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ABSTRACT

A systems approach has been used to develop and validate instructional materials in medical education. Seven self-instructional units, currently in various stages of completion, form the basis of a basic curriculum in opthamology. Performance objectives for the units were derived from the results of a questionnaire responded to by 1,600 practitioners and students of differing backgrounds and areas of specialization. The instructional materials concentrate on the development of clinical information-gathering and management skills rather than the recall of factual knowledge. The 7 units are expected to consist of approximately 20 hours of instruction. A 5-hour unit on ophthalmoscopy has undergone tryout and revision based on student performance. Performance on newly developed mannequins, which allow simulation of the opthalmoscopic examination, was the criterion measure. Sophomore medical students, after completing the opthalmoscopy unit, were compared to senior medical students who had had experience in using the opthalmoscope with patients. The sophomore students performed an average of 13 percentage points higher over-all than the seniors, and 63% of the sophomores scored higher than any senior. (Author/HS)

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Bruce E. Spivey, M.D.	Principal Investigator
Gary M. Arsham, M.D.	Co-principal Investigator
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BASIC INSTRUCTION IN OPHTHALMOLOGY FOR MEDICAL STUDENTS: A PROTOTYPE FOR INSTRUCTIONAL DEVELOPMENT IN MEDICAL EDUCATION

Gary Martin Arsham, Ph.D.
Department of Educational Psychology
University of Illinois at Urbana-Champaign, 1971

A systems approach has been used to develop and validate instructional materials in medical education. Seven self-instructional units, currently in various stages of completion, will form the basis of a basic, but comprehensive, curriculum in ophthalmology for medical students.

Performance objectives for the units were derived from the results of a questionnaire responded to by 1,600 practitioners and students of differing backgrounds and areas of specialization. The instructional materials concentrate on the development of clinical information-gathering and management skills rather than the recall of factual knowledge. Simulation devices have been developed where appropriate and feasible. Multi-school field testing has been planned. The seven units are expected to consist of approximately 20 hours of instruction.

A five-hour unit on ophthalmoscopy has undergone tryout and revision based on student performance. Performance on newly developed mannequins, which allow simulation of the ophthalmoscopic examination, was the criterion measure. Sophomore medical students, after completing the ophthalmoscopy unit, were compared with senior medical students who had had the typical formal and informal exposures to ophthalmoscopy, plus two years' additional experience in using the ophthalmoscope with patients. The sophomores performed an average of 13 percentage points higher over-all than the seniors. More important, there was a marked shift toward higher levels of performance for more students among the sophomores. Sixty-three percent of the sophomores scored higher than any senior.

Time and cost analysis for the development have been performed and problems and advantages of the approach have been discussed.

Problems and advantages observed for the developmental approach employed are discussed including time committment, subject matter and education experts interaction.

Final Report

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"A Basic Instructional Unit in Ophthalmology for Medical Students: Conceptualization, Development, Validation and Implementation".

Bruce E. Spivey, M.D.
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Preface

The author is especially grateful for the personal support, cogent criticism, and constructive confrontation of ideas offered by Richard C. Anderson, Bruce E. Spivey, August Colenbrander, Robert E. Stake, George E. Miller, and J. Myron Atkin in the development of this project. Michael Versackas, James Brock, and Richard L. Anderson were most helpful in assisting with the development and testing of the instructional materials. Special gratitude is due the author's wife, Diana, who tolerated his necessary absences from Champaign with only the appropriate amount of protestation.

This project was done at the Department of Ophthalmology, University of Iowa, while the author was a Fellow in Medical Education at the University of Illinois. It was supported in part by the U.S. Office of Education, Grant No. OEG-6-70-0028 (509), and in part by a grant from the Sloan Foundation through the Association of University Professors in Ophthalmology. Acknowledgement is also made to the Regional Medical Program Service, Health Services and Mental Health Administration, for support provided to the author through training contract PH 43-67-45 awarded to the Center for Educational Development, University of Illinois College of Medicine.

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CHAPTER I

INTRODUCTION

The purpose of this project was to use a systems approach to develop and validate instruction in medical education, using ophthalmology as the subject matter of the prototype. In a profession where competence is essential, an instructional approach that clearly specifies what needs to be learned, assesses whether or not the student has met minimum standards of performance, and modifies instruction until the goals are achieved appears desirable.

For this project, instructional materials were developed and their effectiveness and attractiveness assessed. The process of development is described, and observations and reflections upon this process are discussed.

Background of Curriculum Development

After the Flexner report of 1910 and until the early 1960's, medical education employed essentially an unchanged curricular structure and strategem: four years of undergraduate medical education with the first two consisting of courses in the basic medical sciences presented in a structured lecture-laboratory format, and the last two years consisting of clinical rotations to the wards and clinics of the teaching hospital. Much of the basic science experience involved listening to information-packed lectures; following time-consuming, detailed instructions in laboratory exercises; examining microscopic

sections of normal and abnormal tissue with little corrective feedback; regurgitating factual information at examination time; and, finally, forgetting the majority of details taught. Most of this information was taught in nonclinical settings with little application to solving clinical problems (Jason, 1970).

The clinical experience had different problems: Students often lacked adequate practice and feedback for effective learning of basic clinical skills, such as auscultation of the heart and lungs. Conditions for learning such skills were trying at best, where, say, six students in succession might be expected to examine a given patient. Under the eyes of the instructor, the sick patient, and his fellow students, the student was unlikely to persist in the examination until he satisfied himself that he "heard" a particular heart murmur, much less learned to discriminate it from a different type of murmur. Furthermore, an unbelievable amount of time was spent waiting while others examined a patient, or doing trivial ward work that had limited and rapidly diminishing payoffs in learning (Fisher and Cotsonas, 1965; Schumacher, 1968). Finally, at a time when most students were still trying to master basic clinical concepts and skills, they often found themselves listening to an instructor deliver an impromptu lecture on a fine point of an obscure disease.

In recent years, however, medical schools have begun to acknowledge these problems and to try to remedy them. Fundamental change in instructional practice comes with great difficulty, but many schools

have taken initial steps in instituting change. A survey conducted in 1968 by the Association of American Medical Colleges served to document some schools' activities (DeMuth and Gronvall, 1970). Of 117 American and Canadian medical schools, deans from 103 responded. Twenty schools reported that a new curriculum was fully operative, while 67 reported that one was in the planning stage. The report noted trends toward shortening the temporal length of the curriculum and increasing the amount of free time (63 schools) and elective activity. (All but three schools have some elective time in their new curricula.) In terms of content, the traditional courses are being reduced in total hours taught (about 25% decrease), as are the clinical courses (10-15%). In 50 schools, family care clinics are planned or in existence. Patient contact begins in the first year in 70 schools, primarily with demonstrations, clinical correlation clinics, and history taking and physical diagnosis.

Regarding teaching format, the report notes a decline in lecture and laboratory time, with an increase in seminars and small-group discussions. To some extent, research opportunities are replacing the analysis of laboratory unknowns and performance of routine procedures. The variety of teaching aids and materials used is increasing, although few schools have used any extensively except for projection slides, movies, and bibliographies. The report anticipated marked increases in use of programmed instruction, single-concept films, and television.

Despite these broad changes in curricular structure, evidence does not show that sophisticated and systematic educational techniques have been applied to major curricular revisions (Arsham, 1970). Specifically, for no major curricular change was the author able to find evidence of (1) specification of behavioral objectives; (2) analysis of objectives into their components and subcomponents ("task analysis"); (3) determination of entering behaviors; (4) design of learning experiences directly relevant and appropriate to the stated objectives; (5) administration of evaluation instruments assessing mastery of the objectives; and (6) diagnosis of deficits with revision of instruction until satisfactory mastery was attained. Elements of a "technologic" or "systems" approach, however, were present in a number of smaller scale curricular modifications (Lazaro, et al., 1968; Froelich, 1969; Jones and Hennes, 1968; Fiel, 1968; Rondell, 1968). These usually were contained in supplementary materials, or in materials that represented a fragment of a standard course. Some showed particular attention to specific behavioral objectives, or detailed analyses of component tasks, or appropriate learning experiences, or objectives-related evaluation, or some combination of these.

More recently, Fiel and Ways (1970) reported the use of a rather complete systems approach in developing self-instructional materials to teach some basic laboratory skills, for example, performing a venipuncture or determining hemoglobin levels. They conducted a small-scale field test and reported that, on the average, students

successfully completed about 93 per cent of criterion-related tasks. It is not clear from their report whether or not revisions were made early in the instructional development on the basis of student trials.

Evidence shows that at least a few medical schools are making efforts to develop behavioral objectives for large portions of their curricula. For example, as part of Ohio State University College of Medicine, the plan for its experimental "Pilot Medical School" specifies development of detailed instructional objectives for all elements of its modular curriculum (Ohio State University, 1970; Prior et al., 1970). Additionally, faculty expect to provide lists of relevant instructional resources to accompany the objectives (Mager and McCann, 1961), as well as computerized criterion-referenced self-evaluation.

The Abraham Lincoln School of Medicine of the University of Illinois College of Medicine (University of Illinois, 1970) made preliminary attempt at specification of objectives in the clinical area. These objectives were created jointly by a group attempting to define goals in all relevant clinical disciplines. The following objective is a typical example: "By the time of graduation from medical school, each student should be able to recognize . . . [by] physical examination . . . [a] breast lesion greater than 1 cm. in diameter."

The University of Iowa College of Medicine also has produced a document delineating objectives--these in every basic science or clinical area to which the student is exposed (University of Iowa, 1970). Here, representatives from each discipline developed their own objectives.

There is wide variation in specificity, which the creators recognize. They have planned more detailed development, and a revised edition of the objectives is expected by 1 August, 1971.

The above three reports came to the author's attention by serendipity, and how many more such documents exist is unknown.

Purpose of Project

It was the purpose of this project to develop instruction using a systems approach that might serve as a prototype for instructional development in medical schools. The need for improved instruction in medical schools clearly exists. A plan that would specify systematic revision of instruction until it demonstrably reached its objectives seemed to hold promise for improving the medical school curriculum.

Specifically, the plan was as follows:

1. To develop and validate instructional materials using the systems approach, outlined in greater detail in Chapter III. If this method resulted in effective and attractive instruction, other curriculum developers might be stimulated to apply it in their own medical areas.

2. To describe the developmental procedures and problems. Without detailed consideration of the steps taken and the obstacles encountered, others might experience similar difficulties in implementation. By providing at least one set of solutions to the developmental problems,

others should be helped to apply the systems model. Furthermore, such a description would also provide information that could lead to modification of the model itself.

3. To specify the financial costs and time expended. This is essential if others are to consider the plan for their own developmental use. Without this information, it would be very difficult for an institution or group, given the resources available in money and personnel, to make informed decisions regarding feasibility.

4. To plan a large-scale field test, to be conducted after completion of the dissertation. (This is discussed further in Chapters III and VII.)

If such a plan for instructional development were carried out for each discipline in each medical school, there would be a tremendous amount of duplicated effort; there is no need to "rediscover America." On the contrary, if this prototype were to be successfully applied by others, wide collaborative efforts should be employed in each medical area.

One solution to the problem of dissemination and duplication of effort would be to develop cooperative approaches to instructional goal-setting and materials development. Two professional groups in medicine (the Therapeutic Radiologists of the American College of Radiology and the American Society of Clinical Pathologists) have agreed to begin such efforts (Lysaught, 1969). Their plan is similar to several successful secondary school curriculum projects (Grobman, A., 1969; Grobman, H., 1970).

A second possible solution would be to enlist broad-based support for a particular instructional unit developed by a single institution or group. A likely mechanism by which to achieve this would be through a professional specialty group. Even without these efforts, however, it is likely that attractive instruction will be utilized in medical schools other than those in which it is developed. For example, a series of programmed videotapes used to teach interviewing skills is in use in 15 medical training centers (Enelow, et al., 1970), and a series of slide audiotape units in obstetrics and gynecology is in use in 25 medical schools (Chez, 1970b).

A third possibility for increasing multi-school use of instructional materials and decreasing overlap of effort is to obtain the opinions of a large number of varied, appropriate persons regarding what students need to learn. This could be done by means of questionnaires that ask respondents to rate various unambiguous educational goals. Then instruction based on these goals could be developed, either by a national organization or a local individual or group.

The second and third possibilities were employed in this project. Specific objectives in ophthalmology for medical students were determined (Spivey, 1970), utilizing a questionnaire technique described in Chapter II. Furthermore, the generalizability and national utility of an instructional unit based on these objectives is recognized and desired by a specialty group consisting of all ophthalmology chiefs in medical schools (Association of University Professors in Ophthalmology, 1970).

In the next chapter, the objectives and the method used for determining them are described. In Chapter III, the plan for their implementation is presented.

CHAPTER II

DEVELOPMENT OF OBJECTIVES

As indicated in Chapter I, medical educators have, as have educators in general, become increasingly aware of the potential advantages of precise specification of educational objectives. Particularly because of the rapid rate of increase of medical knowledge, earlier specialization, greater individualization of educational experiences in medical school, and shortening of training time, it is becoming more and more essential for a medical discipline to decide the minimum acceptable levels of competence for a graduating medical student.

The objectives upon which this project is based rose from the background described. Bruce E. Spivey, an ophthalmologist at the University of Iowa, felt that it was important to specify the minimum knowledge and skills in ophthalmology that a medical student should master by the time he graduates. He independently developed a technique similar to one used by Maguire (1968). Spivey (1970; 1971) developed a questionnaire listing 44 potential performances in ophthalmology and distributed it to persons with a wide variety of medical backgrounds. The performances were organized in seven broad areas of ophthalmological problems, and formulated in specific behavioral terms. Table 1 is an example of one of the problem areas, with eight specific performances represented. Respondents were asked to rate each behavior according to how essential it was, in their opinions, for a graduating medical student to master.

Table 1

Example of Questionnaire No. IV of VII
(From Spivey, 1970)

IV. When confronted by any cooperative adult patient, as a minimum acceptable performance, the graduating medical student should be able to:	Essential	Desirable but Not Essential	Useful but Should Not Be Required	Of No Importance	I Have No Basis for Judgment	Do Not Write in This Space
1. Measure the patients intra-ocular pressure with a Schiøtz tonometer	4	3	2	1	0	20
2. Discuss the daily pressure variation, and how the obtained pressure relates to the continuum of intraocular pressures	4	3	2	1	0	21
3. Evaluate the nerve head (making a decision of normal, glaucomatous, or nonglaucoma but abnormal disc)	4	3	2	1	0	22
4. Draw or interpret visual fields of a person without ocular disease or with early, mid, and late glaucomatous field changes	4	3	2	1	0	23
5. State when and why gonioscopy should be done	4	3	2	1	0	24
6. Draw conclusions as to diagnosis and therapy when given the intra-ocular pressure, the results of gonioscopy, and visual field findings	4	3	2	1	0	25
7. Outline in concise verbal statements the general forms of therapy for primary and secondary glaucoma	4	3	2	1	0	26
8. Indicate the pharmacologic and systemic effects of the possible medical treatments for glaucoma	4	3	2	1	0	27

The questionnaire was distributed to approximately 3,400 people, most of whom were located in the state of Iowa (Table 2). The over-all response rate was about 47 per cent. Included in the group were medical students, interns, residents, generalists, and specialists with and without specialty board certification. On the basis of chi square analysis of the responses to each performance, subgroups were arranged into four separate categories: medical students, generalists, ophthalmologists (practitioners and heads of departments), and board-certified specialists (Table 3).

Substantial agreement on any one performance was considered to exist when the mean value for a group of respondents was 3.37 or greater (where 4.0 is "essential" and 1.0 indicates "of no importance"). Actually, 17 of the 44 performances were above this level when all respondents were considered, and no other performances had a mean greater than 3.18. The same performances would have been identified if the criterion had been "80 per cent of the total respondents list the behavior as essential or desirable, with more responding essential than desirable."

Of these 17 identified performances, four involved history-taking, six involved some form of patient examination, three required administering some form of therapy, two were related to establishing a diagnosis, one called for self-evaluation, and one specified establishing an etiology. These performances are presented in more readable form in Table 4, organized into the original seven basic ophthalmologic problems.

Table 2

Distribution and Return of Questionnaire
(From Spivey, 1970)

	No. Contacted	No. Returned	%
Medical students			
Iowa, third year	82	44	54
Iowa, fourth year	91	43	47
Minnesota, third year	104	104	100
Illinois, fourth year	8	8	100
Interns and residents			
Interns, Iowa	41	15	37
Residents, Iowa	225	131	58
Residents (ophthalmology), Minnesota	18	18	100
Residents (ophthalmology), Illinois	25	12	48
Medical school faculty			
Clinical } Iowa	178	119	67
Nonclinical } Iowa	97	50	52
Clinical (South Carolina)	35	20	57
Other (clinical and nonclinical)	15	15	100
Practitioners in state of Iowa			
(No medical school affiliation)	2,430	958	39
Association of University			
Professors of Ophthalmology	89	66	74
Total	3,438	1,603	46.8

Table 3

Possible Curriculum Content for Medical Students in Ophthalmology
(From Spivey, 1970)

All Respondents, n = 1,490	Generalists, n = 423	Specialists with Boards, n = 441	Medical Students, n = 191	Ophthalmologists, n = 101	Tabulated by Various Respondent Groups Mean response of 3.37 or greater (4.0 = essential and 1.0 = of no value)
					I. When given a cooperative patient with an opacity of the cornea or lens, or a retinal abnormality, utilizing external and funduscopic examination, as a minimum acceptable performance, a graduating medical student should be able to:
X	X	X	X	X	Elicit a history pertinent to the general health and ocular status; and
X	X	X	X	X	Indicate verbally the location of the findings and describe the appearance
	X				State an opinion as to the possible effect on vision
	X				State the relationship of the ocular findings to any general disease processes, or the association of the ocular history and findings of other unidentified systemic disease(s)
					II. When given a typically cooperative patient (ranging from a child of 3 years to a normal or illiterate adult, with "normal" or abnormal vision) as a minimum acceptable performance, a graduating medical student should be able to:
X	X	X	X	X	Obtain a history of the visual complaint
X	X	X	X	X	Measure and record the distance and near visual acuity
	X		X		Make an estimate of the patient's functional status ("normal," impaired, or legally blind), and
	X				Evaluate color vision
					III. When given any individual (newborn to elderly) with unilaterally or bilaterally red eyes, as a minimum acceptable performance, the graduating medical student should be able to:
X	X	X	X	X	Obtain a contributory history if possible and examine the patient and his eyes in a manner adequate to provide a decision about diagnostic possibilities and therapy
X	X	X	X	X	Include in the decision a statement regarding etiology (ie, injury, inflammation, glaucoma, infection, or degeneration)
X	X	X	X		Take a culture if indicated by the examination, and
	X				Outline therapy appropriate for the diagnosis or possible diagnoses
					IV. When confronted by any cooperative adult patient, as a minimum acceptable performance, the graduating medical student should be able to:
X	X	X	X	X	Measure the patient's intraocular pressure with a Schiøtz tonometer, and
X	X		X		Evaluate the nervehead (making a decision of normal, glaucomatous, or nonglaucoma (but abnormal disc)

Table 3 (continued)

Possible Curriculum Content for Medical Students in Ophthalmology (From Spivey, 1970)

All Respondents, n = 1,490	Generalists, n = 423	Specialists with Boards, n = 441	Medical Students, n = 191	Ophthalmologists, n = 101	Tabulated by Various Respondent Groups Mean response of 3.37 or greater (4.0 = essential and 1.0 = of no value)
					V. If given a cooperative child or an adult with strabismus, as a minimum acceptable performance, a graduating medical student should be able to:
X	X	X	X	X	Obtain a history of the general and ocular status and examine the patient in order to diagnose the type of strabismus (ie, esotropia, exotropia, hype[illegible]) and obtain an estimate of the amount of deviation (small, moderate, large)
				X	State the implications for vision including the prognosis for possible progression of deviation or visual loss
					VI. When confronted by a cooperative patient with an ocular injury (eg, corneal foreign body, acid body or injury, corneal or lid lacerations) a graduating medical student, as a minimum acceptable performance, should be able to:
X	X	X	X	X	Demonstrate immediate diagnostic measures
X	X	X	X	X	Initiate treatment of a nonpenetrating injury
X	X	X	X		Outline possible complications of therapy undertaken or considered
X	X	X	X	X	Arrive at a decision within five minutes of his own competence to continue in the same course of treatment, begin another or refer the patient; and demonstrate his ability to converse with the patient's family regarding:
X	X	X	X	X	The possible need for further treatment
	X				The prognosis
					VII. When given a cooperative patient with a neuroophthalmological problem, the graduating medical student, as a minimum acceptable performance, should be able to demonstrate his ability to distinguish abnormality from apparent normality in a neuroophthalmological examination by including:
X		X	X	X	Examination of the retina and nervehead
X		X	X	X	Ocular motility and pupillary reactions, and
			X	X	Confrontation fields and interpretations of previously obtained tangent screen or perimetric fields
			X		Verbally, identify the approximate site and side of the lesion and make a statement about the most likely cause(s)

Table 4

Possible Curriculum Content in Ophthalmology for Medical Students

As a minimum acceptable performance, a graduating medical student should be able to:

1. When given a cooperative patient with an opacity of the cornea or lens (i.e., cataract) or a retinal abnormality, utilizing external and funduscopic examination, elicit a history pertinent to the general health and ocular status; and indicate verbally the location of the findings and describe the appearance.

2. When given a typically cooperative patient (ranging from a child of three years to a normal or illiterate adult, with "normal" or abnormal vision), obtain a history of the visual complaint; and measure and record the distance and near visual acuity.

3. When given any patient (newborn to elderly) with unilaterally or bilaterally red eyes, obtain a contributory history if possible; examine the patient and his eyes in a manner adequate to provide a decision about diagnostic possibilities and therapy; include in the decision a statement regarding etiology (i.e., injury, inflammation, glaucoma, infection or degeneration); and take a culture if indicated by the examination.

4. When confronted by any cooperative adult patient, measure the patient's intraocular pressure with a Schiötz's tonometer; and evaluate the nervehead (making a decision of normal, glaucomatous, or non-glaucomatous but abnormal disc).

5. If given a cooperative child or an adult with strabismus, obtain a history of the general and ocular status; and examine the patient in order to diagnose the type of strabismus (i.e., esotropia, exotropia, hypertropia) and obtain an estimate of the amount of deviation (small, moderate, large).

6. When confronted by a cooperative patient with an ocular injury (e.g., corneal foreign body, acid burn or injury, corneal or lid lacerations) demonstrate immediate diagnostic measures; initiate treatment of a non-penetrating injury; outline possible complications of therapy undertaken or considered; arrive at a decision within five minutes of his own competence to continue in the same course of treatment, begin another, or refer the patient; and demonstrate his ability to converse with the patient's family regarding the possible need for further treatment.

7. When given a cooperative patient with a neurological or neuro-ophthalmological problem, demonstrate his ability to distinguish abnormality from apparent normality in a neuro-ophthalmological examination by including examination of the retina and nervehead, plus ocular motility and pupillary reactions.

The instruction developed is based directly on the performances specified. The plan for this is presented in the next chapter.

CHAPTER III

A SYSTEMS APPROACH TO INSTRUCTION

In Chapter I, a systems approach to the planning and design of instruction was briefly outlined. Such a strategy was employed in this project and is described in further detail here.

In recent years, several different conceptualizations have appeared that could be termed systems approaches (Benathy, 1968; Nance, 1968; Smith and Smith, 1966; Heinich, 1968). They are all similar in that "every element in the overall educational operation is considered in its relation to other elements and proportioned and controlled so as to optimize the performance of the whole" (Williams, 1969, p. 20). They differ in the choice of elements included and the emphasis placed on each.

The plan outlined earlier is based upon a model sketched by Anderson (1961; 1967) and elaborated by Anderson and Faust (in press). This model can be considered to have six basic elements (see Figure 1). The first is the definition of objectives. It is desirable that objectives specify the outcome in terms of observable learner behavior, indicate the conditions under which the behavior is to be performed, and denote the standard of performance considered acceptable (Mager, 1962).

The first two characteristics have been fulfilled for this project as described in Chapter II. However, no performance standards have been designated. It might be thought that performance standards in a professional descipline such as medicine would be as clear-cut as they

are in parachute-packing, for example. Unfortunately, this does not turn out to be so. There do not appear to be any clear methods to make an absolute decision, beyond the minimum expectation that the graduating medical student will do more good than harm to society by practicing medicine (Mattson, 1970). Thus, a relative standard for performance is usually set, somewhat arbitrarily.

The second element consists of analysis of the objectives into their components and subcomponents -- what has been known as "task analysis," after the early application of this concept in military training (Gagné, 1962). By breaking down the objectives defined earlier into the relevant subskills, subtasks, or subconcepts, it is expected that components will be identified that will enable the learner to proceed from his entering knowledge and skills to those required for performance of the terminal objectives. Hence, these subcomponents could also be considered "enabling objectives." Such enabling objectives become specific guidelines to the type and content of appropriate learning activities. There is no unique analysis: more than one alternative or even equivalent analyses are possible.

It is clear from examination of the objectives listed in Table 4 that, while specifying expected terminal performance, they do not specify enabling objectives. These objectives have been analyzed into their components by the author and reviewed by more expert subject matter specialists. A rough working version (third version) is included in Appendix A, and a much later modification, as the instruction developed, is in Appendix B.

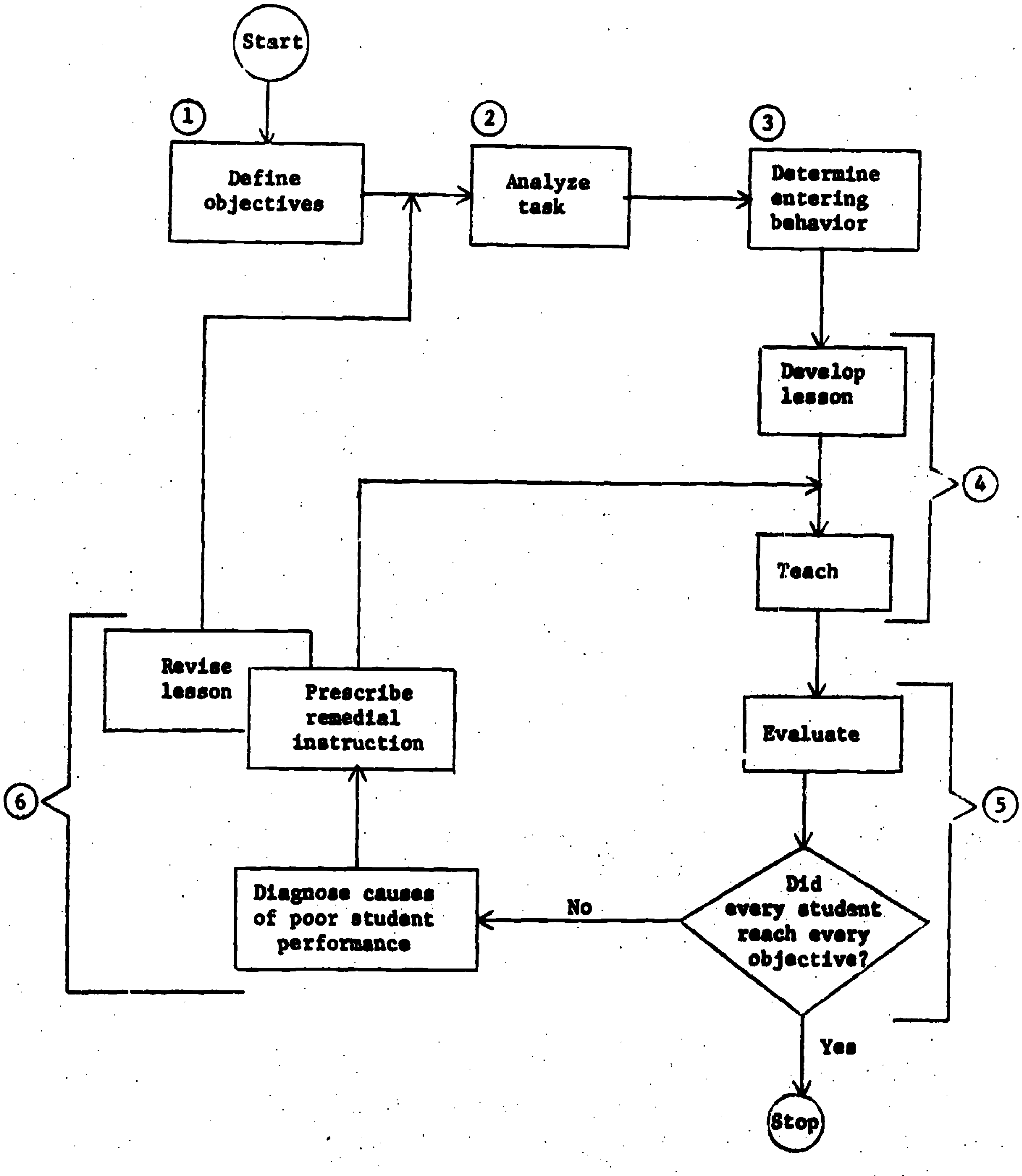

Figure 1. A schematic representation of a strategy for instructional development and quality control. Adapted with the permission of the copyright holder from Anderson and Faust, Educational Psychology, New York: Dodd Mead, in press.

Components in a task analysis should be subdivided until they are at a level of behavior that the learner can be expected to possess when he begins the sequence of instruction. This level constitutes the "entering behavior" of the student, directly related to the terminal performance via the task analysis. Once the entering behaviors are specified, they should be measured for each learner (the third element in the systems model). If it is assumed that the learner enters with certain skills or concepts, then instruction based on this assumption is likely to fail if the learner in fact does not have these entering behaviors. Determining the level of relevant entering behavior implies the importance of developing sensitive and precise diagnostic tests (Gagné, 1970; Glaser, 1963).

The fourth element includes the design of instructional materials and utilization of techniques of teaching -- composing the learning experience that the student undergoes. This is the area that, at the current stage of educational technology, perhaps relies more than any other on intuitive decisions modified by trial and error. Despite this, some guidelines may be applied. Anderson and Faust (in press) consider an instructional episode to include (1) the presentation of an instructional stimulus (e.g., a lecture, reading assignment, laboratory problem), (2) the arrangement for student performance (e.g., taking a quiz, designing an experiment, recording results, drawing conclusions), and (3) provision of feedback. They review important stimulus, response, and feedback factors in instruction (also Anderson, 1967).

Particularly important in instructional design is deciding into which of two broad categories of learning a specific educational task falls: (1) learning a particular response or sequence (chain) of responses; and (2) learning when and under what circumstances one should behave in a certain way (Anderson and Faust, in press). For example, in ophthalmology, learning how to manipulate an ophthalmoscope could be considered to be a task of the first type. Other examples include using a Schiötz's tonometer to measure intraocular pressure in routine glaucoma screening, and removing a foreign body from the eye. For these tasks, it would probably be important to provide a model or demonstration of the skill (using a film, diagram, photograph, or "performance guide" specifying critical steps), and opportunity for practice of the skill with corrective feedback to the student on the nature of his performance.

Examples of the second type include recognizing certain pathologic changes in the eye, discriminating certain signs of disease from others, and then taking appropriate therapeutic action based on these changes or signs. Particularly important here would be strategies used to teach students to notice important cues and to form an appropriate concept of a disease entity by responding to its critical features, ignoring irrelevant characteristics.

In an attempt to facilitate and make explicit the step from task analysis to development of learning experiences, the author planned to use three different forms (Figures 2, 3, and 4).* These forms were not used (see Chapter VIII).

---

*These forms were derived from suggestions and examples provided by Walter Chappell, Coordinator of Medical Instructional Services, University of Iowa.

Date ______________

Unit ______________ Objective ______________

Rationale ______________

Criteria for Successful Performance ______________

Conditions of Performance ______________

Figure 2. Task Sheet

Unit__________ Objective__________ Date__________

Task	
Audio Input	
Written Input	
Visual Input	
Feedback to Student	
Feedback to Instructor Certifying* Non-Certifying	
Model	
Patient	
Ophthalmological Equipment Student Provided Department Provided	
Comments	

*Would add criteria here if needed.

Figure 3. Work Sheet

Unit ______________ Objective ______________________ Date ______________

Task ____

Visual

Audio and/or Description

Figure 4. Storyboard

The fifth element of the systems model involves evaluation, both for purposes of assessing the student's mastery of the educational objectives, and for providing information to the instructor regarding the quality of his educational program. In this project, the assessment instruments are criterion-referenced (Popham and Husek, 1969; Glaser, 1963), with provision made for formative evaluation of the enabling objectives (Scriven, 1967).

Measuring achievement of these intermediate objectives is expected to assist in diagnosing flaws in the instruction, and identifying a given individual's difficulties in mastering the over-all objectives. Diagnosing the causes of inadequate performance, and revising the instruction or providing remedial instruction, comprise the sixth and last element of the systems model. The instruction developed in this project was and will be tried out initially on 1-2 students, and revised on the basis of their performance and comments, until satisfactory mastery and acceptance was obtained(See Chapter V for current stages of completion.). At this point, the instruction was and will be administered to larger groups of 20-30 students for more reliable validation.

Finally, plans have been developed for a large-scale multi-school field test (see Chapter VII). Because of time constraints, this will be implemented after the dissertation is completed. The field test can be considered an additional step in a systems approach, to be used when the instruction will be utilized in institutions other than the developmental one. This field test is expected to provide information on

the effectiveness of the instructional unit under more varied conditions of use than were available in the original environment, as well as on its acceptability and generalizability to other institutions (Anderson, 1969; Stake, 1967, 1969). The field test will secondarily provide data on the comparative effectiveness of this unit and other instruction used in ophthalmology.

The six steps in the systems approach are not necessarily taken in the order presented, nor are the steps, once taken, immune from continuing modification. For example, evaluation instruments may be developed after objectives are developed but before instruction is written. Furthermore, objectives may be revised, for example, following an unexpected insight that the developer capitalized on while preparing the instruction.

Reservations Concerning a Systems Approach

Objections to a technologic model involve both philosophic notions about education (Eisner, 1969) as well as more pragmatic concerns. Both types will be considered in this section.

One of the major criticisms is that such an approach fails to recognize diverse societal value systems and power groups (Atkin, 1967, 1968). However, this project has utilized a method that considered input from various sources and analyzed relative priorities; furthermore, broad-based support has been enlisted (see Chapters I and II). Moreover, this approach at least makes explicit the areas where there may be

competing educational values; thus the competing areas can be dealt with as such, a compromise may be attempted, or the instruction may be modified explicitly in favor of one or the other of the competing values.

Another objection is the potential cost of a systems approach, in terms of both time and money. There is no question that it would be prohibitively costly on an individual basis. However, the payoff would lie in utilization outside of the original institution, where potential users could select and use those parts of the instruction that meet their own objectives.

The argument has been advanced that this model may deaden and dehumanize education, that spontaneous give-and-take will be lost, and that opportunities for capitalizing on unanticipated outcomes will be missed (Atkin, 1968). Although this argument may be less valid for medical students than for less mature learners, certainly medical students undergo many worthwhile but unplanned educational experiences, ranging from exposure to some of the "great men" of medicine to informal group discussions with peers. However, such men are rare, and some informal experiences produce little more than restlessness and fatigue. The author believes that such experiences would best be reserved for the teachers who are truly effective in these settings. (It may even be possible to plan these experiences systematically, if students and faculty are alert observers and critics.) The time gained can be used to learn effectively those important concepts and skills that, in medicine, can be specified in advance but that are not now adequately taught (see Chapter I).

Will short-term goals be emphasized at the expense of long-term ones? (Atkin, 1968). Possibly. Certainly medicine has long-term goals, such as the development of clinical judgment, that are usually reached by small incremental steps over time. It is undoubtedly more difficult to specify the critical components of good clinical judgment than those of an adequate urinalysis. Is it likely that teaching clinical judgment will be avoided and the simpler skills emphasized? Efforts are already being made to learn more about the components of good clinical judgment so that they can be explicitly taught (Elstein, Kagan, and Jason, 1970). As these critical but difficult-to-define areas are identified, more effort is likely to be directed to their instructional elucidation.

Although medicine is a discipline where important concepts and skills can be identified, increasing attention must be paid to its more evasive affective and attitudinal components (e.g., "consideration of the patient as a person, not a disease," or "a positive attitude toward continuing self-education"). Medicine has many goals that are difficult to define behaviorally, or that may represent what Eisner (1969) calls "expressive" objectives. For instance, it may be more desirable for a student to spend one week on the orthopedic service to "get an idea of what orthopedics is like," than for him to learn to "set a simple bone fracture" or to "discuss the social utility of an orthopedist."

For these reasons, reservations expressed here must be kept in mind by one who is pursuing a systems approach as described. By being aware of the potential pitfalls, the developer can plan to avoid them.

CHAPTER IV

THE DEVELOPMENTAL SETTING

The general plan for implementing this project was sketched in the preceding chapter. In this chapter, specific characteristics of the developmental setting are detailed.

The setting for the development and validation of instruction was the Department of Ophthalmology, University of Iowa School of Medicine. The curriculum at Iowa is currently in a state of flux, with many changes being made similar to those described in Chapter I. Clinical rotation through the ophthalmology department is not required, and direct assessment of the level of knowledge or skills in basic ophthalmology, which the students may have acquired by the time they graduate, is not made. Indirectly, students are observed performing on the wards or in the clinics, but no focused attention is paid to specific skills. Rather, it is their more general clinical performance that is rated. Thus, it would easily be possible for a student to graduate from medical school with unassessed or inadequate basic skills in ophthalmology.

It had been agreed by the eye department that criterion-referenced measurement instruments would be developed, based on Spivey's objectives. Each student sometime before he graduates would be required to "check out" his performance on these objectives.

The author is developing these instruments, which are an integral part of the instruction. However, the student is not required as part of the curriculum to work through the instruction. It is, instead,

suggested as one resource, when he is given a list of eye objectives and expectations early in medical school. It is felt that if the instruction is effective, appealing, and meets both a clinical need as well as a formal need (to be "checked out" in ophthalmology), students will choose to use it (Chez, 1970a; Forrester, 1970).

Only three hours per student of ophthalmology studies are allotted in the curriculum, which occurs in the latter part of the second year, during "Introduction to Clinical Medicine." Hence, the major portion of the eye curriculum is self-instructional. The required time was used in small-group instruction, where practice on colleagues was felt to be necessary (e.g., when everting an eyelid). These experiences were as carefully planned as the self-instruction, and may eventually be "automated" to free instructors from repetition (8-16 repeats in one semester) or to increase "quality control," if several instructors are used in rotation. The actual media used in the self-instructional materials depend upon the objectives to be served. Included are text (with or without audio), slides, simulation devices for practice of certain ophthalmology skills (e.g., tonometry, ophthalmoscopy), handouts, performance guides, and the like. Students are provided corrective feedback throughout. The total learning time involved has been estimated to be approximately 17-20 hours.

Self-instructional carrels will be provided in the eye department, and, later, on certain other clinical services (e.g., medicine, surgery,

pediatrics) where a given instructional unit would be particularly relevant. For example, the unit on strabismus is most appropriate in reference to pediatric problems.

The author used a logbook to document the developmental problems encountered (see Chapter VIII). This record is a "voyager's description," a journalistic report detailing anecdotes that were felt to be significant, and noting important decisions made and steps taken as the project progressed. Interpretation of these data was in large part subjective; hopefully they can shed some light on some of the empirical questions raised by critics of the systems approach.

Finally, a time record was kept by the author, by the ophthalmologist who is working closely with the author on the development of the instruction, and by three medical students interested in medical education who spent elective time to assist in the development of the material.

Categories for this record are indicated in Figure 5. Expended time was recorded daily in quarter-hours. Analysis of these records can provide at least a rough estimation of the man-hours required to develop such a unit (see Chapter VI). Expended time and calendar time are not necessarily the same: for example, one man spending 40 hours to develop instruction does not mean that he (or anyone else) is able to create it in five 8-hour days.

Financial expenditures were analyzed from standard records kept by the fiscal agent responsible for administering the funds for this project.

Date	Working on Instructional Materials							
	Writing, preparing, and revising materials	Viewing and reviewing materials	Organizing	Reading directly relevant materials	Consultation with Colleagues on Project			
					Conceptual and organizational	Audio-visual	Implementation	Outside consultant
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								

Figure 5. Time Record

The following chapters document and discuss the use of a systems approach for instructional development, for the purpose of providing a prototype that can be used in other medical disciplines. Data are provided that will permit a potential user to judge the instruction's effectiveness and feasibility, and to avoid problems in applying the developmental model.

CHAPTER V

DESCRIPTION OF DEVELOPED INSTRUCTION

Development has gone forward in all of the seven major areas outlined earlier (see Figure 6), although materials for each are in various stages of completion. As the instruction for the seven areas has been progressing, the objectives have been modified. The current version of the working objectives is included in Appendix B. (The modifications will be discussed further in Chapter VIII.)

There is one instructional unit for each content area (or major objective); most include slide-tape sequences; all have inserted questions and corrective feedback. The material is adaptable to computer-assisted instruction without significant modification.

The ophthalmoscopy unit was chosen for initial development and completion. It is from this unit that all of the criterion and performance data has been derived. The process and other developmental data, however, have been obtained from all the units.

The Ophthalmoscopy Unit

Ophthalmoscopy is the use of the ophthalmoscope to identify normal and abnormal intraocular and retinal conditions. This area was chosen for initial effort because it involves a skill that has traditionally been difficult for medical students to learn. Often it is not systematically taught. Furthermore, it is an area that involves the

OPHTHALMOSCOPY

VISUAL ACUITY

RED EYE

OCULAR INJURY

GLAUCOMA

STRABISMUS

NEURO-OPHTHALMOLOGY

Figure 6. Content areas in ophthalmology.

ability to both recognize and discriminate among various normal and abnormal situations, as well as requires definite psychomotor skills. Ophthalmoscopy is a skill that most physicians will use regardless of their medical specialty.

The ophthalmoscopy unit is fully operational and has undergone one major revision. It consists of approximately 5 hours of instruction. This unit is probably the most complex of the seven, both in the kinds of skills that it teaches and in the sophistication of the instruction used. It will be described in the most detail, as the kinds of techniques used are also employed in the other units. This unit served as the major learning experience for the author in developing instruction. (This developmental process will be described in more detail in Chapter VIII.) The description of this unit will convey some idea of what the instruction looks like, how it is used, and what it teaches. Such a description will also illustrate the instructional philosophy and technology utilized.

One assumption made was that a student must develop and refine some very basic clinical skills before he can be expected to solve problems and make diagnoses. He can be aware of the fact that a swollen optic nerve (papilledema) is a sign of increased intracranial pressure without being able to recognize papilledema when he sees it. Training such recognition and discrimination skills was thought to be most important, so that at least the instructors could be confident that a medical student would be able to do an adequate examination. Furthermore,

it was felt that the student's confidence in himself would increase if he were certain of some of his basic professional skills.

The ophthalmoscopy unit is divided into three sections. In the first section, students go through a slide-tape sequence with an answer sheet and receive corrective feedback (see Figure 7). During this segment the students learn to describe critical characteristics of the normal and abnormal ocular fundus. In order to do this, they need to use terms that are outlined for them in a chart and a performance guide (see Appendix D). The instructional materials then provide the student with systematic practice and feedback for the visual discriminations and identifications necessary to use the chart.

On the chart are outlined very specifically the features that the ophthalmologists who are working on this project felt were critical to describe accurately the ocular fundus. Developing this chart forced the ophthalmologists to be explicit about the criteria upon which their judgments are based and to define these criteria in concise, simple, and unequivocal statements. This difficult task was considered essential if a medical student were to recognize the most important criteria.

It is not expected that the student will commit to memory all the information on the chart or performance guide. On the contrary, the goal is that he will develop the visual identification skills that will allow him to use the chart meaningfully. The author feels that this is a point often overlooked in medical education. The student commonly may be given a very nice chart or list of important features of a disease;

OBJECTIVE:	DESCRIBE PROJECTED SLIDES
CONTENT:	CONCEPTS
MATERIALS:	TAPE AND SLIDES, CHART, PERFORMANCE GUIDE, QUESTIONS AND ANSWERS WITH CORRECTIVE FEEDBACK

Figure 7. Ophthalmoscopy unit -- section I.

yet he is given no systematic practice and feedback in order to recognize these features. Students should spend more time refining such basic clinical skills as recognizing certain abnormalities when they see, hear, or feel them, rather than being able to recite from memory, for example, five major causes of optic atrophy (or even five major signs of optic atrophy). It is much more reasonable to expect students to look up this information if they are first able to identify optic atrophy.

The second section of the ophthalmoscopy unit teaches the psychomotor skills involved in using the ophthalmoscope (see Figure 8). The heart of this section is a mannequin, developed during this project, that permits simulation of some abnormalities of the ocular media (e.g., the lens or cornea), as well as simulation of the normal red fundus glow and other details of the fundus. The mannequin uses standard 2" x 2" fundus transparencies for this purpose. The advantages of this mannequin for training and for testing are multiple.

First, the mannequin - unlike the patient or fellow student - is always available and infinitely "patient". Second, unlike a fellow student, it can show pathologic variations; and unlike the patient, it can show pathologic changes anytime. The use of the mannequin does not replace experience with patients but rather makes the student much more comfortable when he first approaches them.

The mannequin has two other advantages as a simulation device for learning ophthalmoscopy: (1) It allows the student to practice the difficult skill of coordinating his hand, head, and eye to keep the

OBJECTIVE: USE OF OPHTHALMOSCOPE

CONTENT: PSYCHOMOTOR SKILLS

MATERIALS: MANNEQUIN,
EXERCISES,
PERFORMANCE GUIDE

Figure 8. Ophthalmoscopy unit -- section II.

ophthalmoscope light beam trained on the pupil; and (2) it allows him to practice building a complete fundus image from the small fields seen at any one time.

Section II of the ophthalmoscopy unit does not use slides or audio tape. Rather, it includes a written handout that systematically helps the student through a performance guide to learn the correct psychomotor skills and asks questions of him as he progresses. Many of these questions relate to his skill in examining the mannequin, with feedback provided by a latent-image answer sheet.

The last section (III) puts together the concepts and skills learned in the first two sections and allows the student to integrate and apply them (see Figure 9). This section serves as a self-evaluation unit. It includes a series of five mannequins (10 eyes) that simulate normal and abnormal variations. Here, the student systematically examines the ocular media and fundi of the mannequin with his ophthalmoscope and describes what he sees on a latent image answer sheet (Figure 10). The descriptions that the students are expected to give are those that a medical student or physician should actually record in a patient's chart after ophthalmoscopy. The responses to this section are used as the terminal criterion performance data. (These data are presented in the next chapter.)

The Other Six Units

The remaining units are in various stages of completion. All but two - Neuro-Ophthalmology and Visual Acuity - are nearly ready for pilot

OBJECTIVE: EXAMINE, DESCRIBE UNKNOWNS

CONTENT: SYNTHESIS OF 1 AND 2

MATERIALS: MANNIQUINS,
RECORD SHEETS WITH
CORRECTIVE FEEDBACK

Figure 9. Ophthalmoscopy unit -- section III.

MANNEQUIN "B" O.D.

I.D. Number ____________
Name ____________

Directions: Mark one response in each category (i.e., Media, Disc, Vessels, Background, Macula). IF YOU MARK "ABNORMAL," describe and locate the abnormality. If there are any VARIATIONS OF NORMAL present, describe them also. Be brief and use format you would in writing in a patient's chart. After you have chosen your answer, use the marker to bring out latent image for feedback, scoring, and remedial instructions.

YOUR DESCRIPTION	LATENT IMAGE
MEDIA: ☐ CLEAR ☐ OPACITY	There is a subtle but definite opacity superior nasally in the fundus glow. Its location is corneal; by vertical movement it goes against the observer. Since it's slightly off the visual axis you can miss the opacity if you do not check for it - and you can clearly see the fundus. Score 1 point for noting it and 1 point for correctly localizing it. Total Points ☐
DISC: ☐ NORMAL ☐ ABNORMAL ☐ NOT SEEN	Abnormal. Entire margin is obscured (1 point). There is marked hyperemia (1 point) and many of the vessels coursing over the margins are obscured. C/d ratio is 0 (1 point). This is definite papilledema. If you wrote papilledema without any description, give 1 point. Add points as indicated for noting the above. For abnormal, score 1 point. Total Points ☐
VESSELS: ☐ NORMAL ☐ ABNORMAL ☐ NOT SEEN	Abnormal. Definite irregularity and obscuration of the arterioles (1 point). A/V ratio less than 1/2 (1 point) with the veins enlarged—especially the superior vein. There would be no venous pulsation. Add points as indicated for noting the above. For abnormal, score 1 point. Total Points ☐
BACKGROUND: ☐ NORMAL ☐ ABNORMAL ☐ NOT SEEN	There are no hemorrhages actually seen, but near the obscured disc margin there are many engorged fine vessels. The edema near the disc disappears and the blond fundus is normal except for the disc. For normal, score 2 points. Total Points ☐
MACULA: ☐ NORMAL ☐ ABNORMAL ☐ NOT SEEN	For "Not Seen," score 1 point. Total Points ☐

Figure 10. Mannequin latent image sheet.

testing with 2-3 students.

The unit on visual acuity is in rough form and has been modified to include a general overview of visual function as well as specific instruction in how to measure visual acuity. The content has been well defined but it has not yet been developed into interactive instruction. Teaching the skill of measuring and recording visual acuity will be accomplished using a simple performance guide.

The unit on the red eye consists of a slide-tape sequence that incorporates a question and answer sheet and provides corrective feedback as the student proceeds. The major objectives of the red eye unit relate to (1) recognizing abnormal signs and symptoms of a red eye; and (2) deciding whether these can be treated by the non-ophthalmologist or should be referred to an ophthalmologist. This unit needs only minor content revisions and slides of some additional patients' eyes.

The unit on ocular injury involves learning the psychomotor skills necessary to manage patients with trauma to the eye. This will be accomplished using performance guides as well as practice with colleagues and animal eyes. Some recognition and discrimination of abnormal signs is involved: one of the key issues is that the practitioner must be able to decide whether he can handle the injury himself or should refer it to an ophthalmologist. In this unit, motion may be necessary as a teaching medium, using either selected excerpts of films already produced or a locally produced videotape. The content needs to be resequenced and performance guides must be finalized. About half the necessary slides have been selected or produced.

The unit on glaucoma will include an externally prepared, short motion picture film that describes very clearly the technique involved in measuring intraocular pressure ("Indentation Tonometry Technique in Glaucoma Detection", National Audio-Visual Center, Washington, D.C. 20409). Furthermore, simulated eyes have been developed that can be adjusted to various pressures so that the student can practice the skill of tonometry (measuring the intraocular pressure) and test his accuracy. A performance guide has been developed that delineates the correct procedure. Observation forms should be developed to allow assessment of the critical components involved, in conjunction with the simulated eyes. An important part of the unit includes increasing the value that non-ophthalmologists place on doing routine screening measurements of intraocular pressure. Attempts will be made to assess this by unobtrusive chart audit after instruction.

The strabismus unit is directed at giving the student the skills necessary to test for the presence or absence of strabismus and to be able to classify the type of strabismus. At this point, only minor editorial changes are necessary before the unit is ready for pilot testing.

The content for the neuro-ophthalmology unit has been outlined but substantial work is needed to convert the material into adequate instruction. Slides and drawings must be developed, and a major reorganization and sequencing of the content is planned.

The author expects that the six additional units will be ready for initial pilot trials and revisions this fall. Then they will be included in the large-scale field tests for final validation and revisions (see Chapter VII).

CHAPTER VI

CONSEQUENCES OF INSTRUCTION

Data regarding the consequences of instruction fall into three major categories: The first is performance data related to the ophthalmoscopy unit; the second is attitudinal data derived from a questionnaire administered to students who had completed the ophthalmoscopy unit; and the third involves data on the developmental costs of all the instructional units.

Performance Data

Data relating to student mastery of the ophthalmoscopy objectives were gathered from the criterion test described in Chapter V. The test consisted of five mannequins whose eyes the student was asked to examine ophthalmoscopically and describe. There were a total of 95 possible points.

The test was completed by 19 sophomores who had taken the current version of the ophthalmoscopy unit. It was also administered to 29 senior medical students one month prior to their graduation. The latter had been exposed to the formal and informal instruction in ophthalmoscopy that occurred over the course of their medical school experience. They had had the opportunity for substantial everyday practice with the ophthalmoscope on patients whom they would typically examine during their 2 years of clinical experience. Their scores provide a baseline

by which graduating seniors may be judged in the future, as well as a basis for comparison with the sophomores. The criterion test was also administered to a small number of freshman medical students who had had minimal exposure to ophthalmoscopy.

The results are represented in raw form in Figure 11. All of the freshmen scored below any of the other students, as expected. Although there is some overlap between the scores of the seniors and the sophomores, there is a substantial shift to higher performance levels for the sophomores. Over 60 percent of the sophomores scored higher than any senior.

In Figure 12, student performance data are summarized by content area as well as over-all. In every area, the sophomore students, after instruction, performed better than did the seniors with two additional years of experience. There is a 13 percentage point difference over-all between the means of the two groups. A t-test was performed that indicated a significant difference, $\underline{t}(46) = 5.50$, $\underline{P} < .001$. While neither the sophomores nor seniors were randomly selected, there is no indication that they were anything but representative samples of their classes. Hence, it is not unreasonable to report the results of a test of significance.

Although the criterion test was constructed by ophthalmologists, with apparent face validity, the possibility existed that the test was focused too specifically on the instruction and was not a generally valid measure of ophthalmoscopic skills. To test this, one-half of the group

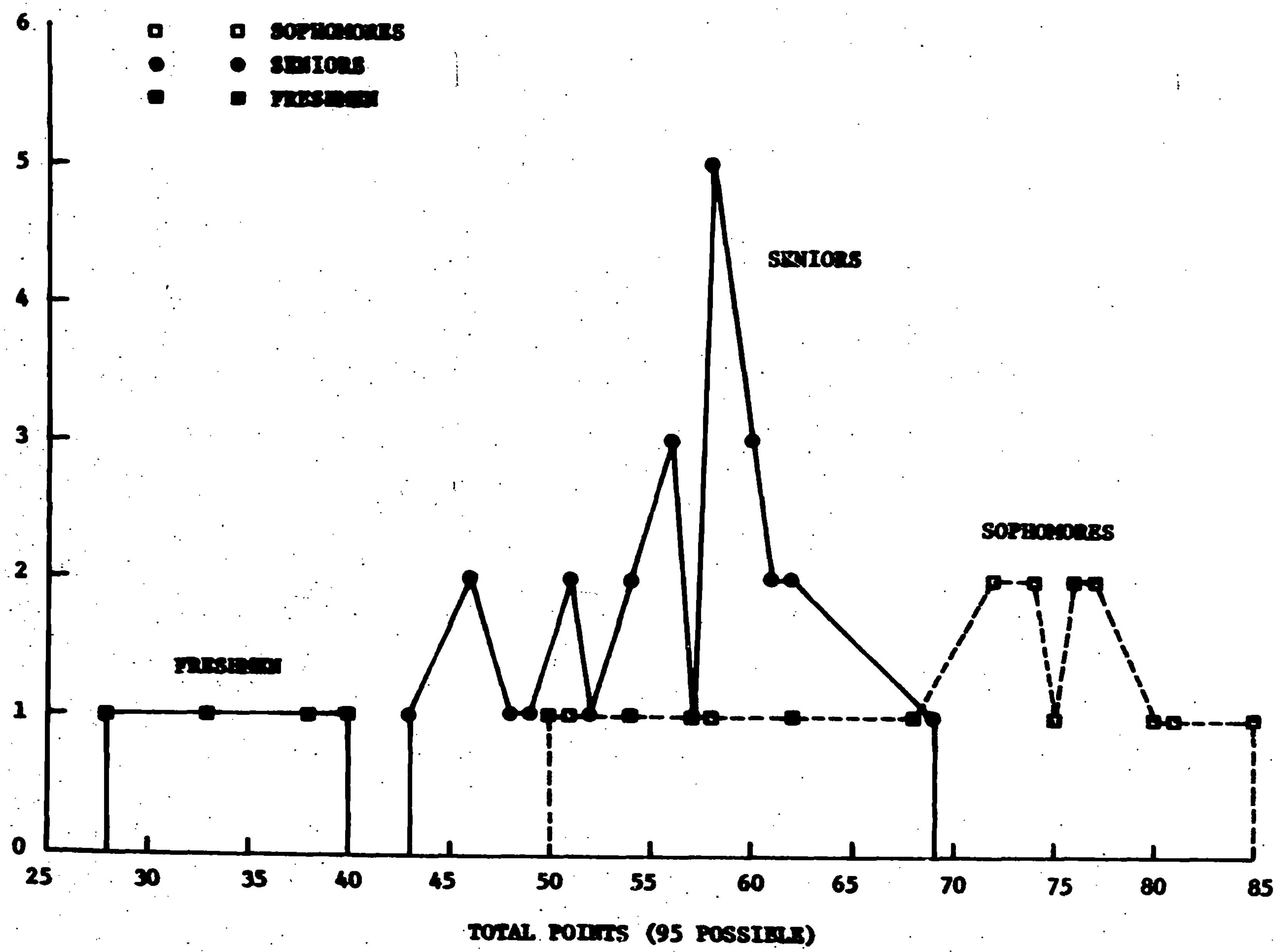

Figure 11. Frequency distribution of scores for freshmen, sophomores, and seniors (Ophthalmoscopy -- Section III).

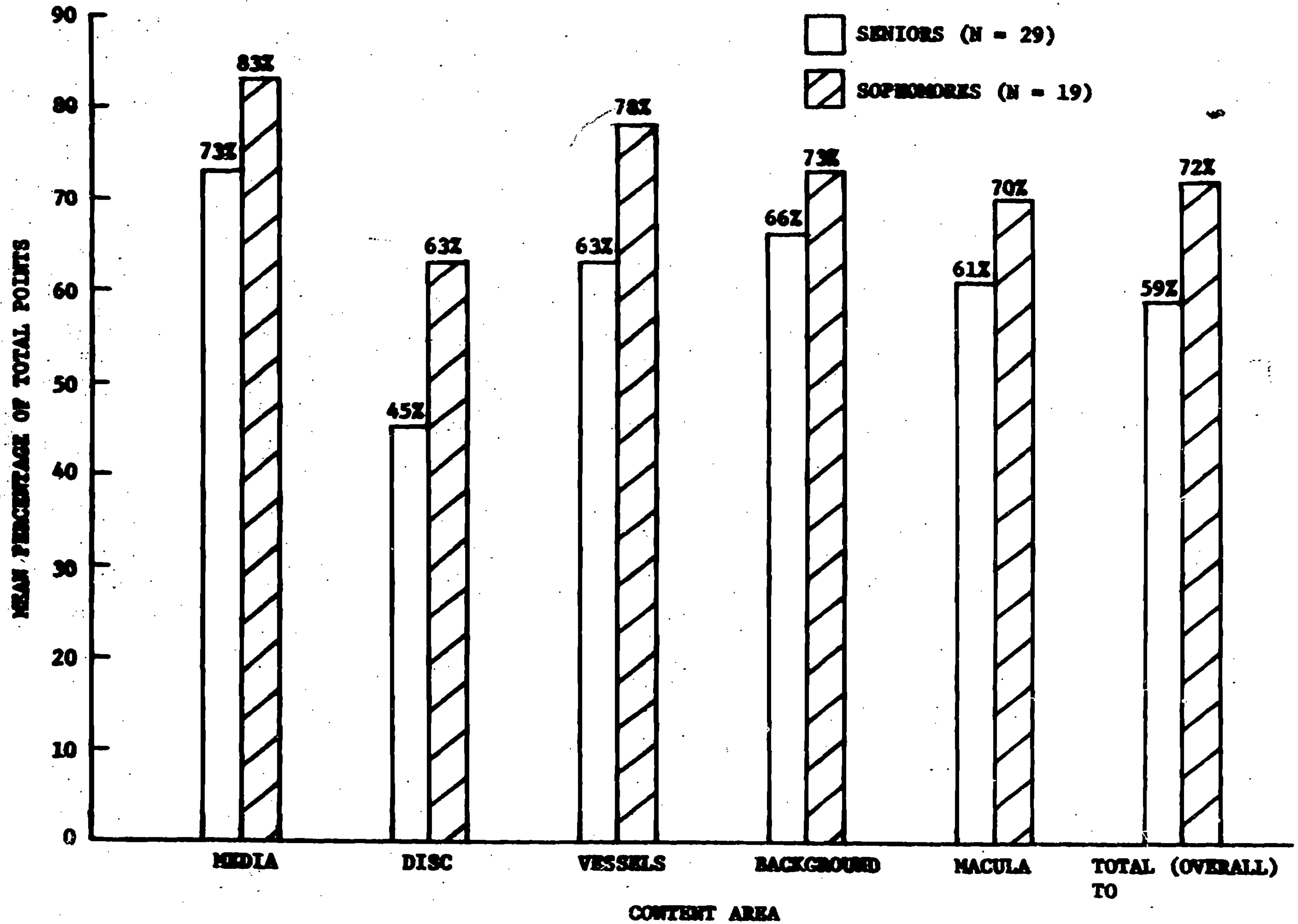

Figure 12. Comparison of sophomore and senior scores according to content area (Ophthalmoscopy — Section III).

of seniors was given the criterion test alone, and the other half was additionally given a chart that outlined all the critical features upon which the test was based.

It was felt that, if the senior student were able to recognize the critical characteristics, the chart would raise the likelihood of his noticing and describing them. Moreover, responses were graded liberally, with complete credit given for synonyms. No difference appeared between the group of seniors who had the chart and those who did not, $\underline{t}(27) = 0.82$, $\underline{P} > 0.1$.

The highest score that any student received was 87 percent correct, with the mean for the sophomores equaling about 72 percent correct. These scores are relatively low compared to the level of performance scores generally expected. However, the same criterion test was administered to members of the Ophthalmology Department, both full-time staff and senior residents. Their performance was no better than the best of the sophomore students, even though they were asked to be careful and thorough. The major reason for the relatively low scores seems to be related to technical problems associated with the mannequin. In a few instances, abnormal details are difficult to see without prolonged and careful examination, due to the quality of the slide or reflections from the mannequin. (Further development has subsequently occurred that should resolve this problem.) Nonetheless, all members of the department who examined the mannequins were favorably impressed with the quality of the simulation and its realism.

On the criterion test, students were also asked to judge each major area of the examination as normal or abnormal, in addition to describing any abnormalities. The results described earlier reflected both how well they were able to describe the abnormalities seen as well as discriminate normal from abnormal. How well they were able to do the latter is indicated in Table 5.

Table 5

Percentage Error in Discriminating Normal from Abnormal Variations of the Ocular Fundus

(Ophthalmoscopy-Section III)

	Mean Percentage False Positives*	Mean Percentage False Negatives**	Mean Percentage Total Discrimination Errors***
Sophomores (N = 19)	18	21	20
Seniors (N = 29)	26	29	28

*Out of 25 possible instances, sophomores and seniors incorrectly characterized a "normality" as abnormal 18 and 26 per cent of the time, respectively.

**Out of 16 possible instances, sophomores and seniors incorrectly characterized an "abnormality" as normal 21 and 29 per cent of the time, respectively.

***Out of a total of 41 possible discrimination errors, sophomores and seniors made either a false positive or false negative error 20 and 28 per cent of the time, respectively.

Students may be able to describe what they see more easily than they are able to interpret what they see as either normal or abnormal. Certainly it is critical for them to be able to recognize that something abnormal exists, even if they are not able to identify it. It is notable that the sophomores made fewer "false negatives" (incorrectly characterizing an abnormality as "normal") than the seniors. This is particularly important for the improvement of the quality of health care.

The amount of time students spent on the ophthalmoscopy unit is indicated in Table 6.

Table 6

Student Time - Ophthalmoscopy Unit
(N = 19)

	PART I	PART II	PART III	TOTAL TIME
MEAN TIME (MIN)	130	56	115	307
RANGE (MIN)	90-180	20-105	60-180	190-410

Although it is difficult to find other time expenditures for comparison, an average of five hours to achieve adequate ophthalmoscopic skills seems very low, particularly considering that this instruction does not require any direct expenditure of faculty time, patient time, or the time of any fellow students. Obviously, further refinement of skills, with faculty guidance, including experience with patients, would be desirable.

Attitudinal Data

Each student who took the current version of the ophthalmoscopy unit was given a questionnaire. The questions and the results are included in Appendix C. Twenty-nine sophomore students took this unit, although not all responded to every question. Furthermore, although all

completed Section I, two did not complete Section II, and 10 did not complete Section III. (This accounts for the N = 19 in the criterion test). It is of interest to note that, although 23 felt that they did finish Section III to their satisfaction, only 19 did in fact write answers to all of the questions in the criterion test.

One of the major reasons for student failure to complete Section III lies in the latent image answer sheets that were used in that section. It was discovered that use of the latent image answer sheets was messy and virtually doubled the length of time needed to complete Section III, because of the time required to bring out the latent image with a crayon. Developing the latent image was a slow process, and often the words were difficult to read. The experience was frustrating for the students and appeared to engender some active hostility. In retrospect, some other form of feedback could easily be provided.

Although many students complained about the length of Section III, the majority felt that Section I, which actually took longer, was about right. This is in contrast to data derived from the original version, in which almost half felt that Section I was too long. Thus it is felt that greater attractiveness, better compliance, and a higher rate of completion for Section III will be achieved when the latent image answer sheets are replaced, even though the same number of mannequins is employed.

Twenty-six of 28 students felt that taking the current ophthalmoscopy unit was a worthwhile use of their time and 27 of 29 would use similar units if available. Most students were very pleased with the content

and organization of Section I (the slide-tape section). Twenty-four of 27 students found the mannequins helpful, although some found them hard to use or were frustrated by technical difficulties.

One thing is obvious from examining the replies that students made to open-ended questions: What some students think is excellent, at least one will find terrible. This only reaffirms a feeling that there is not necessarily any one set of instructional materials that is superior for all students. This suggests that efforts should be made to develop the best possible instruction for all, but also expedite the use of alternative methods by students who desire them. The same criterion assessment would apply.

Developmental Cost Data

Detailed records were kept of the time spent by the author, the ophthalmologist primarily concerned with the project, and three medical students who worked from time to time on the project. Expended time was recorded daily in quarter-hours (in most cases) on a time sheet like the one in Figure 5. A summary of the results is presented in Table 7.

Table 7

Time Spent in Development of
Instructional Materials
(6 Persons - 8 Months)

CATEGORY	TOTAL HOURS
Writing, Preparing, and Revising Materials	457
Reviewing Materials	93
Organizing	57
Reading Directly Relevant Materials	46
Consultation with Colleagues: Conceptual and Organizational	238
Audio-Visual	47
Implementation	51
Outside Consultation	11
OVER-ALL TOTAL HOURS EXPENDED	1,000
Projected Additional Time For Completion of Initial Pilot Testing on All Units	350
Total Actual and Projected	1,350

The project continued over a period of approximately eight months to reach the stage of development indicated in Chapter V. During this time, a total of approximately 1,000 man hours was recorded. This figure

does not include time to develop the initial performance objectives. (It is projected that an additional 350 hours will be needed for completion of initial pilot testing of all the units.)

Although this is only a crude estimate, it likely represents a minimum level. It is more probable that time spent working on the project was forgotten than that time was confabulated to fill a particular slot. Although it is unlikely that any one person would have developed this material working on a full-time basis, the total hours expended divided by a 40-hour week would result in an average expenditure, for one man working full-time, of approximately 25 weeks, or 6 months.

It is not easy to determine exactly how many hours of instruction resulted from this expenditure of time. The ophthalmoscopy unit can be considered to be five hours; however, the recorded time also includes that spent developing the other six units. These units are estimated to involve 15 additional instructional hours. It has been estimated or calculated (e.g., Bryan and Nagay, 1965) that it takes in the range of 100-150 man hours for each hour of instruction. Assuming 20 hours of instruction, and 1,350 man-hours of developmental time, the over-all estimate for this project is 65-70 man hours/hour of instruction. The estimate for the ophthalmoscopy unit alone is 90 man hours/hour of instruction (450 total man hours, 5 hours of instruction).

From Table 7, it is clear that the majority of time was spent in individual writing, preparation, and revision of instructional materials,

and in conceptual and organizational consultation with colleagues on the project. A large amount of time was spent discussing the instruction, as opposed to actually writing or preparing it. This time can be considered as "tooling-up," which is a necessary preliminary to the actual development of instruction. In a sense, this is preparation time. It is somewhat frustrating to spend this time because it has no immediately apparent products, yet it seems to the author to be a necessary component of the developmental process.

The financial expenditures for this project are indicated in Table 8.

Table 8

Financial Expenditures

	CATEGORY	COST ($)	
ACTUAL	Office expenses	150	
	Supplies	1,075	
	*Wages, Temp. Employment ($2.50/hr.)	775	
	*Professional Salaries ($12.50/hr.)	8,125	
	Travel	1,775	
	A-V Equipment for trial testing	1,500	
	Duplication for trial testing	700	
	Secretarial assistance ($2.25-$2.50/hr.)	600	
	TOTAL		14,700
PROJECTED**	Office expenses	100	
	Supplies	300	
	*Wages, Temp. Employment ($2.50/hr.)	375	
	*Professional Salaries ($12.50/hr.)	2,500	
	Travel	800	
	Duplication for trial testing	1,000	
	Secretarial assistance ($2.25-$2.50/hr.)	425	
	TOTAL		5,500
	TOTAL ACTUAL AND PROJECTED		20,200

* No Actual compensation for these services

** Projected additional costs for completion of initial pilot testing on all units

These are strictly developmental and do not include any expenses for large-scale production and distribution of materials. Some of the costs were assumed by the grants under which the project was funded, others were paid for from other funds, where appropriate. Professional salary estimates have been included in the total expenses, although there was no actual monetary compensation for these services.

Under the category of office expenses are included such items as postage and telephone calls, a minor part of this project. A much more significant category was supplies. This area includes such costs as Xeroxing, photography, rental of films or audio-visual materials for review, office supplies such as paper and pens, any educational supplies that were needed on the project including books and monographs, and any graphic art. This category also includes materials to prepare the mannequins. It should be noted that very little original artwork was required in the ophthalmoscopy unit, although more is being used for the other units and is included in the Projected Expenses.

The category listed as travel is one that is probably peculiar to this project. This category essentially reimbursed the author for expenses involved in travel between Champaign, Ill., and Iowa City, Iowa, and related expenses incurred while in Iowa City. Although travel expenses are likely to be needed for most such projects, the amount required is dependent upon the particular circumstances of development (e.g., outside consultations, inspection of other facilities, etc.)

It is possible to calculate the dollar cost of instructional development per instructional hour. from the data available, although again it must be emphasized that this cost is a crude estimate. Developmental costs per hour of instruction are $1,650 for the ophthalmoscopy unit, and average approximately $1,000 for all the units.

It is far easier to analyze the cost of the instruction than it is to analyze its potential benefit or effectiveness. Thomas (1969) outlines and discusses variables involved in a cost-benfit analysis of educational systems. However, he only touches briefly the study of unit costs that relate more directly to this project. Chappell (1970) has developed a model for predicting the unit costs of self-instructional materials in higher education. However, he does not consider means of judging effectiveness.

Hopefully, data from the field test will provide some means of judging relative time costs and effectiveness; however, it will be difficult to estimate "developmental" dollar costs of "conventional instruction" in use in the various medical schools. The best that could be expected would be demonstrating that the instructional units develop higher levels of competence in less student time and less faculty time than the previous instruction, with more favorable student and faculty attitudes.

<u>Summary</u>

Performance on a criterion test by 19 sophomore medical students after taking an instructional unit on ophthalmoscopy was

compared with that of 29 senior medical students who did not take the unit, but had been exposed to the usual formal and informal instruction in ophthalmoscopy. The seniors had 2 more years of experience than the sophomores in using the ophthalmoscope. The sophomores performed better than the seniors in every content area, and over-all scored 13 percentage points higher. There was a marked shift toward higher levels of mastery for the sophomores: 63 percent scored higher than any senior.

Attitudes of the sophomores toward the unit were favorable. Questionnaire results indicated that technical difficulties were encountered using the mannequins and the latent image answer sheets. These problems are being resolved for future versions.

Time and dollar costs have been analyzed for the ophthalmoscopy unit and projected for all of the instruction. The ophthalmoscopy unit required 90 man hours of professional time and $1,650 per hour of instruction. For all of the units, 65-70 man hours and $1,000 per instructional hour are estimated.

CHAPTER VII

PLAN FOR MULTI-SCHOOL FIELD TESTING

The primary purpose of this field test will be to determine whether the ophthalmology instructional units are effective in reaching their objectives in a variety of settings and whether they do so better than the alternatives typically provided in these settings. It is assumed that those schools that agree to participate will have examined the objectives of the ophthalmology units, and will have agreed that the goals are worthy and desirable ones for their students to achieve.

Because the seven instructional units are self-contained, each unit will be independent of the others in terms of implementing the field test; that is, independent decisions will be made for each school relative to which units it will test and when they will be most appropriately used in its curriculum.

It is expected that six medical schools will participate in the field test: University of Florida at Gainesville; University of Pittsburgh; University of California, Los Angeles; University of Minnesota; University of Kansas; and Albany Medical College. These schools all have ophthalmology departments that are interested in teaching and represent a wide geographic distribution. If possible, another southern or southwestern school may be substituted for one of the northern schools.

For each unit for each school, 30 students will be randomly assigned to each treatment: One group will receive the instructional unit; the other group will receive the typical instruction that relates to the objectives of that unit. The criterion test will be administered to both groups as soon as possible after their principle exposure to the instruction. If the control group's exposure is primarily informal and widely disseminated in time, the criterion test will be given shortly before graduation.

A possible statistical technique for the analysis of the criterion test results is the method proposed by Johnson and Neyman (1936). This method permits consideration of the two groups from any one school as samples from a pair of populations matched with respect to school and environmental differences, but differing with respect to the experimental treatment. The assumption is made that the school and method interaction is zero.

A manual will be developed for each unit to serve as a guide for faculty use. This manual will include essential steps that must be carried out for each unit, as well as suggestions for alternative ways to implement the instruction.

It is hoped that such suggestions will broaden the usefulness of the materials in a variety of settings. There is little uniformity in the way certain portions of the curriculum are presented to medical students at different medical schools. For example, ophthalmoscopy may be taught at one medical school in one whole class session lasting two

or three hours; at another school it may be presented in small-group sessions throughout the course of the semester. A third possibility is that it may not be taught formally at all, but rather taught incidentally as part of the physical diagnosis course by a physician who usually teaches a group of four students. Thus the more flexible that the instructional units are for usage in this variety of settings, the more useful they will be.

In addition to the performance data derived from the criterion test, data will be collected on the conditions and problems of usage, using a log to record observations and data as they happen and a structured questionnaire for the summation of data based on the log as well as for additional information. Data will be gathered on the amount of faculty time expended in setting up the instructional unit, the amount of time in administering it, and the amount of time in evaluating it. Comparable data will be collected for the "conventional" treatment. The amount of student time expended in both groups also will be collected.

Faculty descriptions relative to the instruction will be gathered in these areas: the physical setting in which it was used; the structural setting within the curriculum (where it fits in the curricular structure); how many students used the instructional materials at a time; the interval of time necessary for all of the students to receive instruction; a description of what the students were like previous to the instruction (i.e., what previous knowledge and skills they were expected to have or had been exposed to before the instruction); the attitudes of the faculty toward the instructional units (i.e., the

amount of support, both verbal and nonverbal, explicit and implicit, given to the usefulness of the units by the faculty involved); problems incurred in using the units; and apparent advantages and disadvantages that the instructional units have compared to the "conventional" instruction. From the students will be gathered data regarding its acceptability, specific strong or weak points, how often the student looked ahead or listened to the correct answer before writing his own answer, and amount of time actually expended on the unit.

Two additional areas will be investigated locally (at the University of Iowa) with relation to retention and transfer. Those students who took the ophthalmoscopy unit during their sophomore year will be given the same criterion test just before they graduate that they had as sophomores. This will allow a comparison of their performance as seniors with the performance of the current graduating seniors. In addition, it will allow a comparison between their performance as sophomores and their performance as seniors.

A second area relates to how well students have transferred what they have learned to the actual care of patients. For the students who have gone through the ophthalmoscopy unit in their sophomore year, random chart audits will be made on the patients for whom they are caring on the wards or clinics during their junior clerkships. The quality of their ophthalmoscopic descriptions will be assessed. This assessment will be done unobtrusively. If these behaviors are not reinforced by the physicians on the ward with whom the students are working, their

descriptions may well decrease in quality or quantity. Alternatively, if the ophthalmoscopy unit has caused the students to value funduscopic descriptions highly enough to recognize their usefulness and to feel competent about their descriptions, the students' behavior in this area may persist, despite absence of positive external support.

It is expected that the assistance of either a national ophthalmological organization (Association of University Professors in Ophthalmology) and/or a governmental agency (e.g., National Medical Audio-Visual Center) will be enlisted for the administration of the field tests. Such a group would be involved primarily with duplication of the materials, dissemination to the various institutions, and collection of the data. The data will be analyzed by those currently involved in the project.

CHAPTER VIII

THE PROCESS OF INSTRUCTIONAL DEVELOPMENT

This chapter is concerned with observations and judgements that the author has made regarding the processes involved in developing instruction for this project. It is necessarily a more personal account than the preceding chapters. Discussed first are the general procedures that were used as instruction progressed. The second major portion includes observations and reflections of the author that relate to problems in the approach and attempts at their resolution. The third section takes a broader, more philosophic view.

General Procedures

The systems approach outlined in Chapter III was followed with respect to its major components. The only exception was the explicit specification of entering behaviors and their assessment. Assumptions about entering behavior were implicit in the instruction that was designed and were based on the developers' intuition and experience. It appeared that stopping to specify the entering behaviors was more like "busy work" in this particular situation, because the developers (perhaps incorrectly) felt that they were able to go on and develop the instruction appropriately without it. The need to "get on with the instruction" superseded the need for specification of entering behaviors.

The heart of the instructional process consisted of the systematic tryout and revision of materials. This was reflected by initial try-outs on one or two students and a major revision based on data from a larger number of students. The result was the version that yielded the data described in Chapter VI.

Interspersed throughout the ophthalmoscopy unit are frequent questions that test for critical points. Observation of the responses to these questions provided one basis for revision. For example, in the earlier version of the instruction, students made many errors in estimating the "cup-disc ratio." The material was analyzed and revised, resulting in improved performance in this area.

In general, the revision procedures used in the ophthalmoscopy unit differed slightly from those traditionally used in revising programmed instruction. Rather than making a frame-by-frame microscopic revision to improve the performance in any given frame, a more macroscopic analysis was carried out to improve criterion behavior, as illustrated in the example above. Another example of revision based on feedback was concerned with the length of Section I. Many students who took the early version would have preferred the section to be shorter. By reorganizing the presentation and pruning the verbal descriptions, it was possible to improve both attitude and performance as well as decrease the time, despite the addition of approximately 15 slides.

Data from the questionnaires revealed two deficiencies, mentioned in Chapter VI, regarding the mannequins and the latent image answer sheets.

Students found disturbing reflections when examining the mannequins. This has been corrected by using a different film for the fundus transparencies. In addition, a new base for the mannequin is being designed that will eliminate the awkward examining position that the students reported. The latent image answer sheets will be replaced by a simpler form of corrective feedback; e.g., the correct answers can be provided in separate folders for each mannequin.

As the instructional materials developed, not only in the ophthalmoscopy unit,but in the others as well, it was found that the task analysis took the form of charts or performance guides. These comprised the skeleton of the instructional materials and provided the guidelines for further development. The charts and performance guides made explicit the procedures that the student needed to learn, the discriminations or identifications he needed to make, and the actions he would be required to take based on the discriminations and identifications.

Developing these materials was a relatively difficult and time-consuming task for the content experts. It became clear that what they had previously tried to teach students was not that explicit in their own minds. Thus it is not surprising that it is often very difficult for the student to form the appropriate concepts of normal and abnormal and identify certain pathologic changes. Other medical disciplines than ophthalmology undoubtedly have similar problems.

The task sheet, worksheet, and storyboard, described in Chapter III, were never used. The author found it simpler and faster to work in a

less structured fashion. Again, completing these forms seemed to be "busy work" rather than a necessary tool. Others who were involved in delineating content found the sheets to be unfamiliar and obstructive. The sheets forced an attention to detail that may have been too analytic, in the sense that a child who thinks too closely about the steps involved in breathing may find himself temporarily unable to breathe.

The last major point in this section concerns modifications of the original objectives. With very few exceptions, as the instruction was developed, the enabling objectives were modified. This is evident by comparing the objectives in Appendix A with those in Appendix B. However, the major terminal performances developed by Spivey remain essentially unchanged. In each case, as the enabling objectives were modified, they would be rechecked against the original terminal performances in cyclical fashion. The modifications of the enabling objectives resulted from a clearer understanding of the instruction as it became actualized, and from the changing skills and insights of the developer.

It was found that, at least for the author, the specification of enabling objectives was helpful in many ways. Aside from guiding the development of the instructional materials, the objectives allowed relatively clear communication between the subject matter experts and himself. Furthermore, redrawing of the enabling objectives based upon the content developed by the experts helped to clarify, edit, and resequence the content. The author frequently found himself questioning

the content experts as to the importance, necessity, or relevance of including certain material in the instruction. Sometimes this resulted in elimination of the content or making it optional; other times, the discussion gave rise to explicit justification for including the content in terms of the objectives. The objectives eased these critical decisions and made explicit the areas of discrepancy.

Reflections and Observations on the Developmental Process Used

Actualizing the instructional materials. Putting the instruction into "black and white" (or color) was the major source of frustration during development. Once the enabling objectives were prepared for all the units, there was a considerable amount of foot shuffling and delaying tactics: related instructional materials were viewed and reviewed; many films were examined; and several discussions were held that tended toward the philosophic and away from the task. These maneuvers are probably a necessary part of the tooling-up process preparatory to developing the instruction (see Chapter VI). However, it was found that not until a clear "master plan," anchored to the realities of the teaching situation, was developed did additional forward progress take place and attitudinal malaise diminish. This "master plan" essentially consisted of specifying the actual number of students who would be involved in the proposed instruction, what their already predetermined schedules would be, how the teaching units would be implemented into their schedules, etc.

At this point, all of the seven units had approximately equal priority. Meetings were held to try to specify and hone in on the appropriate content for these materials. Many of the decisions dealt with fine points and involved detailed considerations. After these content sessions, the content expert would attempt to specify what needed to be included. Attempts were made to make this content as interactive as possible. More often than not, however, it resulted in essentially textbook-like or lecture-like presentations with little interactive instruction.

It was at this point that the author was preparing the red eye unit and began to develop some notions about how he worked best with the content experts. He found that he was understanding and learning the content as though he himself were a student, with one exception: He was consciously trying to observe his process of learning and the requirements of the instruction necessary for his learning. Often he would have to request clarifications, specifications, or criteria from the content experts. In effect, he simulated a student in a one-to-one tutorial setting, then analyzed the processes he underwent and converted them into instructional materials. This procedure was then utilized more explicitly in developing the ophthalmoscopy unit.

During these periods of intensive developmental activity, it was found that the content experts needed to be in very close physical and temporal proximity to the instructional developer. Not only did substantial blocks of time (e.g., several uninterrupted hours or full

days) devoted only to developing instruction (this is often difficult for busy physicians) need to be set aside, but relatively instant access was also necessary for resolution of small but crucial points. (The relationship of the content expert to the instructional developer will be considered further in a later section.)

In the units that involved selection of slides for purposes of discrimination, recognition, and description, it was vital that the instructional developer be at least as competent as the expected student in discriminating, recognizing, or describing what he saw. It was found that in most cases the content expert, if he tried to develop the instruction using the slides, included much extraneous material and did not develop the critical discriminations and interactions, although undoubtedly there is individual variation. It is not reasonable to expect all content experts to be sophisticated instructional developers. Thus it basically fell to the instructional developer to develop the major line of instructional materials, rather than trying to modify or make more interactive the content that the subject matter specialist had outlined in detail. In the instance where a subject matter specialist is able to write good interactive instruction, the instructional expert may only need to edit the material. This was true with the unit on strabismus.

The author concluded that the two most critical steps involved in actualizing the instruction were the specification of critical features of the instruction by means of charts or performance guides, and the

simulation by him of the student/instructional expert role.

Developmental costs. There is no question that development of such instructional materials requires a far larger investment of faculty time than is expended on the development of the average lecture that may "cover" the same material. (However, this large "up-front" investment probably results in a considerable long-range savings in year-to-year delivery of instruction.) The following quotation is taken from the log kept by the author.

> "What is particularly noteworthy to me is the large amount of time three of us - two ophthalmologists and myself - must spend in detailed consideration and decision making in a content area that includes only a tiny fraction of the total curriculum. To me, this clearly suggests a major reason for the inadequacy of much medical instruction: teachers are unwilling or unable to devote sufficient time and effort to clarify, systematize, make consistent, or in any way "process" the knowledge and skills into a segment that facilitates learning."

The considerable expense raises a question: Is all this time and money really worth it? One answer may involve the "level of instructional power." Like an automobile, instruction can be over-powered for its purpose. Based on an analysis of what is needed by the student to learn something in a given area, various levels of instruction are indicated. For the most part, this analysis is based on the content expert's or educator's rational examination of the teaching area. However, it must be subject to empirical confirmation. On this basis, the simplest instruction that works should be used: One should always begin at the simplest level that one thinks will do the job; otherwise, a more complicated level that works will never permit realization that a

simpler level could have succeeded (Markle, 1964).

To illustrate the notion of "level of instructional power" (or "sophistication"), learning to listen to the heart may be compared to measuring the intraocular pressure with a tonometer. A performance guide would clearly be inadequate for the former; it is necessary to develop fine discriminations to recognize the various normal and abnormal heart sounds. Systematic practice and feedback would facilitate this. However, no such fine discriminations and training appear necessary in learning to use the tonometer. A simple list of directions with appropriate cautions and hints is all that should be necessary. The skills involved are ones that a medical student could be expected to already possess, such as reading a scale and holding his hands relatively steady.

Thus, the level of instructional power needed must be carefully analyzed in order to justify the developmental time and dollar costs involved.

Related to the costs involved is the extent that the instruction will be disseminated and used in other institutions. It is far easier to justify considerable developmental costs if the result will be a savings in faculty time at other institutions. In other words, a multiplier effect is involved that diminishes the time cost of instruction per student. If one estimates that 100 students per year in 10 medical schools will use the ophthalmoscopy unit for the next five years, the developmental cost becomes $1.65/student. (This of course does not include the cost to the school of the materials.)

Time constraints on the developmental process. H. Grobman (1970) discusses how the reality of deadlines, faculty availability, and student availability affect the developmental process. The constraints of the real world often force a developer to stray from the ideal procedures he would like to use. On the other hand, such constraints often spur him to action.

Both effects occurred during the course of this project. Because of the availability and schedules of the students, the development of instructional materials was speeded up. There was less time for leisurely small-scale tryouts and revisions than would have been desirable. Evaluation procedures did not follow as rigorous a methodology as might have been preferable. Certain technical problems involved in the criterion instruments (e.g., the mannequins) were not fully resolved in time for initial formative evaluations. Time constraints undoubtedly were a factor in the failure to explicitly specify entering behaviors.

There is no question that other situational constraints will continue to mitigate the rigor that a pure systems approach idealizes. How essential the polishing of each component step is will vary from instance to instance and be measured by the over-all success of the instruction.

Further observations on content and educational expert interaction. For the last several years, motivated primarily by the programmed instruction movement, content experts have been working with educational experts to develop instruction. Not everyone agrees on the fruitfulness

of this collaboration, although Grobman (1970) feels that, in general, these efforts have been effective in curriculum development projects. The manner in which individuals in these two roles work best together is, however, something that has not been generally agreed upon.

In this project, the author was primarily an instructional development expert, although he did have a substantial amount of general content knowledge. How much this affected the generalizability of his experiences (described earlier) is difficult to estimate, although it undoubtedly considerably improved his developmental efforts. In addition, the primary content expert in this project was a close friend of the author, which further enhanced their productiveness.

Conversations with other instructional developers whose primary background is not in the content area in question have indicated that many have difficulty in asking the right questions of the subject matter specialists, particularly on a one-to-one basis. On the other hand, the critical questions become more apparent if the instructional developer is observing interaction between several subject matter specialists: they question each other. However, the possibility exists that these questions are on a relatively sophisticated point and may not be directly relevant to the instruction of the student. It may fall to the instructional developer to keep the discussion at the appropriate level.

The author, as indicated earlier, was frustrated in his early attempts to develop instruction. This frustration occurred despite the fact that he had some competence in the subject matter, as well as close working relationships with the content experts. It raises some serious

questions in his mind regarding the feasibility of such collaboration when these relatively ideal situations do not exist. Certainly others have collaborated in this fashion with reasonable success, yet it is not clear how painful or frustrating that process was (Wilds, 1971). Furthermore, it has not always been clear whether or not the collaboration was beneficial.

A Broader View Regarding Instructional Development

One of the questions of interest is how generalizable this developmental process is to other content areas in medicine. The author, by no means, feels that all of medicine must be proscribed and systematized. He feels that there are certain areas in which essential skills are undertaught, particularly basic clinical information-gathering and problem-solving skills. Minimum levels of professional competence in these areas should be reached by all physicians. This means that a balance should be sought between the basic educational outcomes needed and the more individualized, specialized experiences. Rosenshine (1970) uses the metaphor of a tree to discuss this point: the trunk includes the fundamental basic learnings and the branches represent the more individualized or specialized experiences. In medical education, we have tended compulsively to prune the branches and allowed the trunk to grow relatively unsystematically and randomly.

In part, this over attention to the branches is illustrated by the development over the past 10 years of many fragmented and highly specialized instructional materials in medicine (Lysaught, 1969). Only recently have groups begun to take an interest in a more holistic

approach. The Association of Professors of Gynecology and Obstetrics has cooperatively organized a series of instructional materials, which it feels represent a minimum comprehensive curriculum in obstetrics and gynecology for medical students. The group has attempted to assemble previously validated instructional materials into one package. In addition, the Bureau of Health Manpower Education is now interested in funding projects that will "fill the gaps" in basic medical instruction. Their guidelines, as well as those of the Cooperative Media Development Program of the National Medical Audio-Visual Center, stress clear objectives and validated instruction.

The approach taken in this project clarifies areas that the project may not have adequately treated or that may have been omitted. This facilitates communication between others who may be interested in using these or similar materials, and it permits them to fill clearly recognizable gaps in the instruction to meet their own educational goals.

One area that deserves future investigation is the "conservative" effect that the clear specification of objectives may have on the overall characteristics of the students that undergo this instruction. In medicine, there has been little systematic investigation of the positive or negative effects of "information overkill." Medical students forget a great deal of what has been taught to them. Certainly they may relearn it, if necessary, faster and easier in the future. What is the effect of this increased breadth and depth on the student? Would he suffer by learning better a more limited set of concepts and skills?

In The Greening of America, Reich (1970) writes philosophically about the pervasive emphasis in our culture on competence, organization, rationality, and the necessary subversion of "self" to the "corporate organizational state." In many respects, the systems approach employed in this project is a product of the "consciousness" that he criticizes. If the critics of a systems approach are prepared to reject the broad philosophical and cultural assumptions upon which this consciousness is based, then it is unclear how medical education can proceed. Using a systems approach to develop instruction in medicine does not negate development of humanistic physicians, nor does it inhibit attention to development of interpersonal and communications skills. If it is agreed that physicians must be competent and must be able to demonstrate minimum levels of professional competence, an approach that specifies these areas of competence, utilizes instruction directed toward these areas, and employs means to assess minimum mastery of these areas appears critical.

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APPENDIX A

OPHTHALMOLOGY OBJECTIVES: WORKING DRAFT (October 1970)

BASIC EXAMINATION SKILLS

Prerequisite Objective: Given a penlight, ophthalmoscope, and a colleague, demonstrate the proper technique for:

A. checking for pupillary response to light (direct and consensual) and accommodation - subdued light (dark)

B. checking ocular motility

(i) elicit and observe normal versions and ductions while identifying the particular extraocular muscle being checked in each of the six diagnostic positions of gaze.

C. examining eye for corneal and lens opacities, red reflex, leucoria

Need Technique

(i) rotate vertically to localize depth of opacity

D. applying drop of appropriate agent to dilate pupil

(i) lower cul-de-sac or cornea

(ii) correct position of gaze (look up)

(iii) not touch eyelashes

(iv) controlling lids at same time

(v) relate innervation of pupillary sphincter and dilator muscles to response to sympathomimetic and parasympatholytic (atropine, cycloplegia) drugs.

E. approaching patient with ophthalmoscope, i.e.,

(i) all right first: eye, hand, index finger

(ii) vertical head orientation, aviods covering fixating eye

(iii) patient to fixate straight ahead

(iv) subdued light

(v) both eyes open or one closed

start at -7 for red reflex

(vi) slow moving in

(vii) focus - correct for refractive error of patient/examiner

(viii) movement to visualize as much of fundus as possible

F. examining fundus

(1) identify "landmarks" in systematic sequence: disc, vessels, general fundus, macula

a) given drawings/photos/overlay techniques (arrow, circle) of several normal fundi, identify/label the following "landmarks": disc (including estimation of cup-disc ratio), nasal and temporal disc margins, pigment cresents, vessels at the disc and peripherally (4 main branches) (arterioles vs. veins), A-V ratio, physiologic cup, macula (absence of vessels there), choroidal vascular pattern, amount of general pigment in retina, i.e. (sub-albinotic, blond, mediterranean, negroid, tigroid).

OBJECTIVES - INSTRUCTIONAL UNIT IN OPHTHALMOLOGY

The following seven patient problems provide examples of the context in which, as a minimum acceptable performance, the graduating medical student, when confronted with any aged, but cooperative patient, should be able to:

CORNEAL, LENS, AND RETINAL ABNORMALITIES
AS DETERMINED BY OPHTHALMOSCOPY

1.1 Indicate verbally or in a drawing the location of the findings and describe the appearance (e.g. size, color, shape, etc.) of an opacity of the cornea or lens utilizing external and ophthalmoscopic examination, after eliciting a history pertinent to the general health and ocular status.

The type of abnormalities the student could expect to encounter include:

corneal opacities (secondary to injury)

leucocoria (cataracts, tumors)

aphakia

vitreous opacities

A. Given drawings/photos of corneal opacities, cataracts, abnormal fundus reflex, and vitreous opacities,

(i) indicate its location ~~and~~ on approximate eyeball diagram

(ii) describe its appearance (color, size, shape, etc.)

B. Select from multiple choice the difficulty involved in examining the fundus in an eye with a cataract.

1.2. Indicate verbally or in a drawing the location of the findings, name it according to the terms below, and describe the appearance of a retinal abnormality, utilizing external and ophthalmoscopic examination, after eliciting a history pertinent to the general health and ocular status.

The type of abnormalities the student could expect to encounter include:

tumors

retinal detachment

papilledema

hemorrhages (round, flame-shaped, etc.)

microaneurysms

exudates

cotton wool patches

(diabetic retinopathy) (hypertensive retinopathy)

active and inactive chorio retinitis

central retinal artery occlusion

central retinal vein occlusion

abnormal a-v ratio

(P.J.L.'s abnormalities)

A. Given drawings/photos of several ocular fundi, describe, locate, and name examples of hemorrhages, exudates, cotton wool patches, central arterial occlusions, central venous occlusions, active and inactive chorioretinitis, retinal detachment, tumors.

need input

B. Given drawings/photos of several normal fundi as well as those with vascular abnormalities from arteriolosclerosis or hypertension, identify the abnormal fundi, and describe the vascular changes (e.g. arteriolar narrowing and irregularity, venous engorgement, branch arteriole or venous occlusion, crossing phenomenon beyond six disc diameter).

(1) select authors' position from among other controversial views regarding

hypertensive and alteriosclerotic vascular abnormalities

C. Given a colleague/patient with a dilated pupil or pupils, examine fundus for: presence of spontaneous venous pulsation (elicit if not present); presence or absence of "vascular crossing phenomena"; and presence or absence of hemorrhages or exudates in retinal substance.

(i) be able to select from multiple choice appropriate place to look for venous pulsations: on disc or disc margins

(ii) be able to describe technique to elicit them if not present (light pressure on globe thru lid)

(iii) identify clinical significance of absent pulsations

1. ↑ intracranial pressure

2. ↑ intra ocular pressure

2. demonstrate his ability to distinguish abnormality from apparent normality in a neuro-ophthalmological examination by including in the evaluation his analysis of the retina (hemorrhages, exudates, cotton wool patches) and nervehead (optic atrophy, papilledema); ocular motility and pupillary reactions; and visual fields by confrontation. * For content, see Dr. Thompson's notes which follow.

   A. Given photos and drawings of abnormal and normal eye movements in various diagnostic positions of gaze, discriminate normal from abnormal.

   B. Given photos/drawings/movies of abnormal (and normal) pupillary shapes, sizes, and responses to light and accomodation, identify the abnormality (e.g. irregular shape, unequal pupils).

      (i) name causes of iatrogenic pupillary deformities

   C. Given photos/drawings of abnormal and normal (including congenital variations) nerve heads, identify papilledema and optic atrophy (non-glaucomatous). **

   D. Given photos/drawings of abnormal and normal retinas, identify hemorrhages, exudates. **

   E. Given a colleague, determine his visual fields by confrontation.

** Can re-utilize instruction from section on retinal abnormalities, using new examples.

STRABSIMUS (SQUINT)

3. examine a patient in order to determine the presence or absence of a latent (phorias) or manifest (tropias) deviation of the ocular axes after obtaining a history of the general and ocular status. If strabismus is present, classify it (i.e., esotropia, exotropia, and hypertropia) and make an estimate of the amount of deviation (small, moderate, large) using the pupillary light reflex (Hirschberg test).

   In addition to congenital or infantile strabismus such conditions as III, (IV), and VI nerve palsies will cause a "paralytic" strabismus. (DEFINE).

   A. Given several verbal and graphic descriptions of patients with strabismus, identify appropriate reasons for treatment (e.g. preventing amblyopia, desiring improved cosmetic appearance, desiring binocularity).

   B. Given various clinical situations, identify which test to use: either the cover-uncover test (detects phoria or tropia), or the alternate cover test (gives idea of amount of deviation), and their respective indications for use.

   Need film, action, practice

   C. Given drawings/photos of various eye deviations and the pupillary light reflex, estimate the amount of deviation (small 5-10°, moderate 15-20°, large 25-70°). (Discriminate normal function from small deviations)

   D. Given drawings/photos of the vergence reflex, qualitate it (poor, good, excellent).

   ACTION

   E. Given a colleague, demonstrate the cover-uncover test and the alternate cover test.

   F. Given a glossary of terms and photos/drawings of various deviations (hypertropia, esotropia, exotropia) of the ocular axes, name them.

4. measure the patient's intraocular pressure with a Schiotz tonometer, and evaluate the nervehead (making a decision of normal, glaucomatous, or non-glaucoma but abnormal disc - e.g., papilledema, non-glaucomatous optic atrophy, drusen, large cup/disc ratio).

   A. Given drawings/photos of fundus, discriminate normal, glaucomatous, or abnormal but non-glaucomatous disc (e.g. papilledema, non-glaucomatous optic atrophy, drusen, large cup/disc ratios).

   B. Name suggested ophthalmic drops to apply for measuring intraocular pressure and dilating pupil to evaluate nervehead.

   C. Measure and record the intraocular pressure of a colleague using a conversion table. Remember the scale reading and the actual intraocular pressure have an inverse relationship.

      (i) given conversion table for the various weight factors, and scale readings, determine intraocular pressure.

      (ii) techniques of tonometry

      - patient comfortable and recumbent with target for fixation (ceiling or thumb)
      - topical anesthesia - wait to take effect
      - holding lids away from globe apply tonometer and engage "neutral", note pressures in scale reading

   D. Given a variety of measurements of intraocular pressure for various individuals, identify those which need referral and/or further measurements, and/or further instructions.

      (i) identify normal range of pressures (include normal variation of pressures with diurnal cycle)

      (ii) identify borderline pressures

      (iii) identify abnormal pressures

      (iv) identify inherent inaccuracy in schiotz measurement

(would also like to have them be able to state how applanation? pressure is taken and be able to list 2 advantages it has over Schiotz).

OCULAR INJURY

5. demonstrate immediate diagnostic measures when confronted with an ocular injury (e.g., corneal foreign body, acid burn, or corneal or lid lacerations) and initiate treatment in all cases except a penetrating ocular injury. Then outline possible complications of therapy undertaken or considered, arrive at a decision within five minutes of his own competence to continue in the same course of treatment, begin another, or refer the patient. In addition, demonstrate his ability to converse with the patient's family regarding the possible need for further treatment.

A. Given a colleague, be able to demonstrate the proper technique for irrigating the cornea and both upper and lower cul-de-sacs when the eye has been chemically injured.

maybe move to pre-requisite obj.

(i) open palpebral fissures with fingers, desueerraes lid retractor or properly bent paper clip (choose appropriate one? know all? why?)

(ii) doubly evert upper lid with Des. lid retractor or paper clip

(iii) ± Ophthalmic drops?

(iv) use IV solution, tap water, etc. to irrigate copiously

? time delays

? nature of injury (what chemical)

? facts about complications, how demonstrate, competence to continue, talks with patients

? refer

? any discrimination of various eye injuries

B. Given a patient problem of penetrating or non-penetrating foreign body in eye, be able to demonstrate the proper management procedures.

(i) given photos/drawings/models/cadaver eyes, discriminate penetrating from non-penetrating injuries a) vision, b) cornea wavy, c) distorted iris, d) cloudy media ?, etc.

(ii) given a model/cadaver eye with an imbedded foreign body, demonstrate proper technique for removing non-penetrating foreign body with cotton swab and needle point.

(iii) given model, tape, gauze, etc., demonstrate correct technique to patch eye.

(iv) given descriptions of management of various foreign body ocular injuries,

a) supply missing steps or identify errors in procedure (include failure to check V.A., use flourescein, determine location, anesthetize cornea, dilate with cyclogel or scopolamine, use steriods or antibiotics when appropriate, apply pressure bandage, refer appropriately if penetrating injury,

b) identify possible complication of Rx.

C. given a patient problem of lid laceration, be able to demonstrate proper management

(i) given photos/drawings of lid lacerations, etc., discriminate globe punctures or injuries from non-injured ones.

(ii) referal to ophthalmologist after binocular patching.

RED EYE (INFECTION)

6. obtain a contributory history and examine a patient with red eye(s) in a manner adequate to provide a decision about diagnostic possibilities and therapy, including in the decision a statement regarding etiology (i.e., injury, inflammation, glaucoma, infection or degeneration) and take a culture if indicated by the examination.

The specific types of pathology which one would have to recognize would be a corneal foreign body (including depth, ocular penetration and ability to remove with applicator or needle), a corneal ulcer, conjunctivitis, anterior uveitis, acute glaucoma.

A. Need to develop systematic examination procedure

B. Given slides discriminate

see Lange p. 59, front cover

? need list of important discriminations

e.g. viral vs. bacterial infection, glaucoma, etc.

C. Given verbal descriptions of historical data, and photos/drawings of various examples of red eyes (? Patient Management Problems), determine appropriate diagnostic and therapeutic measures.

VISUAL FUNCTION

7. measure and record the distance and near visual acuity after obtaining a history of any visual complaint, and then make an estimate of the patient's functional status ("normal", impaired or legally blind).

   A. Given a list of possible indications for measuring visual acuity, identify those which have medico-legal implications or require it for adequate evaluation (e.g. macular degeneration), and therefore necessitate measurement as the first step of the examination or play an important part in clarifying the DDX (glaucoma, corneal foreign body). (Actually probably <u>any</u> exam that includes manipulation).

   B. Given several descriptions of patients, identify those where it is sufficient to check near vision alone, and those where distant vision should also be measured.

   C. Given a list of visual acuity measurements, in meters, classify them according to functional status (normal, impaired, or legally blind).

   D. Obtain the visual acuity of a colleague, and record it in meters or centimeters at distance and near.

      (i) cover untested eye - insure adequate illumination - maintain fixed distance

      (ii) read lowest line on chart visible

      (iii) record line as denominator with distance as numerator

      (iv) if all letters are not read accurately, record as "+" if using next line above, or "-" if using basic line.

      (v) do other eye

      (vi) occasionally may need to measure binocularly because of latent nystagmus

NOTE: we should throw in color vision testing as optional !

APPENDIX B

OPHTHALMOLOGY OBJECTIVES: WORKING DRAFT (May 1971)

I. OPHTHALMOSCOPY

When given a cooperative patient with an opacity of the cornea or lens, or a retinal abnormality, utilizing external and funduscopic examination, as a minimum acceptable performance, a graduating medical student should be able to: elicit a history pertinent to the general health and ocular status; and indicate verbally the location of the findings and describe the appearance.

A. Given slides of normal and abnormal ocular fundi, and a chart delineating critical characteristics:

1.) systematically describe the characteristics of the fundi and specify the location of any significant findings;

2.) make a judgement regarding normality or abnormality of the disc, vessels, general fundus, and macula, after stating the location and appearance of abnormalities.

Example: "Small cotton-wool area at 3 o'clock, 2 DD (disc diameters) from disc -- general fundus: abnormal."

B. Given a mannequin and an ophthalmoscope, demonstrate proper procedure for:

1.) eliciting red reflex (fundus glow);
2.) checking clarity of media; and
3.) systematically examining the ocular fundus.

C. Given an ophthalmoscope and mannequins with several normal and abnormal fundi and media in place:

1.) systematically describe the media, disc, vessels, general fundus and macula;
2.) make a judgement regarding the normality or abnormality of media, disc, vessels, general fundus and macula; and
3.) give the location of any abnormality.

II. STRABISMUS

Given a patient, differentiate between "normal" binocular function, paralytic and non-paralytic strabismus.

A. Given a patient or colleague or photographs plus a performance guide, obtain and interpret versions (and ductions) of the extraocular muscles - specifically as to paretic, overacting and underacting muscles in six diagnostic positions of gaze.

B. Given slides demonstrating the results of either the cover test or the cover-uncover test, interpret them correctly (identify presence or absence of tropia or phoria) and classify it according to type (exo, eso or hyper) (?hypo), and amount (small, moderate and large).

C. Given moving representation and simulator for cover tests and cover-uncover tests, make accurate observations and interpretations regarding presence of tropias or phorias and their classifications.

D. Given a colleague, patient or simulated patient and appropriate performance guide, demonstrate the cover test and the cover-uncover test, while discussing possible outcomes and their correct interpretations.

III. RED EYE

When given any individual (newborn to elderly) with unilaterally or bilaterally red eyes, as a minimum acceptable performance, the graduating medical student should be able to: obtain a contributory history if possible and examine the patient and his eyes in a manner adequate to provide a decision about diagnostic possibilities and therapy; include in the decision a statement regarding etiology (i.e., injury, inflammation, glaucoma, infection, or degeneration); and take a culture if indicated by the examination.

A. Given slides of normal and red eyes, identify the red eye, those with purulent discharge, "mattering", discriminate sub-conj. hemorrhage from conjunctival injection, identify those with peri-orbital redness.

B. Given slides of red eyes stained with flourescein, differentiate damaged from normal corneal eipthelium and in other eyes identify corneal cloudiness, corneal reflex irregularity, ciliary injection ("flush"), corneal lack luster.

C. Given verbal descriptions of historical data, and slides of red eyes, and handout, make a judgement regarding diagnosis (injury, infection, allergy or referable problems like acute glaucoma, herpes, iritis), further diagnostic procedures, and appropriate therapy.
Student is expected to differentiate between those problems treatable by himself, and those that need to be referred to an ophthalmologist. He is not necessarily expected to be able to distinguish definitively between iritis, acute glaucoma and herpes, although he needs to make a differential judgement regarding treatment for non-penetrating ocular injury, infection, and allergy.

IV. NEURO-OPHTHALMOLOGY

As a minimum acceptable performance the graduating medical student, when confronted with any aged, but cooperative patient, should be able to demonstrate his ability to distinguish abnormality from apparent normality in a neuro-ophthalmological examination by including in the evaluation his analysis of the retina (hemorrhages, exudates, cotton wool patches) and nervehead (optic atrophy, papilledema); ocular motility and pupillary reactions; and visual fields by confrontation.

A. Given photos and drawings of abnormal and normal eye movements in various diagnostic positions of gaze, discriminate normal from abnormal.

B. Given photos/drawings/movies of abnormal (and normal) pupillary shapes, sizes, and responses to light and accomodation, identify the abnormality (e.g., irregular shape, unequal pupils).

i. Name causes of iatrogenic pupillary deformities

C. Given photos/drawings of abnormal and normal (including congenital variations) nerve heads, identify papilledema and optic atrophy (non-glaucomatous).

D. Given photos/drawings of abnormal and normal retinas, identify hemorrhages, exudates.

E. Given a colleague, determine his visual fields by confrontation.

V. VISUAL FUNCTION

As a minimum acceptable performance the graduating medical student, when confronted with any aged, but cooperative patient, should be able to measure and record the distance and near visual acuity after obtaining a history of any visual complaint, and then make an estimate of the patient's functional status ("normal", impaired or legally blind).

A. Given a list of possible indications for measuring visual acuity, identify those which have medico-legal implications or require it for adequate evaluation (e.g., macular degeneration), and therefore necessitate measurement as the first step of the examination or play an important part in clarifying the DDX (glaucoma, corneal foreign body).

B. Given several descriptions of patients, identify those where it is sufficient to check near vision alone, and those where distant vision should also be measured.

C. Given a list of visual acuity measurements, in meters, classify them according to functional status (normal, impaired, legally blind).

D. Obtain the visual acuity of a colleague, and record it in meters or centimeters at distance and near.

VI. GLAUCOMA

A. Given a patient over 40 years old (and a performance guide if necessary), routinely and accurately measure and record the patient's intraocular pressure with a Schiotz tonometer as part of the physical assessed examination. Performance will be by using simulated eyes with varying pressures, and by chart audit.

B. Given a patient on whom routine fundoscopy has been performed, recognize abnormally large cup-disc ratios or assymetry of cup-disc ratios greater than 0.2; suspect glaucoma and measure the intraocular pressure. Performance will be assessed using mannequins to allow simulation of an ophthalmoscopic exam.

VII. TRAUMA

As a minimum acceptable performance the graduating medical student, when confronted with any aged, but cooperative patient, should be able to demonstrate immediate diagnostic measures when confronted with an ocular injury (e.g., corneal foreign body, acid burn, or corneal or lid lacerations) and initiate treatment in all cases except a penetrating ocular injury. Then outline possible complications of therapy undertaken or considered, arrive at a decision within five minutes of his own competence to continue in the same course of treatment, begin another, or refer the patient. In addition, demonstrate his ability to converse with the patient's family regarding the possible need for further treatment.

1. At the completion of this unit, you should be able to accomplish, given the appropriate performance guides, the following techniques, and identify (recognize) the correct situations occasions (indications) for their use:

A. Simple lid eversion

B. Removal of external foreign body

C. Flourescein staining of the cornea

D. application of non-pressure or semi- pressure dressings monocularly or binocularly (slides, provide model? and tape?)

E. Irrigation of cornea, conjunctiva, and cul-de-sac (slides needed)

F. Emergency management of lid lacerations

2. A. Given slides of eye injuries identify signs of penetrating injuries

* a, pupil distortion
* b. protrusion of eye contents (incl. iris)
c. ? depth of A/C
* d. ? cloudy media (hemorr. or infection)
e. white reflex (? leucoria)
* f. irreg. cornea
g. hyphema?

AND/OR

B. Given slides (and patient histories?), discriminate penetrating from non-penetrating injuries.

3. Given slides (and patient histories) recognize corneal abrasions (and lacerations)

4. Given slides (and patient histories), recognize corneal (? scleral and conjunctiva) foreign bodies.

5. Given descriptions of patient problems, select from multiple choice (or describe) what you as the initial physician would tell the family regarding possible complications of the injury and therapy, need for further therapy, and prognosis (?)

(Note: this is not exactly what was in the original objective)

APPENDIX C

QUESTIONNAIRE RESPONSES: OPHTHALMOSCOPY UNIT

Results of questionnaire responses to open-ended questions are presented on following pages. N = 29 (Sophomores)

QUESTIONNAIRE

I. Was Section I

painfully long?	too long?	about right?	too short?	superficial?
(1)	(6)	(22)	(0)	(0)

2. What were the good points about Section I?

(See Following)

3. What were the weak points?

(See Following)

4. Was there too much detail in Section I? Yes (1) No (28)

5. Was there too much emphasis on fine points in Section I? Yes (0) No (29)

6. Did Section I belabor the obvious? Yes (3) No (25)

7. Did you find yourself just letting the tape run on? Yes (4) No (23)

8. Good points about Section II?

(See Following)

9. Bad points about Section II?

(See Following)

10. Good points about Section III?

(See Following)

11. Bad points about Section III?

(See Following)

12. Did you find the mannequins useful? Yes (20) No (3) Somewhat Useful (4)

13. Was there anything particularly bothersome about using the mannequins?

(See Following)

14. Did you fill out the mannequin answer sheets before you looked at the answers?

every time (17) occasionally (5) never (5)

15. Did you finish Section I? Yes (29)
Section II? Yes (27) No (2)
Section III? Yes (23) No (6)

16. Did you feel that the ophthalmoscopy unit was a worthwhile use of your time?

Yes (26) No (2)

17. Would you use similar units if available? Yes (27) No (2)

18. Did you look at or listen to the correct answer before you wrote your own answer?

never (12) almost never (12) less than 1/4 of the time (4) less than 1/2 of the time

more than 1/2 of the time (1) more than 3/4 or the time almost always always

19. How do you feel about the ophthalmoscopy unit as a whole?

Good parts?

(See Following)

Bad parts?

0. Was the unit too long (18), too short or about right (10)?

1. Overall comments?

(See Following)

2. Was it frustrating to work through the unit alone (i.e., without a teacher?)

Yes (7) No (22)

If yes, did this frustration <u>reduce</u> (1) or <u>increase</u> (4) as the unit progressed?

3. When you were doing Section III, how often did you refer to Chart I?

never (7) sometimes (14) usually (6) always (1)

4. Why or why not?

(See Following)

Question #2 What were the good points about Section I?

1. good description of main points
2. examination in list form with emphasis on description not pathology was good
3. good description and detail; describes order of exam
4. well organized, very clear and to the point
6. good exposure to a lot of eye signs and vocabulary
7. description of structures visualized & abnormalities, explanation of c/d and a/v
8. all good
9. good expalantions and slides
10. narration and slides were excellent
12. good summary of pathology and anatomy
13. Well organized and understandable
14. clear presentation
15. slides
17. good visualization and explanations
18. good introductory, but part I too concerned with unimportant details
19. excellent on disc
22. most of it
23. good introduction
24. generally good
25. very good
27. well prepared
28. about everything
29. length

Question #3 What were the weak points about Section I?

2. quality of slides not always good
6. too long
9. too long
14. unit required use of too many gadgets
15. verbosity of tape expalanation
16. poor explanation of A/V
19. poor explanation of vessels
21. need definition of OD and OS
28. Could show more normal eyes
29. simplicity

Question #8 Good points about Section II?

1. good description of instruments used
2. shorter than I
3. good description of use of ophthalmoscope
5. adequate
6. opacity discussion was good
7. technique of use of ophthalmoscope
9. Practical experience
10. helpful in technique of ophthalmoscopy
11. ok
12. good anatomy review
13. concise and good test of technique
14. short and concise

17. good way to learn
24. generally good
25. short
29. length

Question #9 Bad points about Section II?

2. didn't like mannequins and didn't have crayons
3. too long
4. mannequin is hard to see
5. marks for corneal abrasion and lens obstruction made it hard to examine
8. hard to self teach this - needs supervision
12. crayon was dedious and messy
14. mannequin difficult to work with
15. What was the point?
16. Not needed with Sections 1 & III
17. hard to see in mannequins. hard to read paper
18. confused about frame of reference of movement in determination of corneal opacity - I thought it referred to movement of gaze and not head
23. Mannequin difficult to use
26. often disagreed with what I'd learned in Section I
28. could say more on use of ophthalmoscope - esp. focusing it.
29. toss out those sheets and give answers or descriptions of each eye.

uestion #10 Good points about Section III?

2. it was the last one
3. Good practice
4. good practice
5. self-testing was good
7. mannequins were good and to study structures
8. excellent
10. good practice
12. good experience in description
13. good practical test of technique
15. variety of lessons in quiz fashion
17. good learning experience
18. good
21. would have been good practice if anything could have been seen
25. emphasis
29 few

estion #11 Bad points about Section III?

1. difficult to use mannequins but good
2. didn't like mannequins or crayons
3. mannequins hard to use
4. mannequins hard to use and too many mannequins
5. lighting of slides in mannequins was so poor that diagnosis wasn't possible
6. difficult to see some slides in mannequins
9. took too long - rubbing in answers took too long (too)
10. too long - mannequins are difficult to evaluate
11. too long and tedious
12. too long
13. too long
14. too long and too much repetition
15. waxing paper was waste of time when answers could be on back

16. Get rid of crayons
17. pretty long - hard to read answers
18. rather laborious
19. hard to visualize mannequins, esp. E
21. hard to visualize mannequins
22. got tired of exposing the damn answers - couldn't see that well
24. too many mannequins - too many poor mannequins =simply overdone
25. too long - hard to see
26. disagreed with wat I'd learned in Section I
28. too long - crayons were messy

stion #13. Was there anything particularly bothersome about using the mannequins?

1. need a solid base at a convenient level
2. nothing particular
3. difficulty in seeing and keeping mannequins steady
4. hard to see
5. hard to see and took too long
6. reflection on lens was bad
7. reflection on lens was bad
8. height of table
9. damn hard to use and see anything
10. hard to see borders and minute variations
12. when get on the table they were so low you almost had to stand on your head
13. no
14. too much reflection from the optics (and something illegible)
15. harder to see than in human eye
16. not as good as people but helpful
17. couldn't move their eyes so hard to see whole of back of eye
19. the "frontal bone" projection gets in way
!0. reflected glare off the pseudo-conjunctiva
!1. areas inferior to disc hard to visualize. Many changes of diabetes, hypertension, atherosclerosis not shown
!3. glass reflection
!5. hard to see structures in periphery
!6. reflection of the "corneas"
!7. couldn't see
!8. I got a stiff neck
!9. glare from eye

tion #19 How do you feel about the ophthalmoscopy unit as a whole?
Good parts?

1. well done
2. instructive and useful - my (eye) exam has improved
4. part I was especially good
5. Part I & II were especially good
6. generally good
7. useful learning experience
8. it's a little late - I had my final bedside critique yesterday
9. small group session was good
0. good except for latent images and crayons which wasted time and was hard to read
1. explanation of cup
2. all good
3. worthwhile in perfecting our technique esp. afternoon session.
4. straight forward
7. Part I was esp. good

18. mannequins useful
20. good
23. good overview of pathology and use of ophthalmoscope
24. provides systematic approach to exam of fundus and media
25. Part I
28. good as a whole

Bad parts?

1. no really too bothersome aspects
2. mannequins and crayons
3. at the end I was beginning to drag
5. Part III worthless
9. self study is tiring - had troubel finding time to do it
10. crayons and latent images
11. mannequin study too tedious
12. a bit long
14. too repetitious
18. I had a lot of questions and no one to ask about them
21. too many technical problems with headaches
26. too long - section I & III disagreed
28. section III too long

stion #21 Overall comments?

1. well done
2. good
3. ok
4. good learning experience
5. if mannequins are used - slides should be easily visible
9. get another set of mannequins - I had trouble getting to use them
10. good; helpful; informative - I feel more confident with use of ophthalmoscope & eye exam
11. good job
13. very helpful
14. would rather discuss technique with staff than hear in unit
16. good effort
19. excellent
!6. I hallucinated during part of the Section I tape
!7. light the mannequins
!9. a good slide show would be better than the mannequins

tion #24 Why or why not? (Did you refer to chart I?)

1. to review the steps of observation
2. to check points of normal and abnormal findings
4. I felt I knew what to look for
5. Part III was waste of time but most of the info in Chart I had been repeated enough that it was programmed into my head by this time
7. to reinforce certain concepts
8. to remember what to look for on the vessels.
9. to make sure I looked at everything
0. it was a useful guide in knowing what to examine & I figured it was better to refer to chart I than leave out important observations
1. I didn't most of the time so that I would learn the parts of the exam in sequence without looking at an outline
2. didn't feel it was necessary
3. laziness and unnecessary
4. tried to remember order of exam

15. why
16. too dumb to remember
17. Instructions were not too long if possible
19. I looked at it prior to doing the unit as a refresher and then made a game of it with myself
21. trying to get an order of examination down pat
22. it was helpful
26. wanted to learn own series to be used in exams
28. to make sure I hadn't missed any observations; to look up normal values (A/V and arterial light reflex)
29. to make sure I was examining and looking at all aspects.

APPENDIX D

CHART AND PERFORMANCE GUIDE: OPHTHALMOSCOPY UNIT --

SECTION I

CHART 1

CRITICAL CHARACTERISTICS	APPROPRIATE DESCRIPTIVE TERMS: NORMAL FINDINGS OR VARIATIONS	PRESUMPTIVE PATHOLOGICAL CHANGES
1.0 DISC		
1.1 Shape	1.1 Regular (generally); scleral crescent (white); pigment crescent (black)	1.1 Irregular - indicates inflammatory reaction or congenital anomaly
1.2 Margins	1.2 Distinct, more sharply outlined temporally	1.2 Obscured, blurred (consider papilledema)
1.3 Color	1.3 "Salmon pink"; deeper pink nasally; may show yellowish-white myelinated nerve fibers	1.3 Pallor, whiteness (consider optic atrophy); hyperemic or hemorrhagic (consider papilledema or venous occlusion)
1.4 Cup-disc ratio	1.4 0.0-0.5; should be equal (within ±0.2 to other (companion) eye	1.4 Greater than 0.5 or unequal to other eye (consider glaucoma)
2.0 VESSELS		
2.1 Number & direction	2.1 Branches to all 4 quadrants	2.1 Absence of a major branch (consider occlusion); vessels pushed nasally in disc (consider glaucoma or myopia)
2.2 Artery/Vein ratio (diameters)	2.2 A/V - greater than 1/2; judge before 3rd bifurcation	2.2 1/2 or less (consider diabetes if veins ↑; consider hypertension or occlusion if arteries ↓); generalized arteriolar narrowing (consider hypertension).
2.3 Regularity of vessels (blood column)	2.3 Progressive regular decrease in caliber toward periphery	2.3 Focal constrictions (consider hypertension); plaque formation (consider ASCVD)
2.4 Arterial light reflex	2.4 Ratio of light reflex to blood column - 1/4-1/3	2.4 Ratio greater than 1/2 (consider ASCVD, hypertension)
2.5 Crossing phenomena	2.5 Venous blood column appears discontinuous under artery. Frequently seen in normals within 2 DD of disc	2.5 Significant if seen more than 2 DD from disc (consider ASCVD), or if with marked venous engorgement peripheral to crossing
2.6 Tortuosity	2.6 Usually congenital, equal in both eyes, and of no significance	2.6 Rarely abnormal (consider vascular disease if markedly assymetrical)
2.7 Venous pulsations at disc	2.7 Normally present but may not always be seen	2.7 Abnormal if unable to produce with light pressure on globe (consider increased intracranial pressure.
3.0 General background of FUNDUS		
3.1 General retinal & choroidal pigmentation	3.1 Corresponds well to patient's skin coloring	3.1 Rarely abnormal (e.g., congenital melanosis, ocular albinism)
3.2 Retinal "Translucency" and integrity	3.2 Nothing should obscure the normal color of the retina & choroid, its pigmentation and blood supply. Myelinated nerve fibers; congenital variation - not pathological	3.2 Hemorrhages: a) pre-retinal (dark with fluid level); b) superficial retinal (flame-shaped); c) intra-retinal (dot- or blot-shaped). May not be able to distinguish small dot hemorrhages from microaneurysms. Exudates: yellowish, do not obscure vessels; sharp or fuzzy edges. Cotton-wool area: whitish, like cumulus cloud (obscures vessels) Microaneurysms: round dots with well-outlined margins, away from a vessel; microaneurysms <75 micron not visible with ophthalmoscope. Fluorescein technique shows smaller ones, and differentiates between small dot hemorrhages and microaneurysms. Drusen: small often multiple, yellowish, round or oval; tend to be rounder than exudates (difficult to distinguish from small, hard exudates) - generally no pathological significance. Retinal edema: whitish, milky appearance, obscuring reddish color
4.0 MACULA		
4.1 General appearance	4.1 Reddish-black color; deeper than rest of retina; usually homogeneous; slight granularity not unusual in children	4.1 Clumped or disrupted pigment; presence of hemorrhages or exudates; whitish dense round scar with pigment around it.

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A Comprehensive Curriculum in Ophthalmology for Medical Students

Ophthalmoscopy

Given an ophthalmoscope and a cooperative patient, the student should be able to:
- describe the condition of the media and fundi
- classify the findings as normal or abnormal
- express an opinion as to possible diagnoses and need for further examination, treatment or referral.

Visual acuity

Given a cooperative patient and a Snellen chart, the student should be able to:
- elicit a history of visual complaints, if any
- measure and evaluate the visual acuity
- examine grossly the visual field
- express an opinion as to possible causes and need for further examination, treatment or referral.

Red Eye

Given a cooperative patient with red eyes, the student should be able to:
- elicit a pertinent history
- perform an adequate examination, including conjunctival culture if indicated, but not slitlamp examination
- express an opinion as to possible causes and need for treatment, further examination or referral.

Strabismus

Given an infant, child or cooperative adult, the student should be able to:
- perform a cover-uncover test and test versions and ductions of extraocular muscles
- interpret the results as normal, paralytic strabismus or comitant strabismus
- express an opinion on the probability of amblyopia and on the need for referral.

Glaucoma

Given a cooperative patient, a Schiotz tonometer and ophthalmoscope, the student should be able to:
- obtain a pertinent history, including family history
- measure the intraocular pressure, evaluate the nervehead, and detect gross changes in the visual field, if present
- indicate the need for follow-up or referral.

Trauma

Given a patient with an ocular injury, the student should be able to:
- determine the presence or likelihood of a perforating injury
- perform immediate treatment where indicated, such as irrigation for chemical injury, removal of conjunctival foreign body, bandaging for perforating injury
- give adequate instructions for treatment, referral and transportation if indicated.

Neuro-ophthalmology

Given a cooperative patient, an ophthalmoscope, and a penlite, the student should be able to:
- examine the ocular motility
- examine the pupillary reactions
- examine the fundus and nervehead
- estimate grossly the visual acuity and the integrity of the visual field
- evaluate his findings as normal or abnormal and express an opinion as to possible causes of neuro-ophthalmological disorders.

PERFORMANCE GUIDE #1

SECTION I

1.0 DISC (approximately 1.5 mm in diameter)

1.1 Observe shape (regular or irregular). Crescents simulate shape abnormality - pigmented or scleral.

1.2 Observe margins
  a) temporal border is normally more distinct,
  b) nasal border normally less so.
  c) if all margins are indistinct (and especially if they appear elevated), think of papilledema.
  d) differential diagnosis problem is "pseudo-papilledema" congenital anomaly - must check the other eye and spontaneous venous pulsations (see later) - must also check for hemorrhages or edema.

1 3 Observe color
  a) lighter pink and brighter than rest of retina
  b) especially pink nasally
  c) can see fine vessels in nervehead substance
  d) if pallor and less than 10 fine vessels, indicative of optic atrophy.

1.4 Observe and estimate the cup-disc ratio
  a) observe central or temporal area in disc
  b) estimate the ratio from 0.0 to 1.0 (usually 0.1 - 0.3). (Assume disc diameter is 1.0, then estimate the cup diameter in relation to this). Depth and transition from cup to nerve tissue is variable and may be difficult to estimate. You should agree within ±0.1.
  c) check and record symmetry or assymetry of ratio in both eyes (consider glaucoma if difference is greater than 0.2).

2.0 VESSELS

2.1 Count number of major branches
  a) vessels bifurcate in or near disc
  b) observe division to 4 quadrants. Follow to "equator" - 8-10 DD out each way.

2.2 Estimate A-V ratio
  a) estimate near disc and before 3 bifurcations
  b) usually 2/3 or 4/5 - vein <u>or</u> artery may be abnormal - sometimes judgement which is offending vessel is difficult. A-V ratio may vary in a given fundus - describe its variation.
  c) progressive decrease in size of both arterioles and veins to periphery.

2.3, Observe light reflex and regularity of blood column.

2.4 a) easiest to observe on arterioles
  b) reflex should be 1/4 - 1/3 size of blood column and regular
  c) reflex usually increased or irregular in abnormality
  d) observe for focal and/or general areas of narrowing and constriction, especially in arterioles; an isolated instance is of less significance than multiple instances.

2.5 Observe for crossing phenomena
  a) observe 2 DD from disc - if only here and not further peripherally, tend to disregard as congenital variation especially if no venous congestion peripheral to junction
  b) if crossing with venous engorgement peripherally, or especially more than 2 DD from disc, then consider pathologically significant.

2.6 Observe for tortuosity - especially of arterioles
   a) note and record - usually congenital. Check both eyes - asymmetry abnormal.
   b) rarely pathologic - do not make much of this.
2.7 Check venous pulsations
   a) normally present; if not seen, may be elicited by gentle pressure on globe; seen best near disc margin.
   b) if not seen or producible, especially when disc has questionably indistinct margins, consider papilledema.

3.0 GENERAL BACKGROUND OF RETINA AND CHOROID

3.1 Estimation of general retinal and choroidal pigmentation.
   a) note general amount of light reflected - the more light reflected, the less pigment
   b) note choroidal vascular pattern - i.e., cord-like structures.
   c) pigmentation corresponds to general skin pigmentation of individual
   d) check to see if there are areas with local accummulation of choroidal pigmentation (nevi) and/or loss of choroidal pattern with pigment margins (e.g., chorioretinal scar).
3.2 Observation of retina between vessels (generally between large vessels in each quadrant) - retinal "translucency" and integrity.
   a) begin near disc observing homogeniety of appearance. Disregard choroidal vessels and pigment which can distract. Highest likelihood of abnormality 5-6 DD from disc and near, around or in the macula.
   b) check for reddish-black homogeneous appearance (later can see accentuation in macular pattern).
   c) abnormalities typically:
      i. hemorrhages - at least 3 types - preretinal (with fluid level), superficial = flame, deep = dot or blot
      ii. exudates - yellowish, do not obscure the vessels. Appear flatter, posterior to vessels; may have sharp or fuzzy edges.
      iii. cotton wool areas = vascular occlusion as with emboli or collagen vascular disease - obscure the vessels; cloud-like.
      iv. microaneurysms (or macroaneurysms) = difficult to tell from dot hemorrhages (but smoother edge). (Microaneurysms are usually 75 microns and not resolvable with ophthalmoscope).
      v. drusen = yellowish, round areas of depigmentation, difficult to distinguish from some exudates with sharp edges.
      vi. myelinated nerve fibers (usually a congenital variation) - may initially be confused with exudates
      vii. retinal edema = whitish, milky appearance to fundus, obscuring reddish color - usually secondary to arterial occlusion or inflammation

4.0 MACULA

4.1 General appearance
   a) always move temporal to disc - center slightly below disc
   b) note avascularity, darker, homogenous
   c) check central foveal reflex (may be absent and yet normal)
   d) abnormalities include pigment disruption, hemorrhage, exudates, microaneurysms
   e) CAUTION: Pigment disruption and fairly gross pathologic changes are not correlated directly with decreased visual acuity!

APPENDIX A

OPHTHALMOSCOPY UNIT TEXT FROM SECTION ONE

4/20/71

SCRIPT

OPHTHALMOSCOPY UNIT - SECTION I

Ophthalmoscopy is the skill of using the ophthalmoscope to examine the fundus or inside of the eye. The fundus is a general term which refers simply to the back of the eye (containing the retina) as seen with the ophthalmoscope. In this first section you will examine a series of different slides of the fundus and will learn how to recognize normal and abnormal variations.

In this unit we will not concentrate on making a diagnosis of disease; rather we will concentrate on accurate observation of several critical characteristics of the fundus. These critical characteristics are indicated for you on Chart 1 along with the normal and abnormal variations. Chart 1 is in the handout that accompanies the unit. Also in that handout is Performance Guide No. 1. The chart and the performance guide correspond to each other as indicated by the numbers in the margin. Although the chart and the performance guide may appear formidable to you now, as you proceed through the section they will become quite familiar. We would suggest at this point that you read the performance guide and the chart to give yourself an overview of this entire section. The performance guide is essentially an expanded summary of Section 1 and should give you all the information that you will need from the unit, thereby obviating the necessity to take notes. When you are done come back to the tape.

This section will systematically cover the four major areas indicated on the chart and performance guide. The four major areas are the disc, the vessels, the general fundus and the macula. You will find it helpful

to refer to the chart as the section progresses. When actually examining the fundus of a patient, you should routinely examine the four areas in the order listed on the chart and the performance guide.

We will begin by rather superficially going over all the critical characteristics of some normal fundi as you orient yourself to some of the landmarks of the fundus and the terminology used to localize various findings.

Now look at Slide 1. The most prominent landmark when observing the fundus is the optic disc. This is also known as the optic nervehead or the optic papilla. It is the relatively prominent yellow-orange round area located at about 9:30 on the screen. At the center of the optic disc is a more pale area. It is known as the physiologic cup. This cup is simply a depression at the center of the disc to where the blood vessels enter and exit the eye. The distinctness of the cup varies greatly among normal individuals. It may be quite conspicious, ir may be entirely absent, or it may be present but not clearly delineated.

Located directly opposite the disc on this slide at about 3:00 is an area known as the macula lutea or simply macula. This is the area with the highest concentration of cones, which is the area of our greatest visual acuity. On the slide it is a darker, uniformly pigmented area that appears to be avascular. The blood vessels approach it but do not actually cross it. Of course there are small capillaries that supply blood, which are invisible to the ophthalmoscope. The whitish C-shaped area that approximately encircles the macula is a light reflex which is often seen in young people, less commonly seen in older individuals, and is completely normal.

Now look at the vessels. You can distinguish the arteries from the veins by comparing the vessels running parallel; veins are usually wider and redder than the arteries. The arteries are narrower and somewhat lighter red in color. The arteries and veins, as they go from the disc to the periphery, gradually narrow and undergo finer bifurcations.

When we are looking at fundus slides we will always be viewing them as though we were looking at a patient with our ophthalmoscope. The disc is always on the nasal side, toward the nose, and the macula is always on the temporal side, toward the ear. With that in mind which eye would you be looking at in Slide 1? Please answer this under Question 1 on your answer sheets which accompany this unit. Please stop the tape and answer the question, then restart. Since the disc is nasal, the patient's nose would be to the left of this slide. This slide, therefore, represents the patient's left eye.

Now look at Slide 2. Slide 2 is a diagramatic representation of the major landmarks that we just discussed. Study this to make sure you are well oriented. Note particularly the cup margin and the disc margin. While the disc margin is normally rather clear, sharp and distinct, the cup margin can vary greatly in terms of its distinctness. With some cups it is almost impossible to tell for sure where it begins and where it ends. With other cups, it is quite clear. Now look at Slide 3. This shows another common appearance of the cup, with the nasal margin of the cup just temporal to the central vessels. This is the situation in Slide 1. Go back now to Slide 1. Slide 1 shows a diffusely outlined whitish area just temporal to where the largest blood vessels enter and leave the back of the eye. We would consider this cup beginning at the temporal side of

the blood vessels where you can first see any light or pale area and extending a very short way temporally as the color gradually changes from a pale white to a pinker orange.

Now if you are sure about the major landmarks, proceed to Slide 4. Slide 4 reviews for you how we would describe the position of a particular lesion found when examining a fundus slide or a patient directly. The common way in which abnormalities or lesions are localized on the fundus is by giving both clockface numbers and number of disc diameters from the disc. The lesion here is located at approximately 1:30 and it is located 3 disc diameters (or 3 dd) from the disc.

Now go on to Slide 5. In this slide you can just barely see the edge of the macula. Can you identify which eye this is? This is Question 2. This is the right eye of the patient since the macula is located at the left of your screen. Another cue to help decide which is the nasal and which is the temporal side of the picture is the pattern and curvature of the vessels as they proceed peripherally. The vessels are usually somewhat more concave toward the macular area or toward the temporal side. The vessels on the nasal side tend to go out straighter and closer to the horizontal, as illustrated quite well on this slide.

Now let us go quickly through the major critical characteristics to note when examining the fundus. Consider the disc first. Refer to Chart 1 as we proceed. The shape is generally regular and in this case somewhat oval. The margins are normally distinct although you may notice that the nasal margin is somewhat less sharp than the temporal margin. This is normal. The color ranges from an orangish to a more pale pink with a much

paler physiologic cup. You will note that the color is somewhat deeper nasally and this is normal. In this slide, we would again say that the nasal cup margin begins just temporal to the largest central vessels as they leave the center of the disc. The important characteristic to observe here is the so-called cup/disc ratio. This is the ratio of the horizontal diameter of the cup to the horizontal diameter of the disc. This is usually estimated by considering the disc diameter as one; the cup diameter then becomes a decimal fraction of the disc diameter. For example, in this case we would estimate that the cup/disc ratio is about .3 to .4. When you estimate the c/d, we would expect agreement within ±0.1. You will have more practice with the cup/disc ratio later.

Now let us examine the vessels. There are branches of the arteries and veins going to all four quadrants. After the very first bifurcation of the artery (which is the central retinal artery) they are actually arterioles; we may call them either. Looking at the ratio of the arteries to the veins the ratio is clearly greater than one half and it is close to 3/4 or 4/5. Again you will have more experience at estimating this ratio later. The purpose of estimating the ratio is to give some indication of whether the arteries are abnormally narrowed or the veins are abnormally widened.

Next we look at the regularity of the blood vessels, particularly the arterioles. There should be a regular smooth decrease in caliber toward the periphery. In this slide, at approximately 6:30 one disc diameter from the disc, we see what appears to be a severe narrowing of the arteriole. In this case, it is not really a pathological narrowing but simply an artifact due to the unusual but normal proximity of the vein to

the artery. Otherwise the blood column in the vessels is regular as it becomes gradually and smoothly narrower.

The arterial light reflex is relatively prominent in this slide. It is the central light area that proceeds along the middle of the arterioles as they progress toward the periphery. It is quite clear in the arteriole exiting from the disc at about 11:30. The characteristic that we pay attention to here is the ratio of the diameter of the white area or light reflection to the diameter of the total blood column. In this case it is about 1/3 or 1/4 which is normal. The arterial light reflex may be increased in vascular disease. Again you will have more practice at estimating arterial light reflexes as we proceed through the unit.

The next point on your chart refers to the presence of crossing-phenomena (or crossing defects). We speak of a crossing phenomenon if there appears some kind of an interruption, obstruction or change in the course of the venous blood column in an area where an artery crosses over a vein. As you will learn later, not all so-called crossing phenomena are abnormal.

On this slide there are two areas where an artery crosses a vein. Can you localize them? This is Question 3. There is a major arteriole crossing a vein approximately 1½ disc diameters at 5:00 and also a smaller one crossing a vein at about 12:30 ½ disc diameter from the disc. Neither of these areas of crossing would be called a crossing phenomenon because there is no obvious interruption of the flow of the blood in the vein. You may also note that at about 11:30 right at the disc margin a vein goes over an artery. We will come back to crossing phenomena in more detail later.

The sixth characteristic of the vessels is tortuosity. Tortuosity is a twisting corkscrew-like appearance of the vessel. Although this is often referred to, it usually is congenital and has no pathological significance. If there is a marked asymmetry of tortuosity between the two eyes, you may consider some kind of vascular disease; however usually it is symmetrical and congenital. This slide does not show any tortuosity.

The last characteristic is called venous pulsation at the disc. This is the characteristic that we will not be able to see when we look at slides as it involves motion and must be seen in a live patient or a film. Venous pulsations are usually spontaneously present or may be easily elicited with slight pressure on the globe. If venous pulsation is not seen or easily elicited, this suggests decreased venous outflow such as with increased intracranial pressure. This is a very helpful piece of evidence in establishing a diagnosis of papilledema. You will learn more about this in a small group session and you will learn how to elicit it properly.

If you wish to read more about vessels in the retina, consult Newell's <u>Ophthalmology</u>, p. 251.

Now we move on to the third major area, the general background of the fundus. Its first characteristic is the general retinal and choroidal pigmentation. There is a wide wide range of normal variation in the general pigmentation of the fundus. Later on, we will show you several different kinds of normal fundi in order to give you an idea of the range. This fundus has normal pigmentation. The second characteristic is what we are calling retinal "translucency" and integrity. Normally nothing

should interfere with the translucency of the retina. The color that we see results from the color of the blood in the choroid plexus behind the retina, and of the pigment cells in the retina and the choroid. When this is interrupted, it is abnormal. The kinds of abnormality that we are talking about here are most commonly different varieties of hemorrhages and exudates and edema. We will look much more carefully at these later on. In this slide, nothing interrupts the normal translucency.

Lastly the macula. In Slide 1 we saw a very clear picture of the macula. It generally has a reddish-black color that is somewhat deeper and darker than the rest of the retina, and is usually homogeneous. In this slide we can just see the edge of the macula and it appears normal.

Up to this point, we have rather quickly and superficially, but systematically, gone through the critical characteristics to be considered when examining a fundus. Now we will proceed in more depth to give you practice at looking at normal and abnormal variations in each of these critical characteristics. This would be a good place to take a short break and get up and stretch your legs if you so desire. Move the rest of the tape fast forward to the end and flip the cassette over to be ready for Part II.

PART II

We have spent a fairly long time at looking at only five slides. As we progress through the next parts of the unit, we will see more slides more quickly. Let us consider some of the critical characteristics of the disc.

Look at Slide 6. The disc is round and its regularity is within normal limits. The margins are sharp with the nasal border somewhat less

sharp. The color of the disc is within normal limits. What would you estimate the cup/disc ratio to be in this slide? This is Question 4. We would estimate the cup/disc ratio to be about 0.1 to 0.2. The cup is rather small in this particular disc and begins just temporal to the central vessels.

Now look at Slide 7. How would you describe the four critical characteristics of the disc? This is Question 5. In this case, the disc is regular in shape, the margins are sharp with slightly less distinctness nasally which is normal, the color is a normal orangish-pink and the cup/disc ratio is very very difficult to estimate in this case. There is certainly no clear cup area delineated. It would be possible to make any number of guesses as to where it did extend, but it is not really possible to see any physiologic cup in this case although there are some scattered whiter, more pale areas on the center of the disc. In this case, the cup/disc ratio is said to be zero.

Now look at Slide 8. Slide 8 shows a very nice example of what is called a scleral crescent. This is the white crescent-shaped area that is at the margin of the disc from 6:00 o'clock going clockwise to 12:00. As you can see, it is whiter than the disc. Would you describe the color of this disc as normal pinkish-orange, or abnormally pale? This is Question 6.

This disc is abnormally pale and represents a case of a patient with optic atrophy. You might incidentally note the relative narrowing of all of the vessels in the slide as well as the relative absence of the small blood vessels on the disc.

Now look at Slide 9. This is a diagrammatic representation which explains the appearance of the scleral crescent, which you saw in the

previous slide. The pigment layer of the retina and pigment cells in the choroidal vessels do not extend all the way to the edge of the optic nerve so that you are looking directly at the white sclera. This is a congenital variation and does not represent any pathological disease process. Of course, the abnormally pale, atrophied disc that we saw previously was abnormal and this diagram does not represent that.

Now look at Slide 10 which demonstrates what is called a pigment crescent. This is an area of dark pigment which also appears along the margin of the disc, often in the shape of a crescent although here it is somewhat less regular. Again this is a congenital variation of normal and represents no pathological process. Its appearance is explained in Slide 11. It is caused by an increased amount of choroidal pigment cells. Such pigment crescents can be of varying width and prominence.

Now look at Slide 12. Do you see any scleral or pigment crescents? This is Question 7. In this slide it is possible to observe both a scleral crescent and a pigment crescent. The scleral crescent is rather thin and extends from about 12:00 to 4:00 at the disc margin. The pigment crescent extends from about 7:30 clockwise to about 11:00. This is a rather uncommon site for a pigment crescent but nevertheless, it can occur there. There is probably also a small amount of pigment crescent located between 4:00 and 5:00 on the disc margin. You might also note that this slide gives a very nice representation of a normal homogeneous slightly dark macula. Slide 13 represents an exaggeration of the crescents seen in Slide 12.

Now let us consider some variations in the distinctness of the disc margins. Slide 14 shows what happens when the intracranial pressure rises sharply which causes congestion of blood vessels and swelling and

edema in the optic nerve. The optic disc becomes raised and, as indicated on the diagram, hemorrhages may be present. The margins become blurred and no longer distinct.

Look at Slide 15, which shows a normal disc. The discs margins in this slide appear somewhat less distinct than others we have seen, but this is within normal limits. The disc appears flat, there are no hemorrhages present, and there does not appear to be any elevation of the vessels as they go over the edge of the disc which would suggest papilledema.

Now look at Slide 16. Are the margins sharp and distinct or are they blurred? This is Question 8. In this slide the margins are blurred. There is a very feathery kind of edematous appearance to the margins of the disc. Notice also that the vessels proceeding over the disc margin, particularly the arterioles, seem to be constricted and blotted out. This is due to the swelling and edema of the disc, and particularly prominent in the small arteriole about 5:30 at the disc margin.

Now look at Slide 17. How would you describe the margins here? This is Question 9. The disc margins here are indistinct and blurred and we see vessels apparently obliterated from the swelling and edema. Just as the swelling would obliterate some of the arterioles and diminish arterial flow to the periphery, the edema would similarly prevent venous blood from returning. Do you think that the veins look engorged or widened in this slide? This is Question 10. The prominent vein at 6:00 or 6:30 is certainly engorged and widened and in general the veins are abnormally engorged. Such venous engorgement is another characteristic that would go along with papilledema. Notice also that the cup is not visible, due to the edema of the disc.

How would you describe the margins in the next slide, Slide 18? This is Question 11. This is a difficult slide. It is clear that the temporal margin appears quite sharp and is nicely outlined by the pigment crescent which is present. On the other hand, the nasal margin is quite indistinct and feathery. This is an example of pseudopapilledema and would be difficult to differentiate from true papilledema; however, the nicely outlined border on the temporal side makes it somewhat easier. Also there does not appear to be any other evidence of increased intracranial pressure such as hemorrhages or venous engorgement. We would not expect you to be able to make a distinction such as this for sure, but we wanted you to see an example of pseudopapilledema.

How look at Slide 19, another example of papilledema with blurred margins and the presence of many hemorrhages radiating out from the disc as though a sudden impact burst many blood vessels causing the hemorrhages. Note the color of this disc which is still relatively normal, pinkish-orange. Compare this with the next slide, Slide 20, which is another instance of papilledema with indistinct disc margins. There is some suggestion of vessels being obscured at the disc and rising up over the edge of the disc although this is fairly subtle. Hote however the color of the disc, particularly the nasal portion. The disc is hyperemic and appears redder than we would normally expect. A hyperemic disc is another sign that would suggest papilledema, particularly in the beginning stages before the increased pressure diminished all blood flow to the disc.

Now look at Slide 21. How would you describe the disc? This is Question 12. The disc appears to be regular in shape, the margins are indistinct, the color appears to be somewhat hyperemic and the cup/disc ratio

appears to be about .1. You might also have noted here that the veins are engorged, and the arterioles are irregular and interrupted by the edema, all which would go along with papilledema.

Now look at Slide 22. How would you describe the four characteristics of the disc in this slide? This is Question 13. In this case, the shape is regular, the margins are quite sharp, but the disc is extremely and abnormally pale, the cup/disc ratio is approximately .1 to .2.

Now look at Slide 23. Can you perceive a cup in this slide? This is Question 14. In this slide, no discernable cup is present; there is certainly a suggestion of a slightly lighter central area to the disc, but it is not sufficiently different from the surrounding color of the disc to stand out as a cup. In this case, the cup/disc ratio would be zero.

Slide 24 shows a diagrammatic representation of two views of the physiological cup. It can be seen that the retinal vessels proceed over the rim of the physiological cup. Look at Slide 25. What would you estimate the cup/disc ratio to be in this particular slide? This is Question 15. We would estimate the cup/disc ratio in this slide to be approximately .2 to .3.

What would you estimate the cup/disc ratio to be in Slide 26? This is Question 16. Here, we would estimate the cup/disc ratio to be approximately .4. It begins just slightly nasal to the temporal vessel origin and proceeds temporally. There is a gradual increase in color and nerve tissue, as you progress from a rather pale to a slightly reddish area. We would locate the cup margin at approximately this change. Notice also the scleral crescent which is not counted as part of the disc diameter!

Look at the next slide, Slide 27. What would you estimate this cup/disc ratio to be? This is Question 17. We would estimate this cup to be about .5 to .6. It seems to begin at the nasal edge of the vessel and proceeds further toward the temporal margin. Again, there is gradual change in color as you go temporally, but you are helped to locate the margin by the vessels going over the edge of the cup, particularly noticeable at 6:00 and 12:00 o'clock.

If you were to see this size cup in an individual, it should raise your index of suspicion regarding the possibility of glaucoma. This would be particular true if the cup/disc ratio in the other companion eye was at least .2 less than in this eye. Although such a large cup/disc ratio may simply be a congenital variation, it is a significant finding, because it might also be the result of glaucoma. We would suggest that whenever you see a cup/disc ratio of this size, .5 or greater, that you check the intraocular pressure in the patient by doing tonometry. An ophthalmologist also would consider doing a visual field.

Now look at Slide 28. What would you estimate the cup/disc ratio in this slide? This is Question 18. We would estimate the cup/disc ratio to be approximately 0.7 to .8 in this slide. Here the cup margins clearly extend nasally from the vessel origins, and we get a suggestion of the vessels plunging over the edge of the cup. Again, do not count the slight scleral crescent as part of the disc diameter.

What would you estimate the cup/disc ratio in Slide 29 to be? This is Question 19. We would estimate the cup/disc ratio here as approximately 0.7. Slide 30 diagrammatically represents an advanced case of glaucomatous cupping. The increased intraocular pressure has caused a large part of

the optic nerve to atrophy and has undermined the normal rim of tissue. In the diagram we see that most of the ring of normal nerve tissue has been atrophied and there is just a small crescent of normal tissue remaining. A characteristic ophthalmoscopic finding is the apparent discontinuity of vessels as you see in vessel A in the upper diagram. Slide 31 demonstrates a similar instance. What would you estimate the cup/disc ratio in this slide? This is Question 20. We would estimate this to be 0.8. There is virtually no normal tissue remaining temporally, but there is about 20% remaining nasally.

Now look at Slide 32. How would you describe the whole disc? This is Question 21. This is an instance where the disc appears to have a regular shape, the margins are indistinct, and there is some suggestion that the vessels have to go over the edge of the disc. Color is probably within normal limits and there is no cup visible so the cup/disc ratio would be zero. This is an instance where no physiologic cup is visible because of swelling and edema of the disc. There may well have been a physiologic cup present before, but now the edema secondary to congestion has obliterated the physiologic depression.

Now look at Slide 33. What is the cup/disc ratio here? This is Question 22. We would estimate the cup/disc ratio to be approximately .7. Now look at Slide 34. What would you estimate the cup/disc ratio here? This is Question 23. It is somewhat difficult to estimate the cup/disc ratio in this slide because we can see clearly that temporally there is very little normal disc tissue left so the cup appears to go almost to the edge and the vessels clearly plunge over the rim at this margin. However, nasally, there remains a rim of normal tissue. So,

in this case, although the cup margin proceeds quite far to the temporal edge, the cup/disc ratio would be about .7 to .8. Notice here that the vessels appear to be pushed nasally and this is a relatively typical finding in glaucomatous cupping.

Also the last two slides which you have just looked at are the right and left eyes of the same individual. While they certainly appear to differ, they are both quite advanced and their cup/disc ratios are not particularly different although the disc and cup look different. Which eye looks the most severe to you? You may have to go back and look at both slides, 33 and 34. This is Question 24. We would say that the left eye, Slide 34, is more severely involved. There appears to be a larger area of more pale, and therefore, more atrophic tissue in the left eye than in the right eye. Thus the atrophy is more severe in the left eye. This would be another good spot to take a short break. Move the rest of the tape fast forward to the end, and start with Side 1 of Cassette No. 2 for the next part.

Next we will consider the critical characteristics of the blood vessels. In general, the purpose of making these observations on the blood vessels is to give us information on which an interpretation regarding vascular disease can be made. There are no absolute indicators of vascular disease, but all of these characteristics taken together can lead to a diagnosis of vascular disease. Again, quoting from Dr. Leinfelder, "Surveying the fundi of many patients, it has been determined that apparent vascular deterioration can be observed in patients without otherwise diagnosable vascular disease, while normal retinal vascular appearances may occur with obvious general vascular disease. . . {most uniformly

recognizable changes} of the vessels consist of irregularity in caliber of the arterioles which appears as loss of parallelism of the walls of the blood column; localized constriction; and obliterative vascular phenomena. These signs are the best indication of involvement of retinal arteries. However, variations of caliber can be simulated by overlying an edematous retinal tissue, adjacent hemorrhage or cotton wool areas, deeper placement of the vessel because of tortuosity, and {by} the vessel {crossing} a light or dark area in the fundus (light areas below an arteriole cause it to appear narrower). On an arbitrary basis, attenuation in caliber is considered mild when it is not immediately noticeable; moderate when easily seen; and advanced when the vessels are affected to a degree that makes {it} difficult to {miss}. Increased light reflex in segments of the same vessel may accompany these changes and there may be crossing effects and generalized narrowing."

In general then, the most important characteristic that will help you interpret whether or not there is vascular disease present is whether or not there is much variation in the caliber of the vessels that you see in the fundus. An isolated instance of narrowing is not nearly as significant as multiple changes in the caliber of the vessels. If you have to make a very fine judgment as to whether or not the vessels are narrowed, the narrowing is of less significance.

Now look at Slide 35. Let's quickly go over the six critical characteristics that you should observe when looking at the vessels. The seventh, as you remember, cannot be observed from a slide. The first is the number and direction of the vessels. There should be branches to all four quadrants of the fundus. Second is the ratio of the arterial diameter to the

vein diameter, the so-called AV ratio. You should judge this before the third bifurcation of the vessels, using comparable branches of the artery and vein. The third is the regularity of the vessels or the regularity of the blood column. This concerns the important characteristic of changes in caliber of the vessel or blood column. Fourth is the arterial light reflex. This is to be recorded as the ratio of the width of the light reflection to the width of the visible blood column. This is diagrammatically described for you in Slide 36. Although the light reflex is not an absolute indicator of vascular disease, when the proportion of the light reflex to the width of the blood column is changed (for example, as indicated in the slide by thickening of the wall of the vessel), there is an apparent increase in the ratio of the arterial light reflex. Now return to Slide 35. The fifth characteristic relates to crossing phenomena which we briefly discussed earlier. These are defects in the apparent bloodflow where an artery crosses over a vein. They are significant if they occur more than two disc diameters away from the disc, or if there is notable engorgement of the vein peripheral to the crossing. The sixth characteristic relates to tortuosity.

Now please describe the six characteristics of the vessels that you observed in Slide 35. This is Question 25. In this slide, all four branches are present. The AV ratio varies quite a bit depending on which branches you are looking at; for example, the vessels at about 6:30 appear to have an AV ratio of about 1/3, certainly less than 1/2, yet the ratio of the vessels at about 11:30 is closer to 1/2, and between one and two o'clock, the ratio is greater than one half. You should report the observed variations rather than give only one number. It would be difficult

in this case to make a general statement about the AV ratio that would indicate vascular disease, particularly because, in the next category, the columns of blood are really quite regular throughout. There does not appear to be anything but a nice, smooth gradual decrease in caliber. The arterial light reflex is within normal limits, about one-third, certainly less than a half. At the points where arteries cross over veins, there is no disruption of blood flow and, therefore, there are no crossing phenomena. Lastly, the vessels are not tortuous.

No go on to Slide 37. The diagram on the right represents an instance where an artery crosses a vein, with peripheral venous engorgement. It is an exaggerated example, but illustrates the point of a significant crossing phenomenon. The diagram on the left of the slide shows peripheral narrowing in an arteriole, in this case secondary to an embolus. You will see examples of such narrowing later. Right now, let's concentrate on crossing phenomena.

Look at the next slide, Slide 38. This slide has several abnormalities on it that are quite striking, including hemorrhages and exudates which we will disregard to the moment. Pay particular attention to the area where an arteriole crosses over a vein at about 6:30, 1½ to 2 disc diameters from the disc. This is a good example of a borderline abnormal crossing phenomenon. There is certainly an apparent disruption of the blood column and just the very slightest suggestion that the vein is engorged peripheral to the crossing. Where you would normally expect the vein to become gradually narrower, it in fact remains the same or slightly engorged. This would be a borderline or questionably significant crossing phenomenon, particularly since it is located just about 2 disc diameters from the disc.

Now look at Slide 39. What do you think of the crossing phenomenon located at about 5:30 within a disc diameter of the disc. Is it significant or not? This is question 26. This defect is probably not significant because it is within a disc diameter of the disc. Although the direction of the vein changes markedly the vein does not appear engorged peripherally. Yet one cannot be dogmatic since there is a linear, streak like hemorrhage one half disc diameter from the disc margin at 3:00. There are also several difficult to see cotton wool areas at 3:00, 2 to 3 disc diameters from the disc. What do you think about the crossing phenomenon located at about 6:30 or 7:00, about 2 disc diameters from the disc? This is question 27. This defect is also probably not significant. Also pay attention to the arterial light reflex as evidenced in several of the arterioles. Notice the major arteriole that bifurcates at the disc about 5:30 and courses downward. The arterial light reflex is prominent and variable. Particularly notice the variability and increase in the branch of that arteriole that courses nasally after bifurcation. In some arterioles the light reflex may appear less than ½ the observable blood column and in others it may appear ½ or more. The point of showing you this slide is that it is often difficult to make a generalized statement about the arterial light reflex, and in itself, an abnormal light reflex does not conclusively indicate vascular disease. In this case, in the arterioles, the blood column and caliber appear relatively regular, with no evidence of focal constrictions. With this evidence at hand it would be difficult to make any unequivocal statement about the presence of vascular disease.

With the presence of the crossing defect, you would certainly be more suspicious. One further bit of evidence is the small linear hemorrhage which is located at 3:00 within a disc diameter of the disc.

Now look at Slide 40. Look at the arterioles in this slide. Would you say that they get gradually and normally narrow, or is there irregular focal narrowing? This is question 28. These vessels get gradually and normally narrower.

Now look at Slide 41. Slide 41 is an example of fairly twisting tortuous vessels. It is in a completely normal individual who is age 27. The tortuosity is congenital with no pathologic significance. Do you think that the light reflex is increased in this case over what is usually considered normal? This is question 29. Yes, we would think that in most of the arterioles there is a light reflex of approximately ½ but since we know there is no other evidence of vascular disease or any disease in this normal individual, we show you this slide to point out again that a given isolated abnormality in terms of the critical characteristic of the slide does not necessarily indicate the presence of vascular disease.

Look at the next slide, Slide 42. Would you call these vessels tortuous or not? This is question 30. Yes, we would consider these vessels somewhat twisting and tortuous, yet there is no way to really evaluate their pathological significance except that it is very rarely abnormal. Really, the only way to gain any further information is by comparing it with the other eye, and even then it is difficult to make a clear judgment. It is something to observe, but not something to place large pathological significance upon.

Now look at Slide 43. The top of the slide, diagrammatically represents focal constriction in the arteriole and the bottom represents generalized narrowing in the arteriole. Inbetween is a vein to demonstrate the relative proportions.

Now look at Slide 44. Do you see irregular changes in the caliber of the arterioles? This is question 31. Yes, there is marked change and variation in the caliber of the arterioles as they proceed peripherally, particularly noticeable around 5:30 to 6:00, although there is irregularity throughout. What about the crossing defect that is located at about 11:30 within a disc diameter of the disc? This is question 32. This is a significantly abnormal crossing. There is venous engorgement, and a marked interruption of blood flow.

Now look at Slide 45. Is there focal constriction and irregular caliber present in the arterioles in this slide? This is question 33. Yes, this is another example of focal constriction and irregular caliber of the blood vessels, most prominent in the inferior anterioles.

Now look at Slide 46. Here again there are many focal irregularities of caliber present. There is also a general impression that most of the arterioles are narrowed. Are these vessels what you would describe as tortuous? This is question 34. Yes, we would say that these are definitely tortuous arterioles, but again, it would be hard to attribute signigicance to that in itself. Certainly, there is vascular disease present.

Now look at Slide 47. What would you estimate the AV ratio to be? This is question 35. We would say that the AV ratio is certainly less than

½ here and we get the general impression that the arterioles are narrowed and, while not difficult to see, certainly much less prominent than one would expect.

Now look at Slide 48. What would you estimate the AV ratio to be here? This is question 36. It varies in some places but it's generally one half or less. And we get the impression that in general all the vessels including both the veins and the arterioles are narrower than usual. This is another instance of optic atrophy with generalized narrowing of the vessels. The AV ratio is not changed because arteries and veins are both narrowed.

Now look at Slide 49. What would you estimate the AV ratio in this slide? This is question 37. In most vessels the AV ratio is within normal limits, greater than ½, close to two-thirds. Yet, again there is the impression, that both the arterioles and veins are generally narrowed. We would not expect you to have this same feeling for generalized vascular narrowing. As we said earlier, when you really have to try to think very hard whether or not vascular arterial narrowing is present, it is probably not terribly significant.

In the preceding few slides, we were looking at abnormal AV ratios where the arterioles were generally narrowed. In the next slide, Slide 50, we have a case again of an abnormal AV ratio of approximately 1 to 3, certainly less than ½, where the veins are widened rather than the arterioles narrowed. Venous widening is often the early sign of diabetic retinopathy. This slide shows an <u>advanced</u> diabetic retinopathy. It will not always be easy to determine whether the veins are widened or the arterioles narrowed, and we would mainly expect attention called to the abnormal AV ratio.

Look at Slide 51. What is the AV ratio in this slide? This is question 38. Here again the AV ratio is certainly less ½, probably close to 1/3. Are the veins widened or are the arterioles narrowed? This is question 39. Again in this case the veins are widened and the arterioles narrowed - i.e. both factors are present. This is a case of papilledema which is similar to some you have seen before, where, because of the congestion, the veins become engorged.

Very briefly we will touch on major occlusive vascular disease. Slide 52 indicates diagramatically the obstruction of an arteriole. Peripheral to the block is retinal edema and swelling and greatly diminished arterial bloodflow.

Slide 53 shows an example of an arterial occlusion simialr to that shown in the diagram. There is an obstruction occluding the arteriole at 11:30, 1 disc diameter from the disc. Peripheral to this is a lighter area of retinal edema, which is actually a very large cotton wool area.

Total central retinal artery occlusion is a true medical emergency. Along with the sudden visual loss, the entire retina will look like the upper part of the slide, except for a "cherry red" spot in the macula. Treatment should be instituted immediately. (See pp. 259-260 of Newell or pp. 43-44, and 110-111 in the yellow Lange publication.)

Slide 54 is an example of a central retinal vein occlusion. Virtually none of the usual landmarks are visible in this slide. There is severe hemorrhage and cotton wool areas. In contrast to the relatively bloodless appearance of a central retinal artery occlusion, the central retinal vein

occlusion appears quite hemorrhagic. In part, it might remind the more imaginative of a strawberry ice cream sundae. This kind of occlusion is often due to arteriosclerosis, with obstruction of the vein secondary to compression by the artery within the shared adventitial coat.

We have finished describing the vessels. Now would be a good place to take another short break. When you return we will consider the general background of the fundus. FLIP TAPE

We'll now begin consideration of the general background of the fundus which includes both the general pigmentation of the retina and choroid, plus the second characteristic, retinal translucency and integrity. We'll consider the general pigmentation first.

Look now at Slide 55 (Slide 55 is a repeat of Slide 1). Slide 55 shows a fundus with average pigment. We will continue to show you a range of normals, in order for you to get the idea of wide range of normal fundus pigmentation. It is very rare to have an abnormally pigmented fundus. This generally occurs in congenital albinism or in congenital melanosis, so the primary purpose of this is for you to recognize that wide variations in the general pigmentation are not necessarily abnormal. Irregular clumping of pigment, in the general background however, may be an indication of pathological process or nevus, etc.

Now look at Slide 56. Slide 56 shows a fairly blond fundus that would typically be found in a light-skinned blond individual. Here the general pigmentation is of a lighter hue. The pigmentation of the fundus generally follows the skin pigmentation of the individual.

Slide 57 represents another kind of normal, and this is what is usually called the tigroid or tesselated fundus because it looks somewhat like a tiger skin. The actual pattern is created by a network of choroidal veins intermixed with choroidal and retinal pigment, providing this tiger-like pattern. The choroidal veins are actually the light pink canal-line structures that you can see in the background. This is a normal variation of pigment content in the fundus.

Slide 58 shows a dark fundus which would normally be seen in a dark or black skinned individual. The vertical line in the slide is just a fixation mark and ends at the fovea.

Now we will consider the variations in normal retinal translucency and integrity. The main point is to differentiate between some of the more important interruptions of the retinal integrity.

Look at Slide 59. Slide 59 is an example of the so-called deep or intra-retinal hemorrhages. These are the dot or blot shaped hemorrhages which look almost as though they were splattered on with a wet sponge. They are of varying size and their borders are relatively blurred.

Now look at Slide 60. Slide 60 shows primarily examples of what are called superficial or flame-shaped hemorrhages. These hemorrhages are linear, primarily because they follow the course of the longitudinal neural fibers in the nerve fiber layer. These are most notable along the vessels leaving the disc at about 1:00, approximately one or two disc diameters from the disc, as well as some located at about 2:00, right at the disc margin and proceeding temporally out.

Now look at Slide 61. Slide 61 is a classic example of a small pre-retinal hemorrhage which is located in front of the retina. (This photograph shows only a small retinal area) These are usually characterized by a fluid level as is evident by the hemorrhage present in the center of the slide. Note also the marked arteriolar irregularity in the vessel coursing across the lower 1/3 of the slide.

Now look at Slide 62. What kind of hemorrhages are present on this slide? This is question 40. These hemorrhages are deep hemorrhages, dot or blot shaped for the most part. The yellowish areas are exudates which we will discuss shortly.

Look now at Slide 63. Located at approximately 9:00 one disc diameter from the macula are two rather small fairly well demarcated red areas. These are small punctate hemorrhages which are often referred to as micro aneurysms. Notice that they are not apparently touching a blood vessel. True micro aneurysms, are ususally less than 75 microns, which is below the resolving power of the ophthalmoscope. Hence, true micro aneurysms are not visible by ophthalmoscopy. So, although one can talk about well outlined punctate hemorrhages characteristic of diabetes, they are not truly the microscopic micro aneurysms. Some may wish to call these macro aneurysms to make a distinction between the actual microscopic lesion. However, as long as one is clear about what he is referring to with the term micro aneurysms, any term is all right. Slide 64 diagramatically represents the relative size between the disc and some micro aneurysms. Slide 65 diagramatically compares micro aneurysms with a sharp margin, to other kinds of hemorrhages which have more blurred margins.

Now look at Slide 66. In this slide both micro aneurysms and deep hemorrhages are present. We could not really easily distinguish the two

on this slide. However, with fluorescein angiography, a special technique where fluorescein is injected intravenously, the micro aneurysms develop as bright areas throughout the retina. Hemorrhages do not fill with fluorescein and are represented as black spots. This is seen on Slide 67. You should compare back and forth between Slides 66 and 67 to distinguish between the micro aneurysms and the deep hemorrhages. The two slides have the smae section of the smae fundus represented on them, although the proportions are somewhat different.

Now look at Slide 68. This slide demonstrates two of the gray or whitish changes which may occur in the retina. In particular we can demonstrate on this slide exudates and cotton wool areas. The exudates are located at approximately 9:00, 1 ½ to 2 disc diameters away, most prominent in the macular area. These are yellowish, well demarcated areas. The cotton wool areas are located at approximately 11:00 and 12:00, and they are whitish, fluffy cumulus cloud-like areas, which, in contrast to exudates, envelop or obscure the blood vessels as a cumulus cloud would. The exudates are felt to be a result of stasis such as may accompany venous micro infarction. Cotton wool areas have been demonstrated to be the result of small emboli occluding terminal precapillary arterioles, but this does not seem to explain the mechanism in all the conditions that they are found. If you care to read more about exudates, we would refer to the section in Prior and Silverstein, pages 108-109.

Now look at Slide 69. What would you call the light area approximately between 10:00 and 11:00 within a disc diameter of the disc? This is question 41. This is a cotton wool area as it clearly envelops and obscures the blood

vessels. If it were an exudate, it would appear to be located beneath the vessels or much flatter and would not obscure the vessel.

Look at slide 70. Notice the small well demarcated yellow dots scattered throughout the background of the fundus. These round yellow areas look very much like exudates with sharp margins. However, they are not. They are called Drusen and rarely have any pathological significance. Often these are symmetrically distributed between both eyes, as opposed to hard exudates which would not be symmetrically distributed. Another way to differentiate the two is that these exudates frequently are larger with irregular margins whereas Drusen are smaller, round and usually distributed in either macula or the entire fundus or both. However, it is sometimes very difficult to discriminate the two.

Now let us look at Slide 71. What are the yellowish areas in this slide? This is question 42. These are rather typical macular drusen (exudates). They are localized to the macula and have produced some pigmentary disruption which often occurs. The vision is normal even though this is a rather pathologic picture.

Now look at Slide 72. What is the light-colored area at 11:00 two disc diameters from the disc? This is question 43 on your answer sheet. This represents a cotton-wool area. It looks fluffy and cloud-like and definately obscures the vessels.

Now look at Slide 73. The lighter white area located at 6:00 near the disc and of slightly larger size is an artifact. Also, the black small areas are artifactual. Describe and name any abnormalities with regard to the retinal translucency or integrity that you see. This is question 44. In this slide are located several areas of exudates, most noticeable at approximately 2:00 and 3:30, two to three disc diameters from the disc. There is also a small area located about 1:00. These areas are yellowish and do not obscure the vessels. The vessels clearly go over them. Additionally, there are several small micro-aneurysms present. It would be, of course, hard to tell these from small dot or deep hemorrhages. There is, for example, one

present very near the periphery of the slide at about 2:30, four disc diameters away. There is also one present at about 5:00 one disc diameter away. How would you describe the arterial light reflex in this slide which is Slide 73, question 45? The light reflex does vary somewhat in this slide. Particularly in the vessel coming from the disc at about 6:00, the light reflex is quite prominent, maybe even greater than one half, whereas in the arterioles coming off the disc at about 11:30 or 12:00 it is less than a half and within normal limits. Of course, we have other evidence for disease in this fundus.

Now look at Slide 74. The large whitish area at the disc margin which obscures the vessels and is kind of whitish yellow could be mistaken for a cotton wool area. However, this is a congenital anomaly called myelinated nerve fibers and generally has no pathological significance. They are typically located at the disc margin although they may very rarely be seen in other areas of the fundus. Often times it is possible to make out a linear pattern of the nerve fibers, which will help you to distinguish it.

Now look at Slide 75. Slide 75 shows, particularly at the center of the slide, a diffuse area kind of milky appearing area, with a brighter white area in the center. This is diffuse retinal edema tending to obscure the reddish color of the normal pigment. This happens to be a case of acute chorioretinitis. It may be difficult for you at this point to reliably distinguish between the whitishness from retinal edema and some of the other whitish abnormalities that we have seen. Try to get in mind the soft diffuse kind of whiteness merging slowly to the normal that is evident ~~by~~ in this picture.

Now we have finished the section on the general background and will briefly

consider the macular region.

The next slide, Slide 76, shows a normal macula with a relatively even distribution of pigment, no clumping, somewhat darker reddish or brownish than the rest of the background of this blond fundus. There is a prominent scleral crescent at the temporal disc margin. The vertical line in the upper half of the slide ending at the fovea is a fixation target. artifact

Slide 77 shows clumping of pigment in the macular region with some suggestion of edema of the surrounding retina (in this case the macula). This is abnormal.

Now look at Slide 78. Fully describe this slide using all the critical characteristics that we have discussed, beginning with the disc, then the vessels, the general background, and then the macula. This is Question 46.

The disc is regular in shape, the margins are within normal limits although not sharp. The color is a normal pinkish-orange, the cup/disc ratio is approximately .2. The disc appears within normal limits.

With regard to the vessels, there appear to be branches to all four quadrants, the AV ratio varies, in most cases it appears to be about 1:2 although in some cases it is greater than 1:2, in some cases it is less than 1:2. There is definite irregularity of caliber in some of the arterioles as they progress toward the periphery, particularly noted at approximately 6:30 one disc diameter from the disc. The arterial light reflex is variable and ranges from greater than one half at 11:30 one disc diameter away to less than a half at 6:30. There is a crossing defect at approximately 11:30 within a disc diameter with venous engorgement

peripheral. This would be a significant crossing phenomenon. Another crossing located just peripheral to it is also significantly abnormal. The vessels do not appear tortuous. In sum, there is definite evidence of vascular disease.

Considering now the background of the fundus, the general retinal and choroidal pigmentation is within normal limits. With regard to the retinal translucency and integrity, there are definite abnormalities present. At least two kinds of hemorrhages are present: There is a superficial flame-shaped hemorrhage present at about 8:30 quite close to the disc. There are several others present as well. There are also deep dot or blot shaped hemorrhages, particularly noticeable at approximately 10:00 two disc diameters from the disc. There are several cotton wool areas including those located at approximately 7:00, 1½ disc diameters from the disc, and at 5:30 quite near the disc. There are also exudates present around the macular area. The general background of the fundus in terms of its translucency and integrity is certainly abnormal in this case. There is a suggestion of retinal edema located in the same area as the smaller cotton wool area, that is, at 7:00 1½ disc diameters away.

The macula appears normal, but there are the presence of exudates around the macula.

Now look at Slide 79 and again describe all the critical characteristics of the fundus. This is Question 47.

The disc is ~~round~~ regular, the margins are clearly outlined and sharp, color is within normal limits (a slightly pale pink or orange), and the cup/disc ratio is zero or 0.1. It is very difficult to visualize clearly any cup in this slide.

There are vessels to all four quadrants. The AV ratio is generally about one half or less. There is irregularity in the caliber of the arterioles, particularly notable at 11:30. The arterial light reflex is within normal limits, less than one half. There do not appear to be any crossing defects of significance (or otherwise), and there is no notable tortuosity.

Regarding the general pigmentation, this is a dark fundus, but within normal limits. Considering the retinal translucency, there are several superficial flame-shaped hemorrhages present with white centers at 8:00 and 10:00. Cotton wool areas are present near the disc. In fact, they surround the disc and overlie or obscure underlying vessels.

The general appearance of the macula is also within normal limits with no obvious clumping or granularity of the pigment.

That completes Section I of the unit on ophthalmoscopy. Remaining now are Sections II and III. In Section II you will learn the basic skills in handling the ophthalmoscope, and in Section III you will put that together with your knowledge of the fundus abnormalities, observing with your ophthalmoscope various normal and abnormal slides simulated in a mannequin. We would suggest that you wait a day or several hours before you begin Section II and Section III. This will give you an opportunity to see how well you can use what you have learned in Section I.

There is also an optional addition to Section I, which you are invited to study if you desire. It is short and contains brief descriptions of some less common, but nonetheless important fundus abnormalities. Slides and additional tape are available from the same location you obtained these.

APPENDIX B

NEURO-OPHTHALMOLOGY UNIT TEXT FROM SECTION ONE

Neuro-ophthalmology

This unit contains four sections. Listed in order they are: Visual fields, pupils, motility and the fundus. Besides the tapes which contain the narrative describing slides there are several handouts which accompany each section. These handouts include objectives for each unit and sheets upon which your answers to questions asked in the tape should be written. The correct answers to the questions are given on the tape so that you may evaluate your own performance on the unit. The individual sections are self contained units so that it is not necessary to complete all four at once. It is suggested, however, that you complete each individual section in one sitting.

There are five structures through which light passes before it is converted into an impulse to be carried by the optic nerve. The five structures are: the cornea, the aqueous, the lens, the vitreous, and the retina. An opacity in any of these will cause a field defect by preventing, partially or completely, the entry of light into the eye. If a patient has an opacification of the lens called a cataract this may cause a field defect. Slide 1 shows a cataract that can be readily seen with only a flashlight. An ophthalmoscopic exam may also reveal a retinal cause of visual field defects, as for example a retinal detachment which is shown in Slide 2. Opacification of the cornea may be a rather obvious cause of a field defect.

Slide 3 shows a pseudomonus ulcer of the cornea. A patient's facial configuration, for example, a protuberant brow, a large nose, or drooping upper lid may give false field defects. A normal visual field defect is

the blind spot. The normal blind spot exists because there are no visual receptors in the optic nervehead. A scotoma is a localized defect in the visual field that is surrounded by areas of intact field. A relative scotoma is one that is present for only certain strengths of illumination. An absolute scotoma is insensitive to light no matter how strong that light is. With this in mind, what effect, if any, does the strength of illumination have on the measurement of visual field? This is Question 1.

The brighter the illumination the larger the visual field becomes, thus with very weak illumination field defects may not be evident because the field at that illumination is not large enough to include them. Large blind spots may be due to papillitis, glaucoma, chorioretinitis and retinal detachment to name some of the causes. If a patient has a lens that is completely opaque in one area, no vision is possible through that area of lens. If, however, the lens is not completely opacified but only cloudy what would you expect the effect to be on vision? This is Question 2.

There will not be a complete field defect but a relative defect. Vision is not totally lost in the area but is somewhat cloudy or blurred. Because some defects are relative but not complete the usual confrontation method of checking visual fields must be modified to pick up these relative defects. Most medical students and physicians are familiar with the method of confronting the patient and having him state at what point he sees the doctor's finger wiggle. However, try the following test on yourself. Hold up a translucent sheet of paper, a piece of cloudy glass, etc., to the light and then wiggle your own finger. Can you see it move? Of course you can. No one asked you if could see it clearly. If no one

asks that question many patients will not volunteer the information. The following method will help overcome the situation.

Slide 4. Confront the patient as usual. Cover one of the patient's eyes. Have the patient fix his gaze on your nose. Then hold up both hands at eye level with palms facing the patient. Have the patient tell you which palm is clearer. Repeat this with your hands in a higher and lower position than original. The X's on the slide depict the three hand positions that you should use. Then repeat this procedure with the other eye. This will allow you to pick up relative field defects. This is a simple screening method and takes only 5 to 10 seconds to perform but it will catch many patients missed by the standard wiggling finger method of confrontation visual field testing. Other causes of field defects require some understanding of neural pathways, which we shall now consider.

What a person sees with each eye separately constitutes the visual field for that eye. For the moment, we will consider the visual field of each eye to be an area that can be divided into a right and a left half as shown in slide 5.

Associated with the left side of the visual field of each eye are nerve fibers running to the right cerebral hemisphere. Similarly, to the right visual field in the left hemisphere. What cerebral hemisphere is operational when a person sees an object on the temporal side of the visual field in OS and on the nasal side of the field in OD? This is Question 3.

The right hemisphere. This question simply described the left half of the visual field for each eye. This is related to the right hemisphere. A retinal area is related to, but not equal to the visual field. The

right retina of each eye is associated with the right cerebral hemisphere and similarly for the left retina and left hemisphere. Since the right retinal area is associated with the right cerebral hemisphere, what visual field is it associated with? This is Question 4.

The left visual field. Thus the left visual field, right retina are both associated with the right hemisphere and the right visual field and left retina with the left hemisphere. Since the above is true, choose the diagram from Slide 6 or Slide 7 that best illustrates the correct relation between visual field, retinal area and cerebral cortex. This is Question 5.

Slide 6 is correct. Turn to Slide 6 if you are not already there. This shows the left visual field projecting an image on the right retina which in turn sends an impulse to the right cerebral hemisphere. Similarly on the other side. Simplistic though it is, this slide essentially diagrams the important neural pathways involved with visual fields. We will now present the same pathways as shown in Slide 6, but labeled this time.

Turn to Slide 8. You have probably heard of the term tunnel vision to designate lateral visual field defects in each eye. Where would a lesion have to be placed to cause this? This is Question 6.

Refer to Slide 8 now and whenever you would consider it helpful. The answer is optic chiasm. Notice the fibers crossing to the opposite hemispheres carry impulses from the temporal visual field of each eye. Tunnel vision is more correctly called bitemporal hemianopsia. Bitemporal and hemi referring to the temporal half of the visual field of each eye, hemianopsia meaning loss of vision. Bitemporal hemianopsia is a type of

heteronymous hemianopsia; heteronymous implying that one part of the visual field of one eye is gone and a different part of the field of the other eye is missing. In this case the left half of the field for the left eye and the right half of the field for the right eye are missing. What effect would a lesion have if it totally obstructs impulses traveling along the right optic tract? Specify the visual field defect. This is Question 7.

The left half of the visual field of each eye would be absent. Knowing what a heteronymous defect is, can you figure out what this condition is called? See Slide 8. It is called homonymous hemianopsia; homonymous referring to a defect that affects the same part of the visual field in each eye. In this case the left part. The results of sectioning the right optic tract might be depicted diagrammatically in the following manner on a patient's chart.

Slide 9. The lined area indicates the lost portion of the visual field. The clear area indicates where vision has been retained.

Go to Slide 10. If the patient had the following visual field loss, where would his lesion be? This is Question 9.

The lesion may partially affect either the left optic tract or optic nerve. Because the defect is not bilateral we cannot localize it closer. The condition shown above is a unilateral hemianopsia, that is, loss of half of the visual field in one eye. The could obviously apply to any defect of half of the field in one eye. Thus the term unilateral hemianopsia is not specific enough to allow you to localize a lesion. Draw the defect that results from sectioning the left optic nerve.

This is Question 10.

Slide 11 depicts this field. Not only does the left half of the visual field project on the right half of the retina but also the top half of the visual field projects on the bottom half of the retina. Therefore, the retinal image is upside down and backwards from the actual position of the object that a person is looking at. We may thus essentially divide the visual field and the retina into quadrants. Just as the right retina projects to the right hemisphere and the left to the left, so does the upper retinal area project to the upper occipital lobe and the lower to the lower occipital lobe. The structure dividing upper from lower occipital lobe is called the calcarine fissure, with the visual field defect as shown in Slide 12. This defect is a right inferior homonymous quadrantanopsia. Where is the lesion in the occipital lobe? This is Question 11.

The lesion is in the left occipital lobe above the calcarine fissure.

Case 1: A 23 year old female who has a history of nothing more than the usual childhood diseases comes to your office complaining of headaches and amenorrhea. She has no visual complaints. While giving a physical exam, you notice that her hands are very large and her facial features seen quite coarse. On confrontation fields the patient says that your right hand is more blurred in OS and your left hand in OD. Postulate one cause of these conditions. Diagram the field defect and then name it. This is Question 12.

Turn to Slide 13. A pituitary adenoma causing acromeglia is a likely cause of the temporal hemianopsia that is described in Case 1 and shown here.

Case 2: A patient comes into the emergency room after being involved in a fight with several other men. His face is quite bruised and he has a big lump on the back of his head but all things considered nothing serious seems to have occurred. So you clean him up and send him home. A few days later the patient returns. At this time he is almost comatose and has some left hemiparesis and a severe headache. Remembering the history of head trauma, you do an angiogram. This establishes the diagnosis for you because it shows a large mass distorting the pathway of the middle cerebral artery. Postulate a diagnosis and describe a field defect consistent with this patient. A subdural hematoma causing left homonymous hemianopsia due to interruption of the right optic tract is likely what exists in this patient.

Case 3: An elderly male with symptoms of basilar artery insufficiency such as drop attacks and diplopia complains of walking into objects on his right side. His blood pressure is 190/110 and he has no functional deficits on neurologic exam except for a right homonymous field defect. What might have caused this in such a patient? This is Question 13.

An occipital lobe infarction is quite possible in this hypertensive patient. This could destroy part of the visual cortex and could cause the homonymous defect described.

Case 4: You are reading a patient's chart. It says he has right hemiplegia caused by a stroke. The visual field defect is stated but the writing is illegible. The defect is either homonymous or heteronymous hemianopsia. Which to you seems more likely and why? This is Question 14.

Homonymous seems more likely. This stroke could have affected the left

optic radiations and/or the left parietal and temporal lobes more similarly on the right. Injury in these places can cause homonymous hemianopsia.

Case 5: Turn to Slide 14. Here is the field of a patient with an intracranial tumor. Postulate a specific type of tumor, its location and how it could cause this defect. This is Question 15.

The answer is a pituitary adenoma. This tumor doesn't interrupt all the chiasmatic fibers at once, thus causing an abrupt and complete bitemporal hemianopsia. It starts in the superior temporal quadrant in each eye and then progresses to involve the whole temporal half of the visual field. Finally, it causes a total visual field defect if let go long enough.

Case 6: Here is the visual field from another patient. Slide 15. This defect is also caused by an intracranial tumor. Locate this tumor. This is Question 16.

This tumor is in the right occipital cortex below the calcarine fissure. Alternatively, it may be in the right temporal lobe causing damage to part of the visual pathways passing through there.

This ends the section on visual fields. Now is a good time to take a break if you want one. When you come back turn the tape to the section on pupils and start with Slide 19.

PUPILS

The routine physical exam always includes a check on the patient's direct and consensual pupillary light reflexes and the pupils' response to accommodation. In a normal patient checking all three reflexes should take at most about 10 to 15 seconds.

The direct light reflex. Slide 19. In a dimly lit room have the patient fix his gaze on a distant object in the room, then shine your flashlight from the side, the light of your ophthalmoscope also works, into each eye separately. Avoid stimulating both eyes at once and then see if the pupils constrict. Note whether the pupil constricts quickly or sluggishly. You should not stand directly in front of the patient to avoid having the patient focus on you and thus stimulate the near reflex.

The consensual light reflex. Slide 20. The procedure is the same as for the direct except this time when you shine a light into one eye watch whether the pupil in the other eye constricts. Again note whether the reaction is quick or sluggish. If you shine a light in a normal OD the pupils of both eyes will constrict. If you then immediately switch your light beam to the left pupil that pupil will stay constricted if OS is normal. If you do the same procedure on another patient but this time OD is normal and OS is blind, would you expect the same results? This is Question 1.

The answer is no. OD will react directly and cause the blind OS to react consensually. However, OS can react neither directly nor cause OD to react consensually. Thus we see that the pupillary constrictor

mechanisms are intact in a blind eye but that it is unable to get information in to set off these reflexes. With this in mind does the inability of OS to cause either direct or consensual light reflexes indicate a defect in its afferent or efferent pupillary reflex path? This is Question 2.

The defect is in the afferent path. As we said, the pupillary constrictor mechanism, the efferent path, is intact, but since OS is blind the information is unable to traverse the afferent path to activate pupillary constriction. Thus a light shined in OS is unable to cause or maintain pupillary constriction in either eye. If in this same patient a light is shined in OD it constricts directly and OS constricts consensually. If the light is then quickly shifted to shine in OS what will happen to OS if it is blind? This is Question 3.

The constriction in OS will not be maintained so that the pupil there will dilate.

Slide 21. This is called the swinging flashlight or Marcus-Gunn, if you like eponyms, reflex. This reflex can also occur in an eye with retinal or optic nerve damage which is not entirely blind.

The pupillary near reaction and the response to accommodation. Slide 22. For the first two reflexes the patient has fixed his gaze on a distant object. To test the near reflex, start with the patient focusing on a distant object and then have him quickly shift his gaze to a near object. For example, his thumb held about one foot from his eyes. The pupil should constrict as he focuses on the near object. Some ophthalmologists like to use a flashlight to diffusely eliminate the pupil when they test this reflex. This does constrict the pupil somewhat but it also

makes the whole process easier to see. Try it yourself and see if you like it. It is most helpful in brown-eyed people where the black pupil and a dark brown iris are a little harder to distinguish.

Suppose that a student is reading in the library and he rests for a minute and just looks around the room to see what is going on. Then he quickly begins reading again. As he starts reading, do his pupils become dilated or constricted? This is Question 4.

They become constricted. The situation described is one that will elicit the near reflex. Argyll Robertson pupils are suggestive of central nervous system syphilis. These pupils bilaterally do not react to light. Therefore they have no direct or consensual reflex. There is also an irregular pupil but they do constrict on the near reflex. AR pupils are traditionally miotic already, but not always so.

In Slide 23 we see a case of Argyll Robertson pupils. Notice that they are unaffected by dark or light as shown by the black and white boxes respectively on the slide. The third picture shows convergence and subsequent pupillary constriction by the patient. If a patient lacks a consensual reflex but has a direct reflex, what will happen to both eyes when a light is shined in OD? This is Question 5.

OD will constrict and OS will not react. Knowing this may we make any statement as to the presence or absence of the near reflex? This is Question 6.

No. The direct and consensual reflexes and the near reflex proceed by partially different paths as we will see later. Deficiency of one doesn't necessarily imply deficiency of the other.

A 23 year old man with a positive VDRL and FTA test for syphilis is your patient. Confidently you examine his eyes expecting to see Argyll Robertson pupils, but you don't. His entire ocular exam is normal. How do you account for this? This is Question 7.

AR pupils are associated with advanced neuro syphilis, tabes dorsalis or general paresis, but not with cases of recent origin. If this patient was left untreated positive AR pupils would be more likely though not necessarily present when a man was in his 50's or 60's.

There are four categories of causes for unequal pupil size in a patient's eyes. They are: drugs, neurologic disease, ocular disease and congenital. Drugs. There are many drugs which affect pupil size. Your best guide to the specific drug in each case will be the history of what the patient has been in contact with. Determination of whether the pupillary abnormality is unilateral or bilateral may help in some cases to distinguish a local from a systemic drug. Systemic drugs will not usually be unilateral, however, a local agent may be present in both eyes, thereby rendering a distinction from a systemic drug more difficult.

There are essentially three types of drugs that may affect the pupil. Cycloplegics, mydriatics and miotics. A miotic is a drug that constricts the pupil. The drug most frequently used therapeutically to accomplish this is pilocarpine. These drops are instilled directly into the eye. Pilocarpine is a cholinergic drug. It constricts the pupil. Remember, cholinergic constricts, CC. Therefore, one might expect that an anti-cholinergic drug would dilate the pupil. This is, in fact, the case. Dilation of the pupil is called mydriasis and this can be accomplished

with atropine, scopolamine or mydriacyl. These are listed in descending order from long to short duration of action. A cycloplegic drug causes mydriasis and also paralysis of the ciliary body, which blocks the ability to accommodate. The ciliary muscle or ciliary body, they are the same, normally allows accommodation by contracting, thus relaxing the pull of the zonules on the lens. The less the zonules pull on the lens the thicker the lens becomes. This is allowed by the elasticity of the lens and the eye is thus able to focus on a nearer object. A cycloplegic drug prevents constriction of the ciliary muscle, thus effectively blocking the whole process of accommodation. Atropine is a very effective cycloplegic drug.

Slide 24 is a table of some of the drugs that we have been considering. You see a patient with a dilated pupil who is unable to read a newspaper therefore he can't accommodate. Which of the following drugs will not cause such a situation in an otherwise healthy person: a) atropine or scopolamine; b) pilocarpine; c) Neo-synephrine; d) Carbachol? This is Question 8.

The answer is pilocarpine. It constricts the pupil while all the rest dilate it.

If a 19 year old woman visits your office and you notice that her pupils are constricted down to pinpoints, which would you think of first? An anticholinergic drug like atropine or scopolamine, or a morphine derivative? This is Question 9.

A morphine derivative is more likely. Atropine causes mydriasis, not miosis. Anisocoria is a word meaning unequal size of pupils.

Slide 25 shows an example of anisocoria with the left pupil being considerably larger than the pupil in OD. Besides drugs, neurologic conditions like subdural hematoma, aneurysm or tumor may also cause anisocoria. Ocular conditions may cause unequal pupil size. Acute glaucoma causes a mid-dilated pupil, old or recent trauma including eye surgery, or neoplasms of the iris also cause anisocoria. If you have a patient with anisocoria but no evidence of drugs, neurologic or ocular disease can be found, and if this otherwise healthy patient has had anisocoria since birth, what etiology might you suspect? This is Question 10.

The answer is congenital. Congenital differences in pupillary size are not rare with up to 25% of the population having differences of up to 1 mm between each eye. Other causes of anisocoria must be ruled out first, though. If this is done and the pupillary inequality has been present since birth, a diagnosis of congenital anisocoria may be made. We will now consider the afferent and efferent pathways involved in pupillary reactions.

Turn to Slide 26. You are not expected to memorize or to be able to reproduce the diagram on this slide. It is presented only to help you visualize some of the relationships we will be talking about. As such, refer to it whenever you wish.

The pupil constricts when light is shined in it. Thus, these impulses initially follow the same pathway that all visual impulses follow. Therefore, choose the answer which represents the afferent pathway of the pupillary light reflex: a) the optic nerve and retina, or b) the oculomotor nerve. This is Question 11.

The answer is A and this is, of course, logical. The incoming light impulses must pass via the retina and optic nerve so that the information may be processed and the appropriate reactions begun. To consider the afferent pathway for the near reflex the task is simple. The exact pathway is not known and we will not consider the subject any further. The efferent pathway for both the near and the light reflexes is the same. Branches of the third cranial nerve pass by the ciliary ganglion to innervate the sphincter muscle of the iris. You are examining a patient after an auto accident. You notice ptosis and restricted medial movement of OS implying oculomotor damage, although the patient is able to abduct OS. With this information in mind, what statement would you expect to be able to make about the reactivity of both of the patient's pupils? This is Question 12.

The oculomotor nerve has been damaged on the left side. You could expect to see OD dilated due to the damaged innervation to the pupillary constrictor muscle. OS would not constrict to light either directly or consensually and would exhibit no near reflex. Since the afferent pathway the optic nerve of OS is intact, a light shined in CS would constrict OD consensually. If OD were not further damaged itself, it should have normal light and near reflexes. Choose the major nerves involved in the afferent and efferent pathways for the near reflex: a) the afferent pathway is unknown and the efferent pathway is the oculomotor nerve, or b) the optic and oculomotor nerves for afferent and efferent pathways respectively. This is Question 13.

The answer is A. As we have said the afferent pathway for the near

reflex is not definately established. To understand the consensual light reflex we need to know one more thing. At the level of the Edinger-Westphal nucleus (EW nucleus on the slide) some of the fibers from the optic nerve cross over the midline, they decasate to enter the Edinger-Westphal nucleus of the opposite side. They then proceed down the efferent limb of the light reflex on that side. Thus, a light shined in the left eye stimulates nuclei on both sides causing a direct light reflex on the ipsilateral side and a consensual light reflex on the contralateral side. Choose the foil indicating the pathways of the consensual light reflex: a) the optic nerve and the oculomotor nerve or b) the optic nerve then a decasation and the oculomotor nerve. This is Question 14.

The answer is B. The optic nerve then a decsation and finally the oculomotor nerve. Knowledge of the following entities is not considered an objective of this unit, however it is desirable that you be exposed to them. Hippus constitutes a condition in which there is physiologic pupillary unreast. This condition is not pathologic. The size of the pupil rapidly fluctuates about 1 mm in these patients. The tonic pupil or Adie's syndrome is an acquired condition which commonly affects young adult women and which is usually associated with diminished deep tendon reflexes. The shape of the pupil is often irregular and the affected pupil is usually larger than the unaffected pupil. The condition is usually unilateral. The direct consensual and near reflexes are all diminished in the Adie pupil and the pupils react sluggishly. This condition however, is benign and requires no treatment. If a young woman enters your office with equal size pupils which you notice vary in size as you watch them, what treatment would you institute? The woman's

pupillary reflexes are normal. This is Question 15.

The answer is of course no treatment. This is Hippus and it is a physiologic condition. If a young woman with diminished DTR's, miosis, and a drooping eyelid enters your office, would you diagnose Adie's syndrome, prescribe no treatment for it and send her on her way? This is Question 16.

No, this patient has some signs of Horner's syndrome, but the reduced deep tendon reflexes are not part of Horner's syndrome. It is likely that they are caused by two separate processes. Horner's syndrome involves slight ptosis, miosis and anhydrosis, that is, a lack of sweating. It is caused by a lesion in the complex sympathetic pathway due to trauma, mediastinal tumors, central nervous system lesions, or other causes. A fixed dilated pupil is encountered in CNS neoplasms, aneurysms, subdural and epidural hemorrhage and some infections. These conditions via increased intracranial pressure, stretching or other mechanisms damage the oculomotor nerve resulting in paralysis of the sphincter muscle of the pupil.

You are given a history and a physical in a patient the day after he was involved in an auto accident. At first glance he does not seem severely injured, but he complains of diplopia. He tells you that 20 years ago he had syphilis and he is not sure if he was ever treated for it. You also note that his left pupil is dilated and does not react to light. His right pupil is normal. What is your diagnosis? This is Question 18.

From what has been given you can't judge whether his syphilis was adequately treated or not. There are no Argyll Robertson pupils described.

What is probably significant is the association of recent trauma with the fixed, dilated pupil. The possibility of third nerve damage due to pressure from subdural or epidural hemorrhages should definitely be investigated.

A nurse comes into your office complaining of difficulty in reading the names from the bottles of medication she is using. There is no history of any disease, trauma or use of cycloplegic drugs. Upon further questioning you find that her trouble started suddenly at about the same time she was working with a solution of atropine. She denies that she got any of it in her eye but admits that perhaps she spilled a little bit on her fingers. One pupil has negative light and near reflexes and is dilated and the other is normal. What is your diagnosis? This is Question 19.

The nurse probably spilled some atropine on her fingers and then inadvertently rubbed her eye thereby instilling into her eyes a drug which causes cycloplegia for about two weeks. Similar incidents by other medical personnel are not uncommon.

Diabetes is a condition which often damages the oculomotor nerve. As such, would you expect a pupil to be dilated or constricted? This is Question 20.

You would expect a dilated pupil but often this is not actually the case. With diabetes we see a phenomenon known as pupil sparing. Ocular movements requiring an intact oculomotor nerve are blocked but the pupil is not fixed and dilated.

Slide 27 shows this condition in the right eye. An aneurysm of the internal carotid artery often damages the oculomotor nerve which lies adjacent to it. Pupillary sparing does not occur in this case. Would you

expect the pupil to be dilated or constricted on the affected side of such a patient? This is Question 21.

In this case, the pupil is not spared and therefore it is dilated since the innervation to its sphincter muscle is damaged.

Slide 28 shows this in the left eye.

This completes this section of the Neuro-ophthalmology Unit. This is another good time for you to take a break if you desire one. When you return start on the section on Motility.

MOTILITY

Begin by looking at Slide 32 which shows the six cardinal positions of gaze. Don't memorize this slide but refer to it as you need it.

On Slide 32 the letters indicate the extraocular muscle primarily involved in turning the eye to the indicated position of gaze. SR is the superior rectus; LR is the lateral rectus; IR, inferior rectus; SO, superior oblique; MR, medial rectus; and IO, inferior oblique. Now we will determine what must be checked on the motility exam. You have already seen what one component is. What is it? This is Question 1.

The answer is, are the patient's eyes able to move in the six cardinal positions of gaze? We might add that a normal patient's eyes are able to move to extremes of gaze in each position. In actual fact, neuro-ophthalmologists consider an adequate screening exam to consist of carrying the eyes to the extremes of gaze, to the left, right, up and down. Slide 33 shows this.

When you examine a patient, if one eye moves up while the other eye moves down, would you consider this normal? No, of course not. The eyes should move together. This is called conjugate movement when one eye looks up the other eye should look up too. When one eye looks towards the left, so should the other and so on for the other positions. If both eyes move temporally this is not conjugate movement since the temporal direction is different for each eye. Two abnormalities of lid movement should be noted. Ptosis means the eyelid hangs lower than it should, so that the eye looks partially shut.

Slide 34 shows a child with ptosis. Which eye is affected? This is

Question 2. The left eye shows ptosis. With lid lag the upper lid stays above its normal position as a person looks downward, thus several mm of sclera are exposed between the upper limbus and the upper lid, whereas ordinarily none is exposed. Exophthalmos seen in thyrotoxicosis is often associated with lid lag.

Slide 35 shows an example of exophthalmos of endocrine origin. Notice how in this slide no sclera is evident at the lower margin of the upper lid but noticeably more iris is visible in OS than in OD.

Thus we have considered several points in the motility exam. From the functional deficit one is able to deduce the muscle or muscles affected by a particular pathologic process and from the muscles one can determine the involved nerves. If a patient is unable to move his eyes in any direction besides temporally and if his pupil is dilated and his eyelid droops, how much of this will be picked up by the motility examination outlined above? This is Question 3.

The lack of eye movement in all directions but temporally in the ptosis will be noticed. The motility exam per se is not designed to check pupillary abnormality, although in practice one would probably notice an abnormal pupil on a patient anyway. As you might suspect, we are somewhat artificially separating the neuro-ophthalmologic exam into its component parts for purposes of instruction. When you become proficient in the exam, several parts may be done all at once. For our purposes we will consider four causes of non-conjugate eye movement. Three causes you can probably already guess. They are nerve defects, muscle defects, and mechanical abnormalities involving bones, ligaments or facial attachments. The fourth cause is strabismus, which is covered in another self-

instructional unit.

For now we will consider primarily defects in the extraocular muscles and the nerves that supply them. Although we don't wish to have students memorize a lot of facts, it is desirable to have some idea of which cranial nerve innervates which extraocular muscle. The following may help, perhaps. LR-6; SO-4 and all the rest are 3. Translated into English this means that the lateral rectus muscle is innervated by the sixth cranial nerve, the abducens. The superior oblique muscle by the fourth, the trochlear cranial nerve, and all of the other extraocular muscles which include the inferior oblique, the medial, superior and inferior rectus muscles, and the levator palpebrae superiorus by the third cranial or oculo-motor nerve. Interruption of impulses along which cranial nerve will most extensively restrict the movement of the eye? This is Question 4. The answer is oculo-motor. It innervates all of the muscles but the superior oblique and the lateral rectus.

As shown in Slide 36 with only these two muscles remaining, the eye is pulled laterally by the intact lateral rectus and down by the superior oblique. The eye position is thus down and out. The pupil is dilated and there is ptosis that the oculo-motor nerve is completely interrupted. Suppose that both the oculo-motor and trachlear nerves are damaged. What would be the only motion remaining intact? This is Question 5.

Only the abducens nerve remains. It innervates the lateral rectus which, as its name implies, moves the eye laterally. In the normal eye, antagonistic muscles work in pairs, each muscle pulling the opposite direction. In what direction would you expect the antagonist of the lateral rectus to

pull, and what would you expect the name of that muscle to be? This is Question 6. The antagonist of the lateral rectus would pull medially and its name would be the medial rectus. Thus, the medial and lateral recti both act in the directions implied by their names. Unfortunately, the situation becomes more complicated at this point. The superior and inferior recti must be abducted, that is, turned laterally before they act in a direction implied by their names. If the left eye is turned toward the left, what muscle raises it and what muscle lowers it? This is Question 7.

With the left eye abducted, the superior and inferior recti act as their names imply, raising and lowering the eye respectively. If the superior and inferior recti function with the eye abducted, and if the medial and lateral recti move medially and laterally, what muscles have we not accounted for and in what position of the eye do you think they would primarily function? This is Question 8.

The superior and inferior obliques are not accounted for yet. They function with the eye adducted. However, in this case, the muscles function in the direction opposite to that implied by their names. If this is so, what direction do the superior and inferior obliques move the eyes? This is Question 9. When the eye is turned in, that is, adducted, the superior oblique depresses the eye and the inferior oblique raises it.

The Table on Slide 37 is a resume of what we have covered. Refer to it as you like, but don't memorize it. On Slide 38 we see a woman who evidences a normal oculomotor and trochlear nerve but has unilateral abducens palsy. On which side is the abducens nerve damaged? This is Question 10. On the right side. The picture directly in the middle of the slide shows the

patient trying to look toward her right. Her left medial rectus is functioning properly, but notice that the right eye is not turned laterally as far as we would normally expect. Lateral rectus palsy which is the most common palsy affecting an extraocular muscle is evidenced by the inability of the eye on the involved side to abduct. Strokes, tumors and trauma are frequent causes of this condition. It is common due to the long intracranial course of the abducens nerve which makes the nerve very susceptible to a variety of intracranial problems. If unilaterally, a patient's eye is abducted and slightly depressed, in which nerve or nerves do you suspect a lesion would be found? This is Question 11. This is caused by an oculomotor nerve paralysis. The eye is turned out by the unopposed action of the lateral rectus and it is depressed by the superior oblique. With oculomotor paralysis is there ptosis or retraction of the eyelid? There is ptosis. C3 innervates the muscle which elevates the lid, the levator palpebrae superiorus. With paralysis of this, the lid will droop.

Slide 39 shows a man with C3 palsy who demonstrates pupil sparing. The extraocular movements governed by the oculomotor nerve are deficient but the pupils are not dilated on the left side. This patient has diabetes. Pupil sparing is common in oculomotor palsy due to diabetes. The least common extraocular muscle paralysis involves the trochlear nerve. Judging from the action of the muscle innervated by the trochlear nerve, would there by more difficulty in raising or lowering the eye? This is Question 13. Since the superior oblique is affected, there would be difficulty in lowering the eye. There would probably not be very complete inability to depress the eye, however, due to the intact inferior rectus. Complete external ophthalmoplegia represents a rare condition in which all of the extraocular muscles are paralyzed. Therefore the eye does not move and there is ptosis.

Here is a patient on Slide 40 with an intraorbital neuroblastoma. Does he have ophthalmoplegia? If so in which eye? This is Question 14. Yes, the patient does. He cannot move his left eye. Notice that OS is in roughly the same position no matter where gaze in OD is directed. Ptosis is evident in only two of the pictures on this slide because the lids have been retracted for the others. The tumor prevents motion of the eye by being a space occupying lesion of the orbit and perhaps also by nerve damage.

Slide 41. A patient comes into your office complaining of a droopy left eyelid, dysphagia, difficulty speaking and general malaise that is better in the morning than at night. After trying various tests with no positive results you administer 1 mg of Tensilon IV slowly. For several minutes all of these symptoms clear. The bottom row of pictures in this slide show some of this. What is the patient's problem? This is Question 15. This patient has myasthenia gravis. Tensilon is an anticholinesterase drug. Ptosis is often a very early symptom of myasthenia. If the disease does not progress beyond ptosis for several years there is a good chance that it will remain purely ocular. This doesn't occur frequently however.

A 46 year old man with diffuse signs of elevated intracranial pressure such as papilledema and headaches but with an otherwise unremarkable history is referred to you from a local family practitioner. The man is complaining of diplopia. After examining him you determine that he has diplopia only when looking toward the right. Postulate a cause of this man's diplopia. This is Question 16. An abducens nerve injury due to a tumor on the right side is possible. This would block the ability of the right eye to move toward the right.

Presumably the left medial rectus is intact so that in right gaze there is not conjugate movement and thus the visual axes are not aligned as shown

in Slide 42. In this case, the left eye is able to fix on the target but the right eye cannot turn laterally enough to fix on it. This causes diplopia. In all other positions of gaze, the muscles are intact so that no double vision results. Along the same line of thinking suppose a traumatic injury destroys the ability of the right superior oblique to move the eye. In what one position of gaze would the patient experience diplopia? This is Question 17. Gaze downward and to the left would cause diplopia because this gaze is in the direction of action of the affected muscle. Here, however, diplopia may be less severe since the superior oblique is not the only depressor of the eye. The inferior rectus will still be functioning as a depressor. The same situation doesn't hold for lateral rectus lesions since it is the only abductor of the eye. A patient with severe head trauma has bilaterally damaged his oculomotor nerves. His condition is a type of paralytic strabismus, that is, failure of alignment of the visual axes. What direction would his eyes be pointing and anatomically explain why this is so. This is Question 18. Both eyes would be pointing laterally. This type of divergent strabismus is called exotropia. See the unit on Strabismus. It is caused in this case by the unopposed action of the lateral rectus muscles since the abducens nerve is still intact. The intact trochlear nerve and superior oblique muscle would slightly depress the eye but the predominant effect is abduction.

This concludes the unit on Motility. This would be another good time for a break.

THE FUNDUS

Look at the first slide, Slide 45 and state whether you think it is normal or abnormal. This is Question 1. It is normal. As you recall from the ophthalmoscopy unit, a normal disc has sharp, regular borders, a pink-orange color and a cup/disc ratio of less than .5. Note all of this on the first slide.

Slide 46 charts for you the pathologic conditions we will consider in this unit. Refer to it whenever you like to organize your thoughts on the subject.

Now look at Chart 47 and describe the abnormality present. This is Question 2. For a correct answer you should have noted the blurring of the disc margins and the physiologic cup, the edema and swollen appearance of the nerve head and the adjacent retina and the flame-shaped papillary and peri-papillary hemorrhages. The papilla is another term for the optic nervehead. This condition is papilledema or choked disc. It is a non-inflammatory congestion of the optic disc which is usually associated with increased intracranial pressure which we will abbreviate as ICP. Papilledema frequently occurs in conditions causing persistent increased intracranial pressure, such as cerebral tumors, abscesses, subdural hematoma, and certain phases of malignant hypertension. Obstruction to venous outflow by pressure on the central retinal vein as it leaves the optic nerve to pass through the subdural and subarachnoid spaces around the optic nerve is also an important factor in the pathophysiology of papilledema. Therefore, local orbital factors may occasionally produce unilateral papilledema in the absence of elevated ICP. Nerve fiber layer hemorrhages are frequently associated with papilledema of relatively sudden onset.

Turn to Slide 48 and describe what you see. What is your diagnosis? This is Question 3. This is early papilledema and might easily be overlooked. Early ophthalmoscopic findings include distention of retinal veins, hyperemia of the disc and blurring of disc margins. Note these on the slide. One helpful sign in the diagnosis of early papilledema is the absence of pulsation of the central retinal vein. Obviously this is absent on any slide, at the disc and a failure to produce venous pulsation while applying light digital pressure to the lateral aspect of the globe. Visual acuity and fields are usually normal in papilledema, however, the normal physiologic blind spot may be slightly enlarged. Headaches, nausea and diplopia due to sixth nerve palsy may accompany papilledema and are due to the elevated ICP. Papilledema may persist for long periods without a permanent effect on vision or secondary optic atrophy may occur as a complication. A neglected case of papilledema will frequently end up blind secondary to optic atrophy. Papilledema improves within several weeks following reduction of intracranial pressure. Peripapillary edema, exudates and hemorrhages also clear within a few weeks. What characteristics of the normal optic disc are lost when a patient develops papilledema; which remain? Give reasons for your answers. This is Question 4.

In papilledema the edema fluid resulting from the elevated ICP or central retinal vein occlusion causes blurred disc margins and a loss of the physiologic cup. The fluid, however, has little effect on the color of the disc unless optic atrophy develops as a complication of a papilledema or in the general shape of the disc.

A patient is referred to your office. In her chart you see that an aortagram was done about eight months ago and it showed a stenotic left

renal artery. The patient's blood pressure is 320/145 mm of mercury. What would you expect to see in her fundus? This is Question 5. You should expect papilledema with some exudates and hemorrhages. This picture should improve upon correction of the renal artery lesion.

Turn to Slide 49. This slide shows papillitis which at times cannot be differentiated from papilledema by funduscopic findings alone. Papillitis is a term which denotes inflammation, degeneration or demyelinization of the optic nerve associated with the funduscopic picture such as that seen in Slide 49. Papillitis may be due to: 1) demyelinization if the plaque is very near the globe; 2) infarction of the nervehead called ischemic optic neuropathy; and 3) inflammatory neuro-retinitis. Striking visual loss is the hallmark of papillitis and easily allows its differentiation from papilledema, which is not usually accompanied by visual loss. The visual loss in papillitis is usually severe but temporary. There may be eye pain upon movement of the globe. Central scotomas or blind spots are the most common field defects. These may vary greatly in size and density. The affected pupil reacts sluggishly to light. As in papilledema early on the fundus shows distention of the veins, hyperemia of the disc, blurred disc margins and loss of the physiologic cup. Elevations of the disc greater than 3 diopters, that is, the difference in the lens power required to focus on the top versus the bottom of the disc, are uncommon, whereas elevations of six to ten diopters may be seen in late papilledema. Hemorrhages may occur in the nerve fiber layer and surrounding retinal edema is frequently seen.

Listed on Slide 50 are ways in which papilledema can be differentiated from papillitis. Suppose a patient has a funduscopic picture that is consistent with either papilledema or papillitis. You test her visual

acuity and find that it is 20/20, that is, normal in both eyes. She complains of no eye pain but does have headaches. Would you consider this to be papillitis or papilledema? This is Question 6.

Normal visual acuity points to papilledema. The headaches may be due to elevated intracranial pressure which often occurs with papilledema. If you find that the patient described in the previous question has a mother who has multiple sclerosis does this make you more sure or less sure of your original diagnosis? This is Question 7.

It should make you less sure. Papillitis can be due to demyelinating disease into which category MS obviously falls. If a patient who is totally unable to move or else has pain in his eye, does this make you think that the patient has papillitis? This is Question 8.

Not really. Papillitis may be associated with pain which occurs when the eye is moved. In this patient, however, I would look for a cause of paralysis of the left extraocular muscles instead of considering papillitis. Retrobulbar neuritis is a process occurring in the optic nerve that is similar to papillitis except that it occurs posterior to the optic nervehead, thus there are no ophthalmoscopic changes. The patient sees nothing and the doctor sees nothing ophthalmoscopically. However, the light reflex is sluggish in the affected eye, thus giving a positive swinging flashlight reflex. See the section on pupils in this unit for the swinging flashlight reflex.

The patient complains of marked loss of visual acuity and frequently retro-orbital pain with movement of his eye. How would you distinguish between papillitis and retrobulbar Neuritis? This is Question 9.

Use of the ophthalmoscope should allow distinction of retrobulbar neuritis which shows few abnormal findings from papillitis, which shows an edematous blurred disc and loss of the physiologic cup, however, the two entities are very similar, both being grouped under the heading of optic neuritis.

The visual loss in papillitis and retrobulbar neuritis occurs within a few hours of onset and is maximal in a few days. Visual acuity usually begins to improve if it is going to after two to three weeks. Retrobulbar neuritis is nearly pathognomonic for demyelinating process. If the central retinal artery were obstructed, would you expect papillitis or papilledema to result? This is Question 10.

Papillitis due to infarction of the disc would be most likely, occlusion of the central ratinal vein and not artery would more likely cause papilledema. Papillitis associated with inflammatory disease of unknown etiology usually does not recur. Retrobulbar neuritis and papillitis associated with demyelinating disease have good prognosis for an individual attack but recurrences are common and some degree of permanent visual loss is the rule. Treatment is smyptomatic. Systemic cortical steroids may be helpful in persistent disease but should be administered with monitoring by an ophthalmologist. About 50% of the patients between the ages of 20 to 45 who have an attack of retrobulbar neuritis will ultimately develop multiple sclerosis. The figures are slightly less for papillitis but still quite significant. Thus any patient with either papillitis or retrobulbar neuritis needs to be carefully evaluated and followed for MS.

Look at Slide 51 and describe what you see. This is Question 11. Slide 51 shows optic atrophy, a condition where the nervehead loses its normal pink color and turns grey-white, chalk-white or yellow. The disc may have sharp margins as seen in this slide or indistinct margins. Clinically, loss of vision is the only symptom. Visual loss may be in terms of diminished acuity, field defects or loss of color or form perception, depending upon which fibers of the optic nerve are involved. Diminished pupillary reaction is seen in the affected eye. The loss of pupillary reaction in vision is usually proportionate to the disc pallor. The visual loss and disc pallor are secondary to nerve fiber replacement like glial tissue. The visual loss with optic atrophy is irreversible and treatment can only be directed toward the causative factors which are listed on Slide 52.

What are the major symptoms and ophthalmoscopic findings in a patient with optic atrophy? This is Question 12. Visual loss and a pale disc are the major symptoms. The following section will be devoted to anomalies of the optic disc which may be confused with papilledema. The first of these conditions is shown in Slide 53.

Describe the disc and the general fundus on this slide. This is Question 13. This slide shows myelinated nerve fibers of the retina adjacent to the nervehead. These are variations of normal and indicate extension of the myelination process of the optic nerve. Myelinated nerve fibers are also frequently confused with cotton wool areas or exudates adjacent to the nervehead.

Now look at Slide 54 and describe it. This is Question 14. This slide shows drusen of the optic disc, an entity which is different in

pathophysiology from drusen seen elsewhere. Unlike drusens seen elsewhere in the retina, this may be of pathologic significance. When drusen are superficial as in this instance, their glistening irregular appearance is so characteristic that they are easily recognized. However, when they are buried beneath the disc as shown in Slide 55, the differentiation from papilledema is subtle. The following features may be helpful in differentiating buried drusen from papilledema. You may see hyaloid bodies in the disc with drusen. Drusen usually occurs in children and may become more superficial with age. There is a lack of retinal edema and hyperemia of the disc with buried drusen and such a patient may also have hemorrhage. There are several other rare conditions which cause a congenital elevation of the optic disc. These conditions are collectively known as pseudopapilledema and at times are difficult to differentiate from true papilledema.

Slide 56 shows a disc with pseudopapilledema. Whenever a physician is unsure of a differential diagnosis involving papilledema, the patient should be referred to an ophthalmologist for further evaluation. Now let us review this section by studying some cases.

Turn to Slide 57. This 35 year old housewife presents to you complaining of rapidly progressive visual loss OD for the past several days. Her intraocular pressure is normal, her pupils react but they are sluggish. What is your diagnosis of her ocular condition and what systemic disease must also be checked out? This is Question 15. This is papillitis. It is caused by thyroid disease in this case, but a physician should consider the possibility of MS in a patient with similar findings which couldn't be attributed to thyroid disease.

Slide 58. This funduscopic picture was seen in an otherwise healthy 4 year old boy who was being evaluated for a scratched cornea. There were no visual complaints. What is your diagnosis and what would you tell his parents? This is Question 16. This is buried drusen. Inform the parents that the child has an anomaly which should be seen by an ophthalmologist to confirm the diagnosis. Confirmation of the diagnosis is important because drusen of the disc is associated with conditions causing retinal degeneration, optic atrophy, tuberosclerosis, a syndrome of mental deficiency and epilepsy, and von Recklinghausen's neurofibromatosis. Thus, finding drusen of the disc in a patient requires follow-up to check for possible associated conditions.

Slide 59. This 68 year old gentleman presents in your office complaining of progressive visual loss for the past 6 months. He had a cataract removed OD four years ago and had good vision following the surgery. He has been blind OS for many years. The patient now feels that his cataract has grown back. This is the funduscopic picture. What is your diagnosis and what is the prognosis of his visual loss? This is Question 17. This is optic atrophy and the visual loss is permanent.

Slide 60. This 55 year old executive comes into your office for his yearly physical exam. He has no ocular complaints. Here is his funduscopic picture. What is your diagnosis? What disease process must you consider? This is Question 18. The condition is papilledema. You should consider cerebral tumor, cerebral abscess, malignant hypertension, bilateral orbital factors or subdural hematoma as possible causes of papilledema.

Slide 61. This blond 45 year old man complains of rapidly progressive visual loss OD. He has been very irritable and has experienced numbness and tingling of his left fingers for six months. What is your diagnosis

and what underlying disease should be considered? This is Question 19. The diagnosis is papillitis and consider MS.

Slide 62. This 25 year old female school teacher comes to you complaining of afternoon headaches. What is the condition depicted on this slide? Is it related to her problem? What are other conditions with which this may be confused? This is Question 20. The condition is myelinated nerve fibers. It is not related to her problem but may be confused with papilledema, cotton wool areas and exudates.

Name two entities, one visible by ophthalmoscopy, one not that are intimately associated with optic neuritis. This is Question 21. Retrobulbar neuritis and papillitis are both sub-categories of optic neuritis. Papillitis is evident ophthalmoscopically, retrobulbar neuritis involves the same process occurring farther along the optic nerve and thus is not visible with the ophthalmoscope.

Change the slide from among Nos. 63, 64 or 65 which gives the best example of papilledema. This is Question 22. Slide 19 gives the best example of papilledema.

Slide 66 and 67 represent two conditions. One is the slide of a normal the other is the slide of retrobulbar neuritis in a patient with MS. Which is which? This is Question 23. Slide 66 is the normal; slide 67 represents retrobulbar neuritis. As you can see, this slide does show some funduscopic findings, therefore the process of demyelinization isn't entirely posterior to the globe. We might more accurately classify this slide as retrobulbar reuritis - papillitis. Both are consistent with the diagnosis of MS.

Slides 68 and 69 exemplify distinction that is often difficult to make; that is the distinction of papilledema from pseudopapilledema. Make that

distinction for both slides. This is Question 24. Both slides represent pseudopapilledema. This was a difficult question.

What condition is shown on Slide 70? What would you do to treat a patient who had this problem? This is Question 25. The slide is one of optic atrophy. In this case it is congenital. There is really no treatment for ocular disease that has progressed to the point of optic atrophy.

For Slides 71 and 72 identify the pathology evident in each slide. Assuming that these are slides of the same patient state which one was taken first. This is Question 26. Slide 71 is papilledema. It would occur before optic atrophy, which is depicted in Slide 72. Thus we can see that optic atrophy is a complication of papilledema.

This completes the Neuro-ophthalmology unit. While the material is still fresh in your mind, please fill out the questionnaire that accompanies the unit. This will help us to improve the unit on later editions.

APPENDIX C

"A PROTOTYPE FOR CURRICULUM DEVELOPMENT IN MEDICAL EDUCATION"

A Prototype for Curriculum Development in Medical Education

Running Head: A Prototype for Curriculum Development

by

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ABSTRACT

Curriculum development in health sciences education must become more systematic if competent professionals are to be prepared more effectively and efficiently. As a prototype, a systems approach has been used to develop a comprehensive curriculum in ophthalmology for medical students.

Instruction has been developed to meet behavioral objectives previously determined using input from 1600 physicians and students. Evaluation of the effectiveness of the instruction is related directly to the pre-specified goals.

The curriculum is oriented around clinical recognition skills and management of patient problems. It de-emphasizes recall of information that can be looked up when needed. On a test simulating the patient examination, two-thirds of sophomore students after completing a self-instructional unit in ophthalmoscopy outperformed the best senior student who had the usual formal and informal instruction in ophthalmoscopy, plus two additional years experience with patients. Development of the five-hour unit required $8250 and 450 professional man-hours.

Introduction

Much discussion and recent congressional legislation support the development of new curricula, innovative educational techniques, and novel mechanisms of health science education. It is essential that these changes be sound and substantive: educational development must become more systematic to enhance the quality and quantity of our health care delivery.

Yet in the health sciences, educational innovation too often involves only superficial change.[1] Basic "intellectual" skills, involving the recognition of clinical signs and symptoms and the formulation and management of patient problems, have been neglected relative to the emphasis on mastery of verbal information.[2,3,4] The branches of the curricular tree have been carefully and compulsively pruned, while the trunk has been allowed to grow randomly and unsystematically. It is those intellectual skills comprising the trunk that determine the clinical competence of the young physician. This paper presents an approach that specifies these competencies, directs instruction to them, and assesses their mastery by students. As a prototypic example, the development of a basic, comprehensive curriculum in ophthalmology is described. A discussion of the overall developmental problems, time, and costs are presented, as well as performance and attitudinal data for a segment of the curriculum.

A SYSTEMS APPROACH TO INSTRUCTION

In developing the instructional materials a systems approach[5] has been used that includes six key steps:

1) develop comprehensive objectives that specify observable behaviors
2) analyze the task into its component parts and develop detailed intermediate objectives that will enable the student to meet the comprehensive ones
3) develop and sequence instruction that is appropriate to these objectives
4) assess the effectiveness of the instruction by measuring how well students reach the objectives
5) based on evaluation data, modify the instruction until it is satisfactory
6) field test the instruction for effectiveness in a variety of settings

This approach is independent of subject-matter area, goals, methods, or media. It simply forces systematic attention to the goals of instruction, to the best ways the goals can be achieved, and to the methods and results of assessment.

The approach can be used to teach to any variety of objectives: general problem-solving strategies, information-gathering skills, clinical decision-making, verbal information, concepts, clinical observation, patient-interviewing, or surgical knot-tying. It does not advocate or denigrate any particular teaching techniques.

Such an approach may be a frustrating and time-consuming experience. However, when successful, the result is instruction that demonstrably reaches its objectives. When we are concerned with the effective and efficient education of professionals, we cannot be satisfied with less. The process is costly, but the expense can be spread out and shared by the product's utilization in other institutions and with other audiences.

The application of this systems approach to the development and validation of a comprehensive curriculum in ophthalmology for medical students is described below.

DEVELOPMENT OF OBJECTIVES

Performance objectives were derived from a questionnaire responded to by 1600 persons with a wide variety of medical backgrounds.[6,7] They represent a broad base of physician and student opinion and were developed with the support of the Association of University Professors in Ophthalmology. This is in contrast to the more typical processes by which educational goals are devised: judgement of an individual faculty expert; consensus of a faculty or faculty-student curriculum committee; or decision of a departmental chief in consultation with his staff.

Based on these data a comprehensive curriculum in seven basic content areas was developed. The curriculum is oriented around patient problems; clinical recognition and patient management skills

are emphasized, while recall of verbal information is markedly de-emphasized. Provided the student can recognize an abnormality when he sees it, it is reasonable to teach and expect him to read needed additional information, either in the synopses that have been provided, in texts, or in journals.[8]

TASK ANALYSIS

In performing the task analysis and in developing detailed intermediate and enabling objectives several procedures were found to ease the frustrations of the authors and facilitate preparation of the instruction. One consisted of specification of the critical features that the instruction was designed to teach, using charts, tables, performance guides, and flow sheets. These were helpful in providing a skeleton on which to flesh out the instruction and to organize the necessary examples that the student needed to recognize. The clear objectives were essential as guidelines for specification of critical features, and they facilitated communication among all those involved.

A second procedure was the process by which the instructional developers interacted with the content experts. In effect, the instructional developer would simulate a student in a 1-1 tutorial setting, then analyze the processes he underwent and convert these into instructional materials. It became necessary for the instructional developer consciously to observe the process he used

in learning and the requirements necessary for his learning. This mechanism often necessitated his requesting clarifications, specifications, or criteria from the content experts. Often what the content specialists had previously tried to teach to students was not that explicit in their own minds. Thus it is not surprising that students have difficulty forming concepts of normality and abnormality and recognizing certain pathologic changes. Other medical disciplines than ophthalmology may have similar problems.

A third tactic related to the geographic and temporal location of the instructional developers and the content experts. During the periods of intensive developmental activity the content experts needed to be very accessible to the instructional developers. Not only did substantial blocks of time (for example, several uninterrupted hours or full days) devoted only to developing instruction need to be set aside, but relatively instant availability was necessary to resolve small but crucial points.

DEVELOPMENT OF INSTRUCTIONAL MATERIALS

To raise the likelihood that actual student performance would be enhanced, the instruction was designed to be interactive and provide corrective feedback. This suggests the use of small group sessions and specially designed self-instructional units. The self-instructional mode leaves the student more flexibility in utilizing his unscheduled time. It also saves teacher time, usually

in short supply, for the more meaningful interaction that can best occur in a small group or individual encounter.

The self instructional materials all have inserted questions with corrective feedback throughout. The materials are adaptable to computer-assisted instruction without significant modification. Most of the instructional units include slide-tape sequences as well as textual material.

Developing the actual instructional materials was a time-consuming endeavor. A daily record was kept of the professional time spent in developing the instruction. Over the course of eight months approximately 1000 man hours were expended by the authors and three medical students who assisted on the project (Table I). This was after and in addition to the considerable task of developing the general objectives. It is projected that a minimum of 350 additional hours will be required to complete the seven units. The majority of time was spent in individual writing, preparation, and revision of instructional materials, as well as in conceptual and organizational consultation with colleagues. Almost a third of the total time was spent discussing the instruction, as opposed to actually writing or preparing it. This "tooling-up" time can be considered a necessary preliminary preparation for the actual development of instruction. The ophthalmoscopy unit, certainly the most difficult and complex of the units, consumed 450 man hours itself.

Assuming 20 hours of total instructional time and 1350 man hours of developmental time, the overall estimate for this project is 65-70 man hours per hour of instruction. For the ophthalmoscopy unit the figure is 90 man hours per hour of instruction.

The financial expenditures are listed in Table 2. These costs include professional salaries, office expenses, duplication of materials, photography, educational supplies, and the mannequins. Again, it does not include costs for development of objectives. For the 5-hour ophthalmoscopy unit, one hour of instruction costs approximately $1650; approximately $1000/hour is projected for the other units. However, a cost/hour basis, while a handy reference point, is rather spurious. If the goal is mastery (not hours of instruction), only cost/objective is relevant. By having a tape run slower or by inserting irrelevancies any instruction can be made cheaper per hour.

OPHTHALMOSCOPY UNIT

Initial attention was devoted to the development and completion of the unit on ophthalmoscopy (the use of the ophthalmoscope to identify normal and abnormal intraocular and retinal conditions). This area was chosen for beginning effort because it involves a skill that has traditionally been difficult for medical students to learn and often has not been systematically taught. Furthermore, it is an area that involves the learning of concepts, as well as definite

psychomotor skills. In addition, ophthalmoscopy is a skill that most physicians will use regardless of their medical specialty.

One of the typical problems in teaching ophthalmoscopy has been that it has required the presence of patients or fellow students on whom to practice, and the presence of an instructor to provide feedback. Self-instruction in ophthalmoscopy has - to our knowledge - not been tried before. For this project, a mannequin was developed that made it possible to design an effective self-instructional unit for ophthalmoscopy. In the mannequin, regular fundus slides, simulating any kind of fundus abnormality, can be examined with the ophthalmoscope.

The unit is divided into three sections. The first section is a slide-tape sequence, which provides systematic practice with feedback in recognizing a variety of normal and abnormal conditions of the ocular fundus. In the second section the student learns to manipulate the ophthalmoscope for examination of the ocular media and fundus. At the heart of this section is the mannequin that permits simulation of media and fundus abnormalities. The third section consists of five additional mannequins for self-evaluation. The student uses his ophthalmoscope to examine the mannequins and then writes a description of what he sees, just as he would in a patient's chart. Examples used in the evaluation have never before been seen by the student, so his ability to recognize new instances of the concepts is tested, rather than his ability to recall old

examples from the instruction.

After describing each of the 10 eyes, the student compared his description to that given by an expert; thus he could immediately go back and verify the features that he overlooked or improperly analyzed. It took the average student five hours to complete the unit: about two hours for Section I, one hour for Section II, and two hours for Section III (Table 3).

EVALUATION AND REVISION

The ophthalmoscopy unit has gone through several minor changes and one major revision based upon specific feedback from over 125 students' performance. A questionnaire completed after the instruction revealed that nearly all were very pleased with the unit's content and organization, felt that it was a worthwhile use of their time, and would use similar units when available. In order to determine the effectiveness of the instruction, the five-mannequin criterion test was administered to a group of 29 graduating senior medical students. Over the course of their medical school careers these students had been exposed to the usual formal and informal instruction in ophthalmoscopy, but did not use the self-instructional unit. Their performance on the criterion test was compared to that of 19 sophomore medical students who had completed the current version of the ophthalmoscopy unit. Despite the fact that the seniors had two extra years experience with patients,

approximately two-thirds of the sophomores outperformed the best senior on this test, which closely simulated the examination of live patients (Fig. 1). Moreover, sophomores made approximately one-third fewer false positive and false negative errors than did the seniors, suggesting a safer and more efficient level of clinical care (Table 4).

FIELD TESTING

Field testing of the ophthalmoscopy unit in approximately seven medical schools is now being planned. Students will be randomly assigned to experimental and control groups, so that both relative and absolute levels of effectiveness can be assessed. Data will also be gathered on circumstances and problems of usage.

SUMMARY

A systematic approach to instructional development is described, using as a prototype the preparation of a basic comprehensive curriculum in ophthalmology for medical students. Performance objectives were derived from the responses of 1600 practitioners and students. Seven self-instructional units, consisting of approximately 20 hours of instruction, have been designed to meet these objectives. A five-hour unit on ophthalmoscopy has undergone tryout and revision based on student performance. Performance on newly developed mannequins that allow simulation

of the ophthalmoscopic examination was the criterion measure. Sophomore medical students after completing the unit were compared with senior medical students just before graduation. Approximately two-thirds of the sophomores scored higher than the best senior. Development of the five-hour ophthalmoscopy unit required 450 man hours of professional time and $8250. It is projected that, for the other units, an average of 65-70 man hours and $1000 will be needed for each instructional hour. Observations regarding the developmental process include use of charts, performance guides, and flow sheets to structure the instructional materials; simulation of the student role by the instructional developer; and geographic and temporal accessibility of the content expert to the instructional developer.

ACKNOWLEDGEMENTS

The authors are grateful to Richard C. Anderson for his guidance and criticism throughout and to Michael Versackas for his assistance with the collection and analysis of the data.

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TABLE I

Time Spent in Development of

Instructional Materials

(6 Persons - 8 Months)

CATEGORY	TOTAL HOURS
Writing, Preparing, and Revising Materials	457
Reviewing Materials	93
Organizing	57
Reading Directly Relevant Materials	46
Consultation with Colleagues	
Conceptual and Organizational	238
Audio-Visual	47
Implementation	51
Outside Consultation	11
OVER-ALL TOTAL HOURS EXPENDED	1,000
Projected Additional Time for Completion of Initial Pilot Testing on All Units	350
Total Actual and Projected	1,350

TABLE 2

FINANCIAL EXPENDITURES

CATEGORY	COST ($)	
ACTUAL		
Office expenses	150	
Supplies	1,075	
Wages, Temp. Employment ($2.50/hr.)	775	
* Professional Salaries ($12.50/hr.)	8,125	
Travel	1,775	
A-V Equipment for trial testing	1,500	
Duplication for trial testing	700	
Secretarial assistance ($2.25-$2.50/hr.)	600	
TOTAL		14,700
PROJECTED**		
Office expenses	100	
Supplies	300	
Wages, Temp. Employment ($2.50/hr.)	375	
Professional Salaries ($12.50/hr.)*	2,500	
Travel	800	
Duplication for trial testing	1,000	
Secretarial assistance ($2.25-$2.50/hr.)	425	
TOTAL		5,500
TOTAL ACTUAL AND PROJECTED		20,200

* No actual compensation for these services

** Projected additional costs for completion of initial pilot testing on all units

TABLE 3.

STUDENT TIME - OPHTHALMOSCOPY UNIT

(N = 19)

	PART I	PART II	PART III	TOTAL TIME
MEAN TIME (MIN)	130	56	115	307
RANGE (MIN)	90-180	20-105	60-180	190-410

TABLE 4

Percentage Error in Discriminating Normal from Abnormal Variations of the Ocular Fundus

(Ophthalmoscopy-Section III)

	Sophomores (N = 19)	Seniors (N = 29)
Mean Percentage of False Positive Errors (25 possible)	18	26
Mean Percentage of False Negative Errors (16 possible)	21	29
Mean Percentage of Total Discrimination Errors (41 possible)	20	28

Figure 1: Criterion Performance in Ophthalmoscopy using Simulated Patient Examination

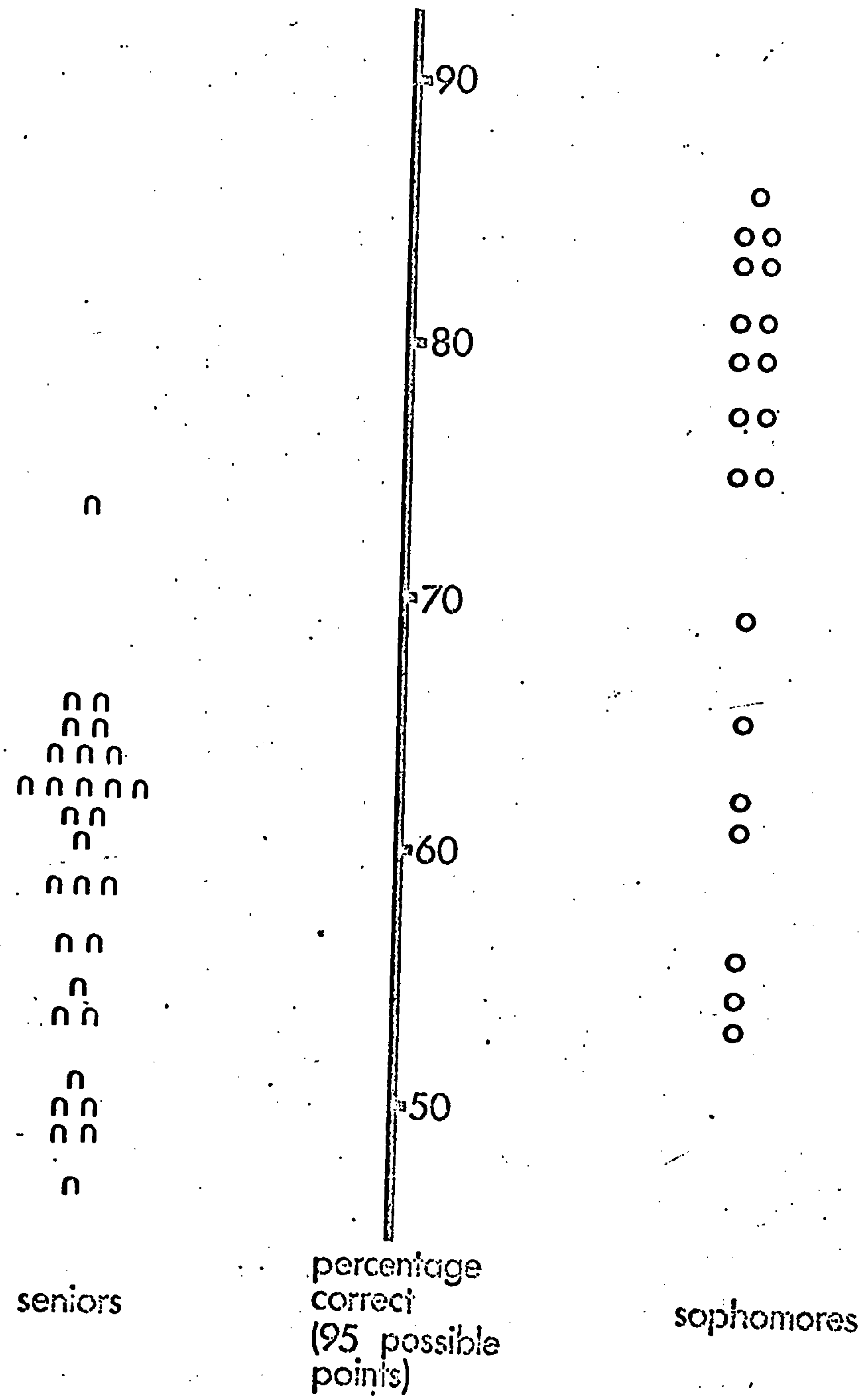

Figure 1: Criterion Performance in Opthalmoscopy using Simulated Patient Examination

APPENDIX D

"BASIC INSTRUCTION IN OPHTHALMOLOGY FOR MEDICAL STUDENTS: A SYSTEMS APPROACH"

Basic Instruction in Ophthalmology for Medical Students: A Systems Approach

by

Gary M. Arsham, M.D., August Colenbrander, M.D., Bruce E. Spivey, M.D.

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Presented at the 5th Rochester Conference on Self Instruction in Medical Education, Rochester, New York, April 2, 1971.

INTRODUCTION:

This is a description of our initial work in developing a comprehensive minimal basic curriculum in ophthalmology, derived with broad-based input, and which could be utilized in whole or in part by many different institutions. For this curriculum, self-instructional materials for medical students have been produced incorporating conceptual skills as well as psychomotor performances in the content.

BACKGROUND:

The basis for the content of a basic undergraduate curriculum in ophthalmology comes from a questionnaire which was developed listing 44 different possible terminal performances (1). Respondents were asked to rate on a scale from 1-4 how essential they thought mastery of the particular behavior was for a graduating medical student. The questionnaire was sent to some 3,400 individuals. This included some

specialists in ophthalmology, many other medical specialists, general medical practitioners, house officers, and medical students. Of these 3,400 persons, approximately 1,600 responded. Of those 1,600 who responded approximately 1,000 were practitioners with no medical school affiliation, about 200 were medical school faculty, 200 were interns and residents, and approximately 200 were medical students in their third and fourth year. Less than 100 of these were ophthalmologists.

Based on these ratings, 17 of the 44 behaviors were determined to constitute the minimum acceptable performance level for a graduating medical student. The criterion for inclusion was that the behavior be listed as essential or desirable (rated 4 or 3) by 80% of the respondents, with more responding essential than desirable.

Cooperative approaches to instructional goal setting and instructional materials development are essential if we are going to be efficient and effective in our efforts to improve health care education (2). For significant developmental efforts to be justifiable in the future, there must be broader acceptance and use of materials developed cooperatively. This was the main reason why we tried to obtain a broad-based and widely representaive sampling of opinions regarding desired performances. When objectives are clearly specified, institutions, departments or individuals can more easily select the instructional materials that will meet their needs and the needs of their students. Moreover, we felt that support by professional specialty groups was another important way to facilitate broader acceptance of the instructional materials, once developed. The Association of University Professors in Ophthalmology has provided this.

DESCRIPTION OF INSTRUCTION:

On this foundation the development of educational materials for medical students has begun.

It was decided that one self-instructional unit would be developed for each of the seven content areas (see Fig. 1). While all of these units are currently in various stages of development, the ophthalmoscopy unit was chosen for primary completion. Ophthalmoscopy is the use of the ophthalmoscope to identify normal and abnormal retinal and ocular findings. These were several reasons for this choice.

Of the content areas, the first two involve mainly examining techniques and data acquisition. The last five, in addition, include aspects of diagnosis and management. Our approach was based on the realization that the student must develop and refine some very basic clinical skills before he can be expected to solve problems and make diagnoses. A student can be aware of the fact that papilledema is a sign of increased intracranial pressure without being able to recognize papilledema when he sees it. We felt that it was important to try to train these kinds of recognition and discrimination skills so that at least we could be confident that a medical student would be able to do an adequate examination. The same observation could be made for areas of medicine other than ophthalmology, for example: cardiac auscultation, abdominal palpation and pelvic examination. As Dr. Lawrence Weed has so convincingly pointed out, the foundation for effective patient care is an adequate data base (13).

Furthermore, ophthalmoscopy traditionally has been a difficult area for medical students to learn. Often it is not systematically

CONTENT AREAS IN OPHTHALMOLOGY

OPHTHALMOSCOPY

VISUAL ACUITY

RED EYE

OCULAR INJURY

GLAUCOMA

STRABISMUS

NEURO-OPHTHALMOLOGY

FIGURE 1

taught. Ophthalmoscopy requires much time for a beginning student simply to orient himself to looking at the fundus. This precedes his learning to recognize the normal landmarks, let alone the abnormal findings. Moreover, we felt that of all the areas of ophthalmology this would be an ophthalmologic skill that he would use most commonly in his career as a physician. Of course, we recognize that a urologist, for example, will use ophthalmoscopy far less than will an internist or a family physician.

Our ophthalmoscopy unit is divided into three sections (see Fig.2): Section I: The first objective relates to the first section of the unit.

Insert Figure 3 about here

In this section students go through a slide tape sequence with an answer sheet and receive corrective feedback. During this segment they learn to describe systematically critical characteristics of the normal and abnormal ocular fundus. In order to do this they need to use terms which are outlined for them in two places: a chart and a performance guide.

On the chart (see Fig.4) are outlined very specifically the features that the ophthalmologists who are working on this project felt were critical to description of the ocular fundus. Developing this chart forced the ophthalmologists to be explicit about the criteria upon which their judgements are based and to define these criteria in concise, simple and unequivocal statements.

OPHTHALMOSCOPY UNIT OBJECTIVES

SECTION I

GIVEN SLIDES OF NORMAL AND ABNORMAL OCULAR FUNDI AND A CHART DELINEATING CRITICAL CHARACTERISTICS:

A) SYSTEMATICALLY DESCRIBE THE CHARACTERISTICS OF THE FUNDI AND SPECIFY THE LOCATION OF ANY SIGNIFICANT FINDINGS;

B) MAKE A JUDGEMENT REGARDING NORMALITY OR ABNORMALITY OF THE DISC, VESSELS, GENERAL FUNDUS, AND MACULA, AFTER STATING THE LOCATION AND APPEARANCE OF ABNORMALITIES.

SECTION II

GIVEN A MANNEQUIN AND AN OPHTHALMOSCOPE, DEMONSTRATE PROPER PROCEDURE FOR:

1) ELICITING RED REFLEX (FUNDUS GLOW);
2) CHECKING CLARITY OF MEDIA; AND
3) SYSTEMATICALLY EXAMINING THE OCULAR FUNDUS.

PROPER TECHNIQUE IS DESCRIBED IN PERFORMANCE GUIDE #2. (NOTE: THIS OBJECTIVE DOES NOT INCLUDE DESCRIPTION OF FUNDUS ABNORMALITIES OR NORMALITIES - ONLY PSYCHOMOTOR SKILLS IN USING THE OPHTHALMOSCOPE).

SECTION III

GIVEN AN OPHTHALMOSCOPE AND MANNEQUIN WITH SEVERAL NORMAL AND ABNORMAL FUNDI AND MEDIA IN PLACE:

A) SYSTEMATICALLY DESCRIBE THE MEDIA, DISC, VESSELS, GENERAL FUNDUS AND MACULA;

B) MAKE A JUDGEMENT REGARDING THE NORMALITY OR ABNORMALITY OF MEDIA, DISC, VESSELS, GENERAL FUNDUS AND MACULA; AND
C) GIVE THE LOCATION OF ANY ABNORMALITY.

FIGURE 2

OPHTHALMOSCOPY UNIT SECTION I

OBJECTIVE: DESCRIBE PROJECTED SLIDES

CONTENT : CONCEPTS

MATERIALS: TAPE AND SLIDES,
CHART, PERFORMANCE GUIDE,
QUESTIONS AND ANSWERS WITH
CORRECTIVE FEEDBACK.

FIGURE 3

SYSTEMATIC APPROACH TO EXAMINATION OF THE OCULAR FUNDUS

DISC

CRITICAL CHARACTERISTICS

1. Shape
2. Margins
3. Color
4. Cup-disc ratio

APPROPRIATE DESCRIPTIVE TERMS

NORMAL FINDINGS OR VARIATIONS

1. Regular-generally; scleral crescent (white); pigment crescent (black).
2. Distinct, more sharply outlined temporally.
3. "Salmon pink"; deeper pink nasally; presence of yellowish-white myelinated nerve fibers.
4. 0.0-0.5; should be equal (within ± 0.2) to other (companion) eye.

PRESUMPTIVE PATHOLOGICAL CHANGES

1. Irregular-consider inflammatory reactions, or congenital anomaly.
2. Obscured, blurred (consider papilledema)
3. Pallor, whiteness (consider optic atrophy); hyperemic or hemorrhagic (consider papilledema or venous occlusion)
4. Greater than 0.5 or unequal to other eye (consider glaucoma)

Figure 4. A re-arranged segment of the complete chart, delineating critical characteristics for examination of the optic disc.

The instructional materials then provide the student with systemic practice and feedback for the visual discriminations and identifications necessary to use the chart. We do not primarily expect the student to commit to memory the information on the chart or performance guide. On the contrary, we would like him to develop the visual identification skills that will allow him meaningfully to use this chart. This is an important point which is easy to overlook. Our students should spend more time refining such basic clinical skills as recognizing certain abnormalities when they see or hear or feel them, rather than being able to recite from memory, for example, five major causes of optic atrophy. It is much more reasonable to expect them to look this up if they first could identify optic atrophy.

Section II: The second section of our ophthalmoscopy unit teaches the psychomotor skills involved in using the ophthalmoscope.

Insert Fig. 5 about here

Note that this does not include any description of fundus normalities or abnormalities. They learned these in the first section.

The heart of this section is a mannequin which permits simulation of some abnormalities of the ocular media, as well as simulation of the red reflex and details of the fundus. The advantages of the mannequin both for training and for testing are multiple.

First, the mannequin, unlike the patient or a fellow student, is always available and infinitely patient. Secondly, unlike a fellow student, it can show pathological variations; and, unlike the patient, it can show pathological changes at anytime. The use of the mannequin

OPHTHALMOSCOPY UNIT SECTION II

OBJECTIVE: USE OF OPHTHALMOSCOPE

CONTENT : PSYCHOMOTOR SKILLS

MATERIALS: MANNEQUIN,
EXERCISES,
PERFORMANCE GUIDE,

FIGURE 5

does not replace experience with patients but rather will make the student much more comfortable when he approaches patients. The more comfortable he is when he approaches his patients with the ophthalmoscope, the more likely he is to use the ophthalmoscope again.

The mannequin has two other advantages as a simulation device for learning ophthalmoscopy: 1) it allows the student to practice the difficult skill of coordinating his hand, head and eye to keep the ophthalmoscope beam trained on the pupil; and 2) it allows him to practice building a complete fundus image from the small fields seen at any one time. It also allows him to practice focusing on opacities at various depths of the ocular media.

Section III: The last section puts together the concepts and skills learned in the first two sections and allows the student to integrate and apply them.

Insert Fig 6 about here

Here he systematically examines the ocular media and fundus of the mannequin while describing what he sees. We have a series of mannequins which simulate normal and abnormal variations. These are being used as a self-evaluation unit. The descriptions that the students are expected to give are what a medical student or physician should record in the chart after ophthalmoscopy. When we later see the student in small group sessions, we also use an observation check list in order to determine whether the student is performing the psychomotor part of the exam in the appropriate manner.

SYSTEMS APPROACH:

The approach we are using to develop this instruction is what has

OPHTHALMOSCOPY UNIT SECTION III

OBJECTIVE: EXAMINE, DESCRIBE UNKNOWNS

CONTENT : SYNTHESIS OF I AND II

MATERIALS: MANNIQUINS,
RECORD SHEETS WITH
CORRECTIVE FEEDBACK.

FIGURE 6

been called by many individuals a " systems approach". There are many such approaches; the one that we are using is a simple one which has been described by Anderson and Faust (4) (Fig.7). Basically it includes a definition of specific behavioral objectives, a task analysis to break down the objectives into their enabling objectives and a determination of the entering behaviors of the students. Then learning experiences are designed which are directly related to the enabling objectives. The performance of the student is evaluated in order to assess how well these objectives have been met. If they have not been met, the instruction is either revised or remedial instruction is provided, and the cycle is re-entered at the appropriate place.

In applying this approach we found that a very critical step occurs between the breakdown into subobjectives and the actual development of the learning materials. This has been our biggest area of frustration. The process that we have finally been able to use successfully has been the following: one of the team who is experienced and knowledgeable about designing instruction simulates a student in a one-to-one tutorial setting, forcing the content experts to be explicit in their instruction and explicit about the kinds of judgements and criteria they are using to make decisions. The instructional expert then processes his newly gained content knowledge into acceptable instruction, which the content experts then edit and revise appropriately.

PERFORMANCE DATA:

Although our ophthalmoscopy unit is currently operational, it is by no means finalized. We are in the process of making a second major revision. Our data are still preliminary. Students are taking an average

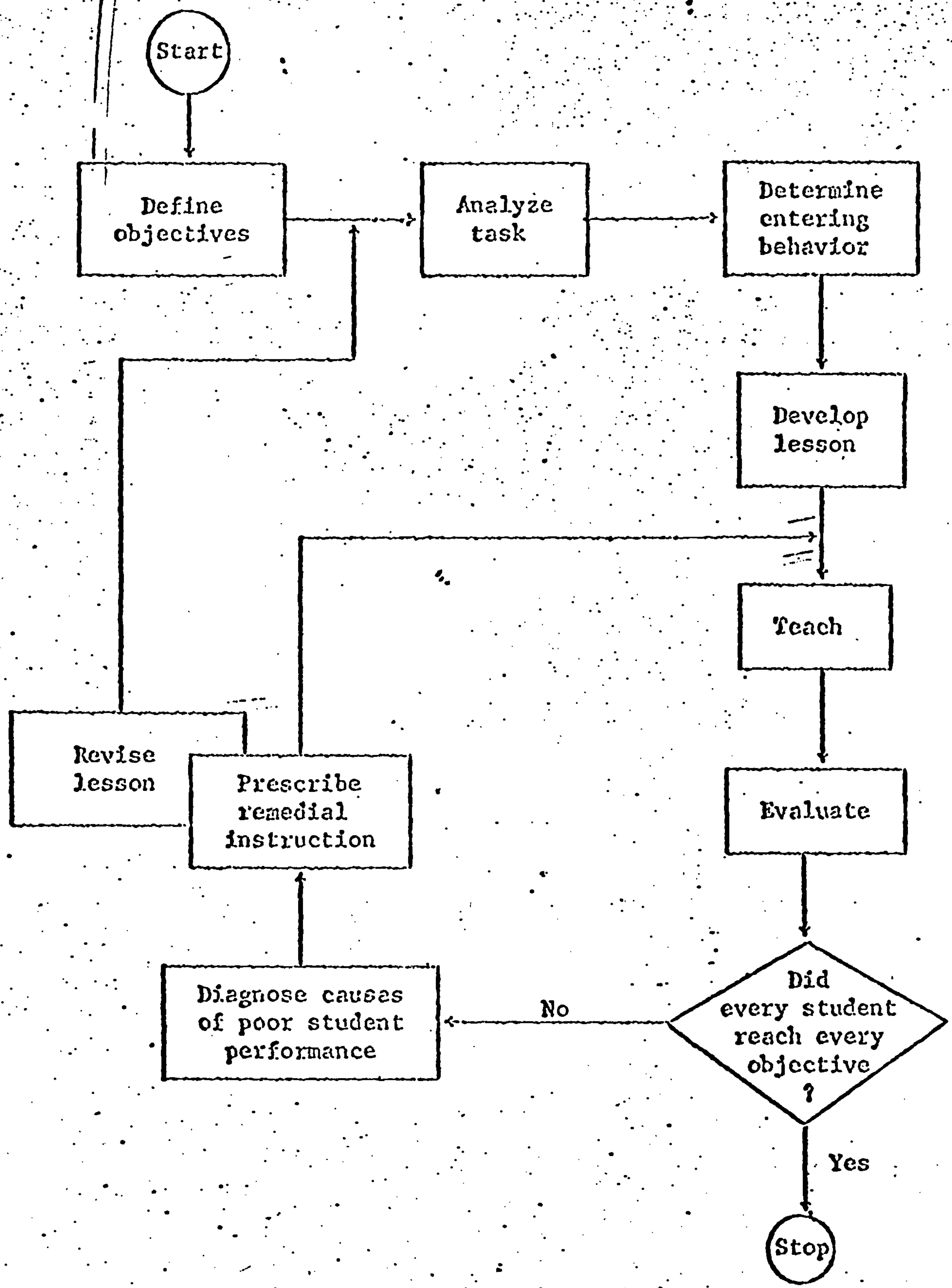

Fig. 7 A schematic representation of a strategy for instructional development and quality control. Adapted with the permission of the copyright holder from Anderson and Faust, Educational Psychology, New York: Dodd Mead, in press.

of five hours to complete the unit with a range of 3 1/2 to 6 hours. While some students felt that this was too long, all thought that it was a worthwhile use of their time and many of those that felt it was too long stated without prompting that they could think of no way that it could be shortened. Students felt that this was a very appropriate way to learn these skills and felt that by using the slides and mannequins they would be able to approach more adequately and competently their patients. The ophthalmology instructors are convinced that the students, following their five hours of self-instruction, come to ophthalmology with a far higher level of skill than was evidenced previously by students who did not have this self-instructional unit. We are now gathering base-line data on fourth year students, which will give us an indication of their competency as a result of their previous planned and unplanned exposures to ophthalmoscopy.

In order to quantitatively describe student performance we have determined the level at which at least 80% of the students performed.

Insert Fig. 8 about here

In looking at these figures, it should be borne in mind that we told the students that they would <u>not</u> be graded and that our observations were only for our own feedback.

We would stress again that these data are preliminary. We are in the process of refining our assessment instruments as well as our instructional materials. The data that we have already obtained have pointed to specific areas of weakness in the instruction and this is being appropriately revised. We are confident that the performances will be

LEVELS REACHED BY 80 % OF THE STUDENTS

PERFORMED CORRECTLY:	80 % OF OBSERVED SKILLS
DESCRIBED CORRECTLY:	75 % OF MEDIA OPACITIES
	70 % OF DISC FEATURES
	50 % OF VESSEL FEATURES

FIGURE 8

substantially improved in all areas as the instruction is revised.

SUMMARY:

We have described a self-instructional unit which is part of a larger project to develop a comprehensive (but minimal) systematic curriculum in ophthalmology for medical students. Much of this material we feel would be relevant and adaptable to use by other professionals. Simulation of the ophthalmoscopic examination using a newly developed mannequin is an integral part of the unit. We have attempted to concentrate not on recall of facts but on the development of visual recognition skills which we would expect the student to retain for a longer time and which are a basic prerequisite to the problem-solving role he will play in the future. Lastly, we have enlisted broad-based cooperative support in hopes that expenditures of time and money by a small group will be efficiently multiplied by use in other institutions and in other settings.

ACKNOWLEDGEMENTS:

We wish to acknowledge the assistance of Michael Versackas in the data collection and analysis.

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APPENDIX E

"BASIC APPROACH TO SYSTEMATIC INSTRUCTION IN CLINICAL SCIENCE (BASICS)"

ABSTRACT

Basic Approach to Systematic Instruction in Clinical Science (BASICS)

by

Gary M. Arsham, M.D., August Colenbrander, M.D. and Bruce E. Spivey, M.D.

This is a report on the use of a systems approach for the development, implementation, and validation of basic instruction in clinical science. As a prototype, a comprehensive curriculum in ophthalmology was created.

Performance objectives are broad-based and were developed with national support, including that of the Association of University Professors ~~of~~ in Ophthalmology. These objectives were derived from a questionnaire, responded to by 1600 practitioners and students of differing backgrounds and areas of specialization.

The instruction, comprising both self-instructional units and small-group sessions, is interactive, with corrective feedback throughout. The teaching is directly related to the pre-specified objectives and was revised until it produced the desired student performance. Simulation devices have been developed where appropriate.

Development of the 20-hour curriculum was estimated to cost, for each instructional hour, 65-70 man hours of professional time and $1000. The five-hour ophthalmoscopy unit, described below, required 90 man hours and $1650 for each hour of instruction.

Evaluation is criterion-referenced; the student's performance is assessed on tasks that closely relate to the desired clinical skills. In the ophthalmoscopy unit, the criterion measure was performance on a simulated ophthalmoscopic examination, using specially developed mannequins. Sophomore medical students, after completing the ophthalmoscopy unit, were compared with senior medical students who had had the typical formal and informal exposure to ophthalmoscopy, plus two years additional experience in using the ophthalmoscope with patients. Approximately two-thirds of the sophomores outperformed the best senior.

Observations regarding the developmental process include: the usefulness of clearly perceived objectives, charts, performance guides, and flow sheets to structure the instructional material; the effectiveness of simulating the student role by the instructional developer to facilitate interaction between subject matter and educational experts; the need for lengthy time commitments to develop such products; and the importance of geographic and temporal accessibility of the content expert to the instructional developer.

Basic Approach To Systematic Instruction In Clinical Science (BASICS)

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We feel that medical education must become more systematic to enhance the quality and quantity of health care delivery. In health science education we are required to verify and certify that a health professional is truly competent. This paper describes an approach that specifies these competencies, directs instruction to them, and assesses their mastery by students. As a prototypic example, the development of a basic, comprehensive curriculum in ophthalmology is described. A discussion of the overall developmental problems, time, and costs are presented, as well as performance and attitudinal data for a segment of the curriculum.

A SYSTEMS APPROACH TO INSTRUCTION

The fundamental approach used in this project has the following key elements: (1) Specific broad based objectives are developed; they describe observable behavior; (2) the objectives are broken down into component parts to specify the behaviors that will enable a student to meet the primary objectives; (3) a variety of interactive learning experiences are planned and prepared that relate directly to the specified objectives; (4) direct assessment is made of how effective the instruction is in reaching the objectives; (5) the instruction is revised until it is satisfactory; and (6) large scale multi-school field tests are carried out to validate the instruction in a variety of settings.

Such an approach may be a frustrating and time consuming experience. However, when successful, we have obtained instruction that demonstrably reaches its objectives. When we are concerned with the effective and efficient education of professionals, we can not be satisfied with less.

This 6-step approach has been applied to the development of a comprehensive curriculum in ophthalmology for medical students. Performance objectives were derived from a questionnaire responded to by 1600 persons with a wide variety of medical backgrounds (Spivey, 1970;1971). These objectives form the basis for the curriculum. They represent a broad base of opinion and were evolved with the support of the Association of University Professors in Ophthalmology.

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This work was done at the Department of Ophthalmology, University of Iowa, while Dr. Arsham was a Fellow in Medical Education at the University of Illinois. It was supported in part by the U.S. Office of Education, Grant No. OEG-6-70-0028(509), by a grant from the Sloan Foundation through the Association of University Professors in Ophthalmology, and in part pursuant to Contract No. PH 43-67-45 with HSMHA, HEW.

The questionnaire yielded objectives in seven basic content areas. It was decided to develop self-instructional units for each of these areas. Most of the instructional units include slide tape sequences as well as textual material. All have inserted questions with corrective feedback throughout. The material is adaptable to computer-assisted instruction without significant modification.

We have attempted to assess the students performance in a manner that closely approximates the actual behavior engaged in taking care of patients (as described in the previously developed objectives). In two of the units we have developed simulation devices for this purpose. In other instances, we use clinical problems with photographic examples of the abnormal conditions. To assess certain other skills we use observation check lists and chart audit.

RESULTS IN ONE UNIT

We chose to devote our initial attention to the development and completion of the unit on ophthalmoscopy (the use of the ophthalmoscope to identify normal and abnormal intraocular and retinal conditions). This area was chosen for beginning effort because it involves a skill that has traditionally been difficult for medical students to learn and often has not been systematically taught. Furthermore, it is an area that involves the learning of concepts as well as definite psychomotor skills. Ophthalmoscopy is a skill that most physicians will use regardless of their medical specialty.

The self instructional unit in ophthalmoscopy takes the average student approximately five hours to complete and is divided into three sections. The first section is a slide tape sequence, which provides systematic practice with feedback in recognizing a variety of normal and abnormal conditions of the ocular fundus. In the second section the student learns to manipulate the ophthalmoscope for examination of the ocular media and fundus. At the heart of this section is a mannequin, developed for this instruction, that permits simulation of media and fundus abnormalities. The third section consists of five additional mannequins, where, for self-evaluation, the student uses his ophthalmoscope to examine the mannequins and then write a description of what he sees, just as he would in a patient's chart.

The ophthalmoscopy unit has gone through several minor changes and one major revision based upon specific feedback from student performance. In order to determine the effectiveness of the instruction the five-mannequin criterion test was administered to a group of 29 graduating senior medical students. Over the course of their medical school careers these students had been exposed to the usual formal and informal instruction in ophthalmoscopy. Their performance on the criterion test was compared to that of 19 sophomore medical students who had completed the current version of the ophthalmoscopy unit. Despite the fact that the seniors had two extra years real experience with patients, approximately two-thirds of the sophomores performed better than the best senior. This was on a task that closely simulated the examination of live patients.

Twenty-six of 28 sophomores felt that taking the current ophthalmology unit was a worthwhile use of their time and 27 of 29 would use similar units if available. Most were very pleased with the unit's content and organization. Twenty-four of 27 found the mannequins helpful.

Field testing of the ophthalmoscopy unit in approximately 6 medical schools is now being planned. Students will be randomly assigned to experimental and control groups, so that both relative and absolute levels of effectiveness can be assessed. Data will also be gathered on circumstances and problems of usage.

DEVELOPMENTAL PROCESS

Developing the instructional materials was a time consuming and arduous endeavor. Over the course of eight months approximately 1000 man hours were expended by the authors and three medical students who assisted on the project. This was after and in addition to the considerable task of developing the objectives. It is projected that an additional 350 hours will be required to complete the seven units. The majority of time was spent in individual writing, preparation, and revision of instructional materials, as well as in conceptual and organizational consultation with colleagues. Almost a third of the total time was spent discussing the instruction, as opposed to actually writing or preparing it. This "tooling-up" time can be considered a necessary preliminary preparation for the actual development of instruction. The ophthalmoscopy unit, certainly the most difficult and complex of the units, consumed 450 man hours itself.

Assuming 20 hours of total instructional time and 1350 man hours of developmental time, the overall estimate for this project is 65-70 man hours per hour of instruction. For the ophthalmoscopy unit the figure is 90 man hours per hour of instruction. It should be re-emphasized that these figures do not include time to develop the initial performance objectives.

It is also possible to calculate the dollar cost of instructional development per instructional hour. These costs include professional salaries, office expenses, educational supplies, duplication of materials, photography, and the materials for preparation of the mannequins. Again, it does not include costs for development of objectives. For the 5-hour ophthalmoscopy unit, one hour of instruction cost approximately $1650; approximately $1000/hour is projected for the other units.

In developing the instruction several procedures were found to ease the frustrations of the authors and facilitate preparation of the instruction. One consisted of specification of the critical features that the instruction was designed to teach, using charts, tables, performance guides, and flow sheets. These were helpful in providing a skeleton on which to flesh out the instruction and to organize the necessary examples that the student needed to recognize. The clear objectives were essential as guidelines for specification of critical features, and they facilitated communication among all those involved. A second procedure was the process by which the instructional developers interacted with the content experts. In effect, the instructional developer would simulate a student in a 1-1 tutorial setting, then analyze the processes he underwent and convert these into instructional materials. It became necessary for the instructional developer consciously to observe the process he used in learning and the requirements necessary for his learning. This mechanism often necessitated his requesting clarifications, specifications, or criteria from the content experts. A third tactic related to the geographical and temporal location of the instructional developers and the

content experts. During the periods of intensive developmental activity it was found that the content experts needed to be very accessible to the instructional developers. Not only had substantial blocks of time (for example, several uninterrupted hours or full days) devoted only to developing instruction to be set aside, but relatively instant availability was necessary to resolve small but crucial points.

SUMMARY

A systematic approach to instructional development is described, using as a prototype the preparation of a basic comprehensive curriculum in ophthalmology for medical students. Performance objectives were derived from the responses of 1600 practitioners and students. Seven self-instructional units, consisting of approximately 20 hours of instruction, have been designed to meet these objectives. A five hour unit on ophthalmoscopy has undergone tryout and revision based on student performance. Performance on newly developed mannequins that allow simulation of the ophthalmoscopic examination was the criterion measure. Sophomore medical students after completing the unit were compared with senior medical students just before graduation. Approximately two-thirds of the sophomores scored higher than the best senior. Development of the five-hour ophthalmoscopy unit required, for each hour of instruction, 90 man hours of professional time and $1650. It is projected that, for the other units, an average of 65-70 man hours and $1000 will be needed for each instructional hour. Observations regarding the developmental process include use of charts, performance guides and flow sheets to structure the instructional materials, simulation of the student role by the instructional developer, and geographic and temporal accessibility of the content expert to the instructional developer.

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APPENDIX F

"INSTRUCTION FOR MASTERY IN MEDICAL EDUCATION"

ABSTRACT

Instruction for Mastery in Medical Education
by
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It is essential that all medical students refine their clinical skills to a level of minimum professional competence. Diagnostic skills acquired in random ward or clinic experiences are an inefficient way to learn and result in lack of quality control. This paper describes techniques for developing more systematic instruction, which concentrates on mastery of clinical recognition and patient management skills, rather than on the recall of factual knowledge.

These techniques were applied to the development of a comprehensive 20-hour curriculum in ophthalmology for medical students. Developing objectives that are oriented around patient problems is the first step. These objectives communicate the major kinds of clinical signs and symptoms with which the student must become familiar. Then, charts, performance guides, and flow sheets that unequivocally and concisely specify the critical characteristics needed for recognition, discrimination and management are prepared. These form the skeleton or organizing principle of the instructional material. Next, examples are carefully selected and sequenced according to the specified critical characteristics. The actual interactive instruction is then developed. Strategies are used to teach students to notice important cues and to form appropriate concepts of disease entities by responding to their critical features, ignoring irrelevant characteristics. Finally, mastery of the skills is assessed using techniques that measure the critical tasks as directly and realistically as possible.

The instruction resulting from application of these techniques is illustrated by a 5-hour unit that teaches the use of the ophthalmoscope in recognizing normal and abnormal variations of the ocular media and fundus. A mannequin developed especially for this purpose permits simulation of the ophthalmoscopic exam.

Using the ophthalmoscopic examination and description of 5 mannequins (10 eyes) as the criterion test, approxiately two-thirds of sophomore medical students after instruction had higher levels of performance than the best senior student after 2 years additional formal and informal ward and clinic experiences with ophthalmoscopy. Moreover, the sophomores made approximately one-third fewer false positive and false negative errors than the seniors, suggesting a safer and more efficient level of clinical competence.

INSTRUCTION FOR MASTERY IN MEDICAL EDUCATION

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In the past, medical education has often been characterized by prodigious dissemination of factual material by teachers and prodigious feats of factual recall by students. In recent years much has been written and said about the need to move away from recall to higher levels of cognitive processes, such as problem solving and synthesis. Yet a great deal of the teaching remains based on remembering factual material or the presentation of preprocessed data that the student will use to solve problems. The assumption made in this paper is that a student should develop and refine some very basic clinical recognition skills before he can be expected to solve problems and make diagnoses. It is useless for a student to be aware that a gallop rhythm is a sign of congestive heart failure if he is unable to recognize the gallop when he hears it. Training such recognition and discrimination skills to the level where the instructors can be confident that a medical student is at least able to do an adequate examination is most important.

Training the student to recognize and discriminate the various abnormalities is very time-consuming. For example, typical objectives of clinical instruction are that "a student should be able to do an adequate physical examination" or "a student should be able to do an adequate pelvic examination". Such objectives imply substantially more learning than is superficially apparent. Because of lengthy instructional preparation time, a student may not receive the systematic practice with feedback needed to learn how to differentiate normal from abnormal, and how to recognize abnormalities, let alone receive practice with feedback in the actual psychomotor skills involved in doing the examination. At the present time several simulation devices are available, such as heart sound generators and pelvic models, that will facilitate learning in these areas. Elaborate simulation devices are not always necessary. Often when the discrimination skill is visual, slides alone may be adequate. However, relatively little software is available to capitalize on the instructional potential of these simulation devices.

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The student should not be left to make the observations and form his concepts of normality and abnormality on his own, using random ward experiences and trial and error learning. Learning to form concepts can be facilitated greatly by planned sequences of examples (Markle & Tiemann, 1970). The instructor must systematically gather the examples, and teach the student to notice important cues. This facilitates the student's responding to critical features of the disease entity and ignoring irrelevant characteristics.

The instructor who tries to teach these skills must analyze his own performance in great detail. If he makes a judgment about an abnormality, he must be explicit about the criteria that he uses and he must be able to define them in concise, simple, and unequivocal statements. This is a difficult and time-consuming task.

Once these critical characteristics and criteria have been defined, they often can be organized into a chart, performance guide, or flow sheet. Such a document forms a skeleton around which the instructional materials can be structured and developed. The primary goal for the student is not to commit to memory all the information on the chart or the performance guide, but to develop the identification skills, whether they are visual, auditory, tactile, or even olfactory, that he will need to use the chart meaningfully. This is a point often overlooked. The student commonly may be given a very nice chart or list of important features of a disease, yet he is not given systematic practice with feedback in recognizing these features. In order for medical educators to raise the level of clinical competence of students, more time must be spent in refining such basic clinical skills as recognizing certain abnormalities when they are seen, heard, or felt, rather than being able to recite from memory, for example, three causes of pericarditis. It is much more reasonable to expect students to look up this information if they are first able to identify a pericardial friction rub.

In developing a basic comprehensive curriculum in ophthalmology for medical students, we have applied this philosophy to the design of our instructional materials. Objectives were developed that are oriented around patient problems. These objectives communicate the major kinds of clinical signs and symptoms with which the student must become familiar. We have markedly de-emphasized objectives that entail the recall of factual material. We feel that the student can look this up either in a standard text or in a synopsis that we have provided him (Weed, 1970). We have concentrated on trying to facilitate his mastery of recognition skills, since he is likely to retain these "intellectual" skills longer than he would be able to recall verbal information (Gagné, 1970).

Chart I is an example from the unit on ophthalmoscopy. (Ophthalmoscopy is defined as the skill of using the ophthalmoscope to identify certain normal and abnormal conditions of the ocular media and fundus). This chart specifies critical characteristics that the ophthalmologists on this project felt were necessary for accurate description. Often it was difficult for the ophthalmologists to agree on which characteristics should be included. Frequently modification of the original characteristics and criteria were necessary as it became obvious that certain features were not particularly useful in describing or identifying the abnormalities, even though they were traditionally taught.

The chart greatly facilitated selection of the positive and negative examples of each critical concept or characteristic. Once these were identified, instructional materials were developed to provide systematic practice with feedback in describing the conditions and differentiating normality from abnormality.

A mannequin was developed both for teaching the psychomotor aspects of the ophthalmoscopy skill, as well as for final assessment. It uses standard 2 x 2 transparencies of the fundus to permit simulation of the ophthalmoscopic examination. For the criterion test, the student was required to examine five mannequins (10 eyes) with his ophthalmoscope, to judge whether there were abnormalities present, and to describe any abnormalities seen. This test was given to 29 senior students just prior to graduation. They had had the usual formal and informal exposures to ophthalmoscopy. Their performance was compared with data from 19 sophomore medical students who had completed the current version of the self-instructional unit. (An earlier version was revised after experience with 110 other class members). The sophomores performed an average of 13 percentage points higher overall than the seniors ($p < 0.001$). More important there was a marked shift toward higher levels of performance for more students among the sophomores. Approximately two-thirds of the sophomores scored higher than the best senior. In addition, in discriminating normal from abnormal, the sophomores made 30% fewer false positive discriminations and 27% fewer false negative discriminations than the seniors. To reach this level of performance the students averaged a total of approximately five hours of instructional time. No direct contact via instructor was necessary; once the student has mastered the fundamental recognition and discrimination skills, the instructor's time can be used for less repetitive, higher level, more meaningful teaching with patients.

SUMMARY.

More instructional effort must be devoted to the systematic refinement of students' clinical recognition and discrimination skills. Recall of factual material should be de-emphasized. Techniques are described that facilitate student mastery of these skills.

Despite the time and effort required for medical educators to devise the necessary learning experiences, the payoff is high in terms of student learning and release of faculty time for more meaningful teaching. On a criterion related task concerned with the skill of ophthalmoscopy, approximately two-thirds of sophomore students after instruction performed better than the best senior medical student after the usual formal and informal exposures to ophthalmoscopy and two years additional experience. Furthermore, the sophomores made one-third fewer false negative and false positive identifications than did the seniors.

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