of each nest box in order to trap the animals periodically to determine individual territories, physical appearance, and male-female relationships. A scoring scale was established as a criterion for the determination of male social roles. The male with the largest territory, best physical appearance, and most female relationships received the highest score and was identified as the dominant animal. Using this technique, a rank order was determined ranging from the dominant to the subordinates.

In these systems 5 male nonsiblings and 10 female nonsiblings were initially placed into the complex population cage. Using 5 males allows the development of a dominant role, a rival, and several subordinates. Twice that number of females allows the development of one or two female nesting and nursery territories. During the first month the males are very aggressive as they compete for social position, but once the hierarchy is established, aggressive activity is minimal.

Once the colony is socially organized and the territories defined, we could administer drugs selectively either to specific role players or to the entire colony. Changes in social roles, territories, and social interactions could then be observed. The drug could be withdrawn and the further behavioral consequences observed.

Fig. 3. Population cage designed to elicit territorial behavior and social organization. The photograph shows three such systems in a vertical support rack.

QUANTITATIVE ANALYSIS OF INDIVIDUAL BEHAVIOR PATTERNS

Investigation of social roles and behavior patterns requires the development of a technique which identified individuals interacting in a population and automatically recorded their behavior profiles. One such behavior-monitoring technique has been developed in our laboratory [8]. It permits individual identification and a quantitative analysis of behavior patterns by utilizing magnetically tagged mice and magnetic detectors (Fig. 4).

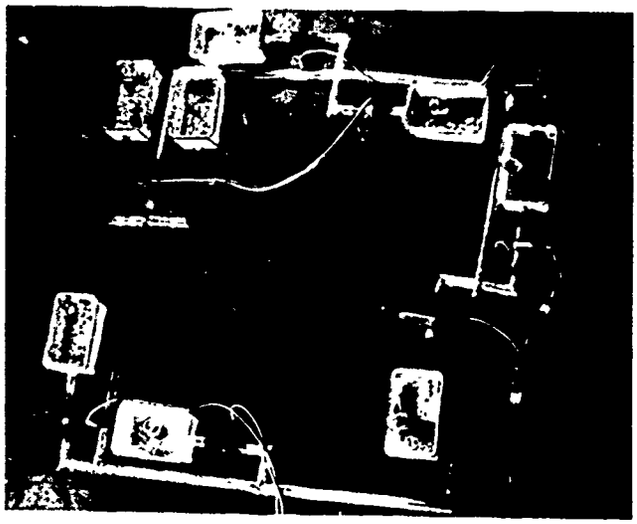

Fig. 4. Instrumented population cage to detect magnetically tagged individuals.

Each mouse is implanted with a small Alnico VIII magnet (1/16" X 3/16") either dorsally between the shoulder blades or ventrally in the lower abdominal wall. By implanting magnets in the entire group and then selectively magnetizing a ventrally or dorsally implanted mouse in an electromagnetic field the colony can be monitored two at a time (Fig. 5). The magnetically tagged mice trigger electronic checkpoints at the nest box portals and a Hall effect detector activates counting circuits, timers, and an event recorder. Using this data, general activity rates, specific behavior profiles, circadian rhythms, and frequency of maternal behavior can be measured for each animal.

Once the behavior profile of each individual has been characterized, drug-induced perturbations could then be examined. If the entire group of individuals were to be administered the drug, it is anticipated that subtle behavior changes could be detected since the profiles are quantitative. Differences would be anticipated in social roles, aggressive activity, male-female relationships, maternal behavior, and territorial behavior.

Fig. 5. Magnetically tagged mouse passing through a portal housing the Hall Effect detector. Left foreground: Hall Effect detector. Right: Alnico VIII magnet.

This behavior monitoring system has been shown to be capable of monitoring the consequences of a social change made in a colony. For instance, if the dominant animal is removed, then the rival animal assumes the dominant role and, with it, the dominant behavior profile. This system can be employed with any population cage that employs a design of interconnected nest boxes, each with an entrance or a portal at which a detector can be placed. The system can therefore be used to study specific types of behavior in environments separate from a large population cage.

Maternal behavior has been successfully investigated, utilizing two nest boxes connected by a long runway (Fig. 6) [19]. A mother was magnetically tagged and Hall effect detectors recorded her movements between the two boxes. A photocell circuit was also used to record the general movement of the infants. The amount of time the mother spent with the litter and specific patterns of the behavior of the animals at each stage of development could be examined. This type of study in which specific behavior can be quantified in a relatively simple cage system lends itself to investigation of drug-influenced behavior since drugs can be administered at different stages of the animal's development and individual behavioral changes recorded.

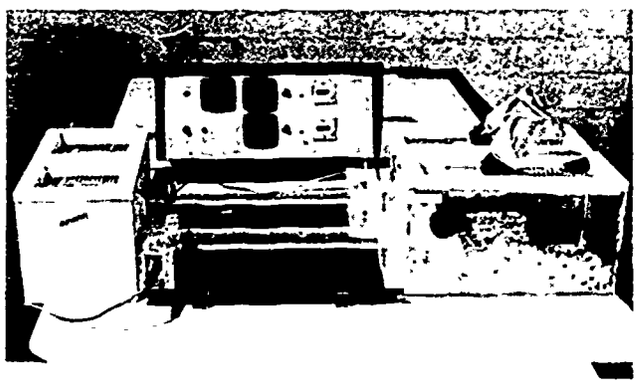

Fig. 6. Instrumented population cage designed to study maternal behavior.

FUNCTIONAL DESIGN FOR SPECIFIC BEHAVIORS

Seeking to measure a greater repertoire of behavioral responses, we have designed a population cage in which each nest box has been arranged to elicit a specific behavior. The modified Reimer-Petras complex cage system referred to above was used together with magnetic tagging, but the individual boxes were constructed differently. Instead of eight identical boxes, each provided with wood shavings, and a supply of food and water, only 3 have wood shavings. A fourth contains food and water but has a bare floor and a fifth is a latrine area with a raised wire mesh floor. The sixth box is an activity area with a wheel and counter. The seventh and eighth boxes are female nesting areas with an enclosure of cotton and wood shavings surrounded by a larger box. This functional design permits quantitative analyses of a greater variety of behavior patterns than a design using identical cages since a record is provided of individual activity and its sequence in time in the different specific areas.

SUMMARY

Colonies of socially interacting mice provide a useful tool with which to study the effects of various drugs. Groups of mice have an organized social structure with a wide variety of behavioral responses that can be selectively elicited through the use of differently designed environments. Aggression can be elicited in population cages emphasizing social interaction without social organization, or territorial defense and social organization can be demonstrated with a different cage plan. The population cages described can be constructed with a minimum of expense and effort. They lend themselves to the study of the effects of drugs since basic behavior patterns and social roles can be detected by periodic trapping of the individuals. With some further basic laboratory tools physiological and biochemical correlates can be measured.

More sophisticated electronic techniques are much more expensive but permit individual identification and quantitative analysis of behavior patterns for 24 hours at a time. The advantage of this latter approach is that automatic

continuous long-term monitoring of an animal's activities permits a quantitative determination of behavior. This permits the detection of subtle behavioral changes that otherwise would not be observed. It has proven useful as a technique for the study of population dynamics and behavior profiles.

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This paper was presented as a part of a "Teaching Session" at the spring meeting of the American Physiological Society, April 1972 at Atlantic City, New Jersey.

SCHEDULE OF FUTURE MEETINGS OF THE AMERICAN PHYSIOLOGICAL SOCIETY

*1973 Spring– Atlantic City, N.J.–April 16-20
1973 Fall–University of Rochester, Rochester, N.Y August 20-25
*1974 Spring– Atlantic City, N.J. April 8-12 Biochemists Meeting in Minneapolis–June 2-6
1974 Fall– State University of New York at Albany–August 11-15
*1975 Spring–Atlantic City, N.J.–April 14-18
1975 Fall–Michigan State University, East Lansing, Mich

* In connection with annual meeting of the Federation of American Societies for Experimental Biology

FREE PUBLICATIONS

The subscribers to *The Physiology Teacher* are offered their choice of the 19 books listed below free of charge. These books, from excess inventories of the American Physiological Society and from the Interdisciplinary Communications Program of the Smithsonian Institution, have been donated to *The Physiology Teacher* for complimentary distribution. Costs of handling and mailing have been estimated at $1.00 for four books.

The number available of individual books is variable, so that we cannot guarantee to fill all requests for each book. When our stock of a given book is depleted, we will substitute another, as close to the subject matter requested as possible. Please order in lots of four (4) on the enclosed order blank. Order as many as you wish, providing a check or money order for one dollar ($1.00) for each four. PAYMENT MUST ACCOMPANY ORDER, we will not be able to bill for payment.

LIST OF PUBLICATIONS AVAILABLE:

HISTORY OF THE AMERICAN PHYSIOLOGICAL SOCIETY. The Third Quarter Century, 1937 1962. W.O. Fenn 1963. 182 pages. A chronological record of Society activities, membership, officers, publications, and organizational relationships.

MIRROR TO PHYSIOLOGY—A Self-Survey of Physiology. Editor, R.W. Gerard, 1958. 372 pages. Describes activities, employment, income, motivations, mobility and training of physiologists.

SOME FOUNDERS OF PHYSIOLOGY, Editor, C.D. Leake. 1956. 122 pages. Short biographies of some thirty of the world's elder statesmen in physiology, with photographs.

PERSPECTIVES IN PHYSIOLOGY—A 1953 International Symposium. Editor, Ilza Veith. 1954 171 pages. Development of physiological research organization of physiology; the Russian view; philosophical limitations; survey of physiological science.

TISSUE ELASTICITY—Papers from a 1955 Congress. Editor, J.W. Remington. 1957. 203 pages. Molecular structure and mechanical behavior of macromolecules; protein structure and elasticity; elastic properties of muscle, changes in length of blood vessels, pulse wave velocity; mechanical properties of lungs.

FACTORS REGULATING BLOOD FLOW—Proceedings of the Third Conference of Microcirculatory Physiology and Pathology in 1956 Editors, G.P. Fulton and B. Zweifach. 1958. 98 pages. Regulation of peripheral blood flow; interrelation of physical and physiological factors; capillary permeability; hydrostatic pressures.

LABORATORY EXPERIMENTS IN GENERAL PHYSIOLOGY (Revised 1967)—A set of selected, tested experiments in the field of cellular and general physiology primarily designed for advanced undergraduate students. 156 pages, unbound.

MARINE BIOLOGY II. PROCEEDINGS OF THE SECOND INTERNATIONAL INTERDISCIPLINARY CONFERENCE. Edited by Carl H. Oppenheimer. 1966. 370 pages. The Conference report is divided into three sections. natural phytoplankton societies, synecological problems, and integrative in vivo and in vitro aspects, with a summation of each.

MARINE BIOLOGY III. PROCEEDINGS OF THE THIRD INTERNATIONAL INTERDISCIPLINARY CONFERENCE. Edited by W.T. Edmondson, 1966. 312 pages. Concentrates on the ecology of invertebrates. Some of the topics handled are: Sampling Organisms, Feeding, the Quality of Food, Seasonal Aspects of Food Relationships and Breeding, Effects of Quantity, Quality, Change of Diet, and Nutritional Value of Food, Algal Mutualism, Plankton, Vertical Migration & Benthos.

MARINE BIOLOGY IV. PROCEEDINGS OF THE FOURTH INTERNATIONAL INTERDISCIPLINARY CONFERENCE. Edited by Carl H. Oppenheimer. 1968. 486 pages. Unresolved problems in marine microbiology are the focal points in this book. Contents. Sampling Techniques, Validity of Present and Past Collecting Methods. Media-Organic and Inorganic Requirements, the Question of Overfeeding, Distribution, Effects of Temperature, Pressure, Currents, Organic Matter, Living Organisms, Autotrophy, & Pollution & Methods of Determination in Sea Water Systems.

MARINE BIOLOGY V. PROCEEDINGS OF THE FIFTH INTERDISCIPLINARY CONFERENCE ON MARINE BIOLOGY. Edited by John D. Costlow. 1969. 588 pages. Contents. Life Histories and Species Selections in Cultivation. Laboratory Methods in Cultivation. Pond Culture and Ecology in Natural Selection. Economic Aspects of Cultivation. References.

DRUG INFORMATION FOR THE HEALTH PROFESSIONS. Edited by Isaac D. Welt.

I. PROCEEDINGS OF THE FIRST CONFERENCE ON DRUG INFORMATION, 1967. 1970. 480 pages. Contents. Introduction Part 1. The Present Situation, D.C. Leake. Part 2. Communications and Information Science, F.A. Tate. What Practicing Physicians Want to Know About Drugs and Why, I.S. Wright, W.G. Clark. What Practicing Physicians Should Know About Drugs and Why, L. Lasagna. Difficulties of Members of the Health Professions in Obtaining Information They Want and Should Have, J.K. Weston. General Discussion and Summary, M.L. Tainter.

II. PROCEEDINGS OF THE SECOND CONFERENCE ON DRUG INFORMATION. 1968. 1970. 402 pages. Contents: Introduction Obtaining Needed Drug Information. Analyzing Drug Information. Storing Drug Information. Retrieving Drug Information. Distributing Needed Drug Information, General Discussion. Summary of Proceedings.

CONFERENCES IN CELLULAR DYNAMICS. Edited by Lee D Peachey.

PROCEEDINGS OF THE FIRST AND SECOND INTERDISCIPLINARY CONFERENCES. 1968. 446 pages. Contents. I: Physical-Chemical Aspects of Membrane Dynamics and Model Systems. Anisotropic Surfaces and Protoplasmic Movements. Pertinent Observations in Biological Systems. II: The Physical Chemistry of Interfaces. The Structure of Membranes. Cell-Surface Properties of Cells as Related to Cell Locomotion. Surface-Active Enzymatic Reactions. Immunological Reactions. Cellular Aggregation. References.

PROCEEDINGS OF THE THIRD AND FOURTH INTERDISCIPLINARY CONFERENCES. 1967. 310 pages. Contents: III: The Cell Division Cycle. Structure of Spindles and Fibrous Components and Distribution of Microtubules. Mechanism of Mitosis. Summary of the Problem. IV: Polypeptide Hormones. Steroid Hormones. Insulin References.

PROCEEDINGS OF THE FIFTH INTERDISCIPLINARY CONFERENCE, 1969. 551 pages. The final conference in the series on Cellular Dynamics with aging as its subject discusses control and regulation, genetic instability, limits in capacity for differentiation and division, crosslinking of macromolecules and pigment accumulation, and aging in specialized cells.

LEARNING, REMEMBERING AND FORGETTING. Edited by Daniel P. Kimble.

THE ORGANIZATION OF RECALL. 1969. 289 pages. Contents Relations Between Short-term Memory, Long-term Memory and Learning, A.W. Melton. Distinctions among Various Types of Memory, G.H. Bower. Arousal and Memory Trace, E.L. Walker Central Nervous System and the Organization of Behavior, L Weiskrantz. Electrophysiological Studies of Memory Mechanisms, E R. John. Organized Forgetting, H.B. Barlow. Some Comments on Memory, E. Galanter.

EXPERIENCE AND CAPACITY, 1969. 246 pages. Contents. Action Contingent Development of Vision in Neonatal Animals, R. Held Some Ways in Which Experience Affects Learning, R.A. Hinde The Effects of Hormones in Infancy on Central Nervous System Organization, S. Levine.

* * *

THE WAY OF AN INVESTIGATOR, Walter B. Cannon, M.D Facsimile of 1945 edition. Reprinted 1968. 229 pages. An autobiographical account of Dr. Cannon's work and a description of how the scientific investigator goes about doing his job.

REVIEW OF AUDIOVISUAL MATERIAL

The American Physiological Society, under contract with the National Medical Audiovisual Center (NMAC) of the National Library of Medicine, is conducting reviews of audiovisual educational aids in physiology. (*The Physiology Teacher*, Vol. 1, No. 6, July 1972). Review panels have been established in the following areas: General and Cell Physiology, Neurophysiology (incl. Special Senses & Behavior), Muscular and Skeletal Physiology, Circulation (incl. the Heart), Respiration, Excretion (incl. Body Fluids), Digestion, Endocrinology and Metabolism, Reproduction, Temperature Regulation (incl. Hibernation), Environmental Physiology (incl. Aviation, Space, Diving, Exercise & Work Physiology), Comparative Physiology (incl. Invertebrate Physiology), Plant Physiology (incl. Microbial Physiology), and Physiology in General & Miscellaneous (incl. Hygiene).

A combined panel for Endocrinology & Metabolism and Reproduction met during July 1972, and reviewed 56 educational motion pictures in this area. The panel was composed of the following members: Jack L. Kostyo, Ph.D., Chairman, Department of Physiology, Emory University, Atlanta, Ga. (Panel Chairman); Alfred E. Wilhelmi, D. Phil., Chairman, Dept. of Biochemistry, Emory University School of Medicine, Atlanta, Ga.; William F. Ganong, M.D., Chairman, Dept. of Physiology, University of California, San Francisco, Calif.; Jack Gorski, Ph.D., University of Illinois at Urbana, Urbana, Illinois; Neena B. Schwartz, Ph D., Dept. of Neuroendocrinology, Univ. of Illinois College of Medicine, Chicago, Illinois; and Carol Proudfit, Ph.D., Dept. of Neuroendocrinology, Univ. of Illinois College of Medicine, Chicago, Illinois. Attendees from the APS Education Office Staff were Orr E. Reynolds, Ph.D. and William D. De Hart, Ph.D.; Nursing Education Representatives present were Claire Parsons, Ph.D., School of Nursing, Univ. of Virginia School of Medicine, Charlottesville, Va., and Ellen Fuller, Ph.D., Dept. of Physiology, Emory University, Atlanta, Ga.

Each film was rated on a scale of 1-3 (poor), 4-6 (adequate), and 7-10 (good to excellent), in three categories: content, educational design and production quality.

The following list of films comprises those which received a rating of adequate or better in all three categories. Each title is followed by the numerical ratings in two categories: content and production quality. The recommended audience is indicated for each film. Descriptive paragraphs are as supplied by the producer, some with minor editing. Asterisks are placed after titles of films rated by APS Education Office Staff. Review of audiovisual materials in Neurophysiology were conducted in September 1972, and Musculo-Skeletal and Respiration in October. The recommendations of these panels will appear in subsequent issues of *The Physiology Teacher*.

I. Graduate Students, Medical Students, Allied Health, and Nurses

Aldosterone: Story of a Hormone

Documents the history of aldosterone through interviews with physicians who pioneered the development of this hormone. Reviews the action of aldosterone in edema and hypertension, and shows how knowledge in this subject area is applicable to daily care of patients.

34 Min. Sound. Color. 16MM. Motion Picture.
Content 8; Production quality 9
Available from: G.D. Searle & Co.
P.O. Box 5110
Chicago, Ill. 60680
Recommended: Medical Students, Allied Health, Nurses

Sperm Maturation in the Male Reproduction System

Shows changes in motility of rabbit spermatozoa as they move through each part of the epididymis.

13 Min. Sound. Color. 16MM. Motion Picture
Content 8; Production quality 9
Available from: University of Washington
Audio-Visual Services
114 Lewis Hall
Seattle, Wash. 98105
Recommended: Graduate & Medical Students, Allied Health, Nurses

High Speed Cinematography of Human Spermatozoa

Presents ultra-slow motion pictures of human sperm locomotion as it appears under the microscope, showing and analyzing the movement patterns of freely swimming spermatozoa including speculations on the mechanism of movement of these organisms concluding with electron microscope photographs of the detailed anatomy of the spermatozoa.

17 Min. Sound. Black & White. 16MM. Motion Picture.
Content 9; Production quality 7
Available from: New York University Film Library
26 Washington Place
New York, N.Y. 10003
Recommended: Graduate & Medical Students, Allied Health, Nurses

Ovulation and Egg Transport in the Rat

Shows scenes of ovulation as observed in the living animal. Each series of ovulations is preceded by animated drawings of the various types of ovulation. The film illustrates also the method of egg transport from the fimbriated end of the oviduct into the dilated ampulla. Examples of ciliary activity as observed with the phase microscope are included.

15 Min. Sound. Color. 16MM. Motion Picture.
Content 9; Production quality 10
Available from: University of Washington
Audio-Visual Services
114 Lewis Hall
Seattle, Wash. 98105
Recommended: Graduate & Medical Students, Allied Health, Nurses

Transport of the Ova

Presents experimental data on egg descent in the reproductive tract of ewes via photographic time lapse studies of artificially sustained ewe isthmus segments. Demonstrates peristalsis and antiperistalsis as the driving forces behind egg movement. Considers isthmus egg permeability as a function of time after ovulation, and more specifically, as a function of normal oestrus hormone balance.

Photographic Time Lapse Studies
20 Min. Sound. Black & White. 16MM. Motion Picture.
Content 8; Production quality 4
Available from: French American Cultural Services & Educational Aid
972 Fifth Avenue
New York, N.Y. 10021
Recommended: Graduate & Medical Students, Allied Health, Nurses

Clinical Entities, Cushing's Disease

Patients having Cushing's disease are compared with patients who are simply obese. After demonstrating the characteristic differences in fat distribution, the film clearly describes the causes and pathophysiology of Cushing's disease with the aid of animation and patients with the disease. The rational treatment for each aspect of the disease is described.

32 Min. Sound. Color. 16MM. Motion Picture.
Content 8; Production quality 8
Available from: McGraw-Hill, Inc.
Text Film Division
330 W. 42nd St.
New York, N.Y. 10036
Recommended: Medical Students, Allied Health, Nurses

Clinical Entities, Hypertension of Adrenal Origin—Aldosteronism and Pheochromocytoma

The approach is geared to the working tools available to the practitioner of medicine, particularly the history and physical examination. The electrolyte changes that occur in each entity are described, and the hormonal defects are presented through animation techniques.

12 Min. Sound. Color. 16MM. Motion Picture.
Content 8; Production quality 8
Available from: McGraw-Hill, Inc.
Text Film Division
330 W. 42nd St.
New York, N.Y. 10036
Recommended: Medical Students, Allied Health, Nurses

The Physiology of Normal Menstruation *

Explains the relationship of five principal hormones concerned with the normal menstrual process.

22 Min. Sound. Color. 16MM. Motion Picture.
Content 8; Production quality 9
Available from: Loma Linda University
Motion Picture Library
Audio-Visual Service
Loma Linda, Calif.
Recommended: Medical Students, Allied Health, Nurses

The Physiology of Reproduction in the Rat *

Contrasts the behavior of the female rat during the period of estrus with her behavior between periods. External behavior of both male and female during mating is shown. Time lapse photography shows the penetration of the ovum by the spermatozoa.

20 Min. Sound. Color. 16MM. Motion Picture.
Content 9; Production quality 9
Available from: American Medical Association
Motion Picture Library
535 N. Dearborn St.
Chicago, Ill. 60610
Recommended: Medical Students, Allied Health, Nurses

Diagnosis in Clinical Disorders of Calcium and Bone Metabolism (Parts I & II)

Discusses primary hyperparathyroidism, parathyroid dysfunction in renal failure, and postsurgical and idiopathic hypoparathyroidism. Features Robert Heaney, M.D., Professor and Chairman, Department of Medicine, University of Nebraska School of Medicine.

19 Min. Sound. Black & White. 16MM. Motion Picture.
Content 6; Production Quality 5
Available from: National Medical Audiovisual Center Annex
Station K
Atlanta, Ga. 30324
Recommended: Medical Students, Allied Health, Nurses

II. Allied Health and Nursing Students

The Patient Who Cannot Drink *

Reviews the basic facts of fluid balance, shows the principal electrolytes of intracellular and extracellular compartments of body fluids. Presents the concept of the milliquivalent as a measure of the activity of electrolytes, and explains the role of the kidney in maintaining electrolyte balance. Raises questions for students regarding the fluid problem and the supportive care of two patients who cannot eat.

18 Min. Sound. Color. 16MM. Motion Picture.
Content 5; Production quality 9
Available from: Mayo Clinic
Section of Photography
Rochester, Minn. 55902
Recommended: Nursing Students

III. High School and Introductory College

Overture: Development of a Chick Embryo

To the score of Beethoven's Egmont *Overture*, time-lapse photography with a microscopic camera unfolds the development of a chick embryo. Creative editing and the music make this a work of art as well as a scientific exploration.

9 Min. Sound. Color. 16MM. Motion Picture.
Content 10; Production quality 10
Available from: McGraw-Hill, Inc.
Text Film Division
330 W. 42nd St.
New York, N.Y. 10036
Recommended: High School & Introductory College

Reproduction in Animals

This film introduces fundamental principles of the process of reproduction among animals, with the emphasis on reproduction in mammals. The function of each parent, the three main types of sexual reproduction, the development of the embryo, and birth processes are illustrated.

11 Min. Sound. Black & White/Color. 16MM. Motion Picture
Content 7; Production quality 9
Available from: Brigham Young University
Chairman, Audio-Visual Center
Provo, Utah 84601
Recommended: High School & Introductory College

The Discovery of Insulin

Dramatizes the inspiring story of Drs. Frederick Banting and Charles Best, young Ontario doctors who discovered insulin in 1921. Their work with dogs at the University of Toronto answered questions about one of man's most baffling diseases and created a new lease on life for thousands of diabetics.

19 Min. Sound. Black & White. 16MM. Motion Picture.
Content 7; Production quality 7
Available from: International Film Bureau, Inc.
332 S. Michigan Ave.
Chicago, Ill. 60604
Recommended: High School & Introductory College

The Egg and Sperm

Explores details of organization in animal sperm cells, the egg, and the gonadal structures. Uses a 3-dimensional model of human sperm constructed from electron microscope photographs to study functions and parts, and traces development through animation.

15 Min. Sound. Black & White. 16MM. Motion Picture.
Content 5; Production quality 10
Available from: McGraw-Hill, Inc.
Text Film Division
330 W. 42nd St.
New York, N.Y. 10036
Recommended: High School & Introductory College

When Life Begins

Shows the developing fetus from the earliest moments of fertilization of the egg to the time of birth, all through the miracle of live motion picture photography within the womb. The various stages of development of the main external organs of the fetus are outlined, and the film ends with a live birth sequence.

12 Min. Sound. Color. 16MM. Motion Picture.
Content 9; Production quality 10
Available from: McGraw-Hill, Inc.
Text Film Division
330 W. 42nd St.
New York, N.Y. 10036
Recommended: High School & Introductory College

Obesity *

Illustrates the physiology of fat formation in the human body and analyzes physiological and psychological causes of overweight. It reveals ways in which body weight can be controlled and explains the danger of uncontrolled fat accumulation.

12 Min. Sound. Black & White/Color. 16MM. Motion Picture.
Content 7; Production quality 9
Available from: Encyclopedia Britannica Films, Inc.
1150 Wilmette Ave.
Wilmette, Ill. 60091
Recommended: High School & Introductory College

Measuring Oxygen Consumption *

Shows the construction and use of a simple apparatus to measure oxygen consumed by small mammals in demonstrating an important aspect of metabolic studies. Materials used are readily available in most classroom laboratories.

6 Min. Sound. Color. 16MM. Motion Picture.
Content 4; Production quality 7
Available from: University of Colorado
Extension Division
Bureau of Audio-Visual Instructions
Stadium 348
Boulder, Colo. 80302
Recommended: Introductory College

Hormone Control in Regeneration *

Diagrams the role of the nerves and the pituitary gland (specifically the ACTH hormone) in limb regeneration of appendages in mammals, showing antler growth in deer as the only true example.

15 Min. Sound. Color. 16MM. Motion Picture.
Content 4; Production quality 8
Available from: McGraw-Hill, Inc.
Text Film Division
330 W. 42nd St.
New York, N.Y. 10036
Recommended: Introductory College

The Hormones: Small but Mighty *

Describes the ways in which hormones are produced in the glands and circulate in the bloodstream and explains what happens if they do not perform their functions adequately. Explains how hormones stimulate and control the functions of growth, metabolism, and reproduction.

29 Min. Sound. Black & White. 16MM. Motion Picture.
Content 9; Production quality 5
Available from: Indiana University
Audio-Visual Center
Bloomington, Ind. 47401
Recommended: Introductory College

Hormones

Defines "hormones" and "target organs" and discusses experiments of Bayliss and Starling that led to discovery of hormones. Covers chemical constitution of hormones and demonstrates hormonal changes in rooster and caterpillar. Dr. Farner details one complete hormone cycle, using the effect of length-of-day on the reproductive system of the Hale White Crown Sparrow.

30 Min. Sound. Black & White/Color. 16MM. Motion Picture.
Content 4; Production quality 8
Available from: University of Minnesota
Audio-Visual Service
2037 University Ave. S.E.
Minneapolis, Minn. 55455
Recommended: High School & Introductory College

Hormone Controls in Human Reproduction

Examines relationship of the endocrine system to the ovarian and uterine cycles and feedback effect in the human female. Studies the action of estrogens and progesterone on the pituitary gland. Shows how development of the embryo depends on synchronization of these activities.

20 Min. Sound. Color. 16MM. Motion Picture.
Content 4; Production quality 8
Available from: McGraw-Hill, Inc.
Text Film Division
330 W. 42nd St.
New York, N.Y. 10036
Recommended: High School & Introductory College

Sexual Reproduction

Uses a variety of plants and animals to show that although sexual reproduction may differ in certain details from organism to organism, its basic features remain the same. The production and union of gametes, models of cells and chromosomes are used to illustrate that through random assortment and chance union, sexual reproduction makes possible great variation which has benefitted man and insured the survival of many living things in a varied environment.

15 Min. Sound. Black & White. 16MM. Motion Picture.
Content 4; Production quality 8
Available from: University of Nevada
Audio-Visual Communication Center
Reno, Nev. 89502
Recommended: High School & Introductory College

The Fertilization Process

Depicts successive steps of release approach, penetration, nuclear fusion, and activation. Explains scientific investigation of separate phases, and significance of experiments in chemotaxis by Rothschild and Lillie.

15 Min. Sound. Color. 16MM. Motion Picture.
Content 5; Production quality 7
Available from: McGraw-Hill, Inc.
Text Film Division
330 W. 42nd St.
New York, N.Y. 10036
Recommended: High School

Vertebrate—Part I (Fertilization and Early Development)

Opening scenes reveal transparent, unfertilized eggs, about the size of a pinhead, of the tiny freshwater fish, *Oryzins latipe*. Sperm cells, resembling miniature tadpoles, move actively on the surface of the eggs. Fertilization occurs as soon as the first sperm penetrates the micropyle of the egg. This sets off rapid changes: a surging motion of the protoplasm takes place, and the orderly process of cell division starts and continues until a ball of cells, the blastula, is formed.

15 Min. Sound. Color. 16MM. Motion Picture.
Content 7; Production quality 5
Available from: Encyclopedia Britannica Films, Inc.
1150 Wilmette Ave.
Wilmette, Ill. 60091
Recommended: High School & Introductory Colleo

IV. Middle School, Elementary, and Lay Audiences

Boy to Man *

Explains some of the common physiological manifestations of maturation. It is designed primarily for showing to boys just entering adolescence. It presents the changes of adolescence, moving from the superficial changes of growth, skin, voice, and body hairs to the more complicated phenomena of glandular changes and sexual maturation.

17 Min. Sound. Color. 16MM. Motion Picture.
Content 7; Production quality 9
Available from: American Medical Association
Motion Picture Library
535 N. Dearborn St.
Chicago, Ill. 60610
Recommended: Middle School Students

The Story of Menstruation *

The complex problem of menstruation is presented in a simple and diagrammatic manner. The anatomical and physiologic relationship of the endocrine glands and the development of the internal genital organs are demonstrated through animation. The process of pituitary hormone stimulation of the ovary, ovulation and menstruation are also presented. The entire film is directed at the pre-adolescent or adolescent female. Advice is given concerning irregularities of menstrual flow during the first year, bathing, exercise, discomfort, constipation, diet, etc., during the menstrual period.

10 Min. Sound. Color. 16MM. Motion Picture.
Content 4; Production quality 9
Available from: American Medical Association
Motion Picture Library
535 N. Dearborn St.
Chicago, Ill. 60610
Recommended: Elementary School Level

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