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**Conceptual Knowledge Foundations for Naval Medical Training: A
Scheme for Directed Curricular Planning and Instructional Design**

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13. ABSTRACT (Maximum 200 words)

A mail survey was conducted among individuals associated with Submarine IDC program, including corpsmen, corpsmen instructors and medical officers. The purpose was to identify medical conditions (e.g. appendicitis) a corpsman sees on a boat and basic medical science concepts particularly pertinent to working with these problems. Twenty eight medical conditions were identified in this manner, and they were all rated by respondents regarding their commonness, importance, difficulty, and how well corpsmen are prepared to work with these conditions. Biomedical concepts were treated similarly.

On the basis of survey results, corpsmen were tested about their ability to work clinically with several important and difficult medical conditions identified from the survey, and about their knowledge of the important related biomedical science. Second year medical students served as a comparison group.

It was found that corpsmen and second year medical students (and their instructors) performed about equally well on important clinical measures, such as forming differential diagnoses, detecting danger to the patient, and taking appropriate action. However, all Navy personnel lagged far behind medical students on conceptual knowledge of the relevant basic sciences, perhaps leaving them short on ability to respond to novel conditions, to improvise, to defend their decisions to supervisors and so forth.

Suggestions are made regarding changes to the corpsman training program which might help corpsmen to acquire and be able to use more basic science conceptual knowledge in their clinical practice. The results from the survey about what is important and difficult can be used to focus new instructional effort. Corpsmen themselves offered desired changes both to training and to operational procedures for a corpsman on a boat.

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TABLE OF CONTENTS

Background and Introduction	01
Objectives	07
Survey Design and Results	09
Basic Science Studies - Method	21
Basic Science Studies - Results	25
Program Changes Suggested by Survey Respondents	30
Conclusions and Implications	32
References	38
Appendix A	43
Appendix B	45



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Conceptual Knowledge Foundations for Naval Medical Training

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for
Manpower Personnel and Training Research and Development Program
(Contract #N00014-88-K-0286)

BACKGROUND AND INTRODUCTION

The officers and crews of the submarine fleet on active missions rely exclusively upon Nuclear Submarine Medical Technicians (NEC-8402s)--also referred to in this proposal as Submarine Corpsmen or IDCs--for their medical attention, with only the Trident class of submarine normally supporting a Medical Officer who is a physician. Because a boat's complement is necessarily young men, with normally only a few Senior Officers and Chiefs exceeding the age of twenty-five, the scope of medical practice is limited to a level taken to be safely manageable by corpsmen with appropriate advanced training. Nuclear Submarine Medical Technician Training at the Naval Undersea Medical Institute (NUMI) provides such training, focusing intensely upon primary care fields: emergency medicine and surgery, internal medicine, and emergency dentistry. For the preservation of mission integrity, MEDEVAC (transporting a sick man off of the boat to other medical facilities) is frequently not an option in the Silent Service, and medical care, when needed, must be delivered by the corpsman (IDC) without the benefit of either consultation or sophisticated laboratory support. This factor places a premium on what particular medical knowledge the IDC both has and can apply in the special clinical task environment provided by a submarine. The corpsman often must be able to evaluate the patient, formulate diagnosis, prescribe management, and provide follow-up care.

In contrast, classical civilian medical care is highly externalized, with attending physicians relying heavily upon external resources: consultants, supporting laboratories, nursing staff, library support, telecommunications, and so forth. These external resources are either not available to, or are limited to the Submarine IDC at sea. For him the resources are highly internalized. The onus is largely upon what the corpsman can do himself, with what he has to work with. What he knows is crucial to which medical problems he can solve. While modern medical care depends upon highly specialized integrated teams of professionals working to complement one and other, the Submarine IDC is relatively alone and must function effectively, combining only the knowledge he has with the limited support resources afforded by the special circumstance of a submarine at sea.

Desirable Qualities of the Independent Duty Corpsman (IDC)

The prime objective of education for Independent Duty Corpsmen is to produce paramedical specialists capable of managing in a competent and humane manner the health problems of the personnel assigned to their care. A secondary objective is that they be prepared for continuing education; either further advanced specialist training or regular updating of currently existing knowledge and skills. To achieve this, the corpsmen produced must have both knowledge and the ability to use that knowledge. Equally important, they must be able to recognize when a health care problem is beyond the scope of their expertise. They must know their own limitations--when to seek expert referral or assistance--but still manage to function according to principles of sound medical practice when superior expertise is quite difficult to obtain (for example, on a submerged submarine on a strategic mission or when strategic considerations render expert referral inadvisable). No school can teach all the knowledge, facts, concepts, and skills that may eventually be needed. Even if this could be done, much of the knowledge would be forgotten by the students and much of what remained would be out of date or inappropriate in the face of ever advancing medical know-how. Skills of self-directed learning are therefore essential if the corpsmen are to remain competent and effective upon assuming a duty assignment after leaving the setting of formal education.

In sum, desirable qualities of the product of IDC training, the corpsmen, include the following:

- 1) The ability to handle routine cases competently. The corpsman must be able to deal effectively with the typical medical problems indigenous to the population under his care and to the settings of corpsman practice. Because of the relatively restricted age-range of patients and known characteristics of the duty environment, common problems can sometimes be anticipated (e.g., Duffy, 1984).
- 2) The ability to recognize non routine problems and to take appropriate actions. The corpsman must be able to recognize when a problem is outside of the scope of his competence so that help can be sought, if this is possible. When immediate consultation is not feasible, the corpsman must be able to manage non-routine problems aptly until help can be obtained.
- 3) The ability to apply what is taught. Knowledge cannot be "inert," but, rather, must be linked to the contexts of application, so that its potential usefulness can be recognized, and it must be organized in a way that supports use, reasoning, and, at times (e.g., nonroutine cases), a degree of adaptive flexibility and inventiveness.

- 4) A firm basis for further growth of knowledge and skills. This includes the ability to appraise his own knowledge, to know when and in what ways it is deficient, and the ability to use resources and experiences effectively to improve. It also includes knowledge that is in a form amenable to change.

Definitions and a Statement of the Issues to be Addressed

With these overriding objectives in mind, this project undertook to determine some specific en route goals to help enable the Submarine Corpsman Training Program to continue its ongoing progress in developing and improving the training of Submarine Independent Duty Corpsmen. In the subsections to follow, knowledge and learning experiences that appear useful in promoting desirable capabilities for the corpsman are discussed. In the discussion, the following definitions apply:

- a) Conceptual knowledge refers to a network of knowledge structures that constitute an individual's understanding of concepts and principles pertinent to a problem (e.g., Feltovich, Spiro, & Coulson, 1989; Hiebert & Lefevre, 1986). In the context of the discussion, it can be assumed to refer to biomedical science concepts pertinent to medical problems faced by the corpsman.
- b) Procedural knowledge is knowledge of how to accomplish tasks (Anderson, 1983; Hiebert & Lefevre, 1986). This includes algorithms or protocols for handling specified kinds of problems, manual skills, and so forth. Procedural knowledge can be learned and applied by rote, or may be grounded in or related to conceptual knowledge to various degrees.
- c) Case-based learning. This is learning that takes as its focus problem instances in the domain of application of knowledge (e.g., Barrows, 1983; Spiro, Vispoel, Schmitz, Samarungaven, & Boerger, 1987; Spiro, Coulson, Feltovich, & Anderson, 1989). With regard to corpsman training, this is learning that focuses on medical cases--their presentations, variations, solutions, and the conceptual knowledge pertinent to their understanding.

As will be seen in the remainder of the report, much of what was investigated and discovered in the research project has to do with the actual and desirable roles of these in the training and performance of the Submarine IDC. The project particularly focused on the IDC's knowledge of and ability to use basic biomedical conceptual knowledge in working with clinical problems, since there is reason to believe that such knowledge is important for enabling the cognitive qualities in a corpsman that are desired.

Dealing with Routine Problems

To the extent that situations of problem solving or other applications of knowledge can be anticipated and are regular (substantially non-varying), training for working in these situations can be relatively procedural. However, even classic looking, "textbook" medical cases can contain elements of irregularity and variation (Feltovich, Johnson, Moller, & Swanson, 1984; Lesgold, Feltovich, Glaser, & Wang, 1981), suggesting the need for training on dimensions of case variation (which can be accomplished by case-based instruction) and for a conceptual foundation to be used in resolving apparent anomalies in problem features (Lesgold, et al., 1981).

Dealing with the Non-Routine

For the corpsman, knowing when he needs consultation or other decision aids is a matter of judgment or "educated common sense." This ability is often the product of extensive practice and experience, as wide experience with cases yields knowledge of ranges for patients' signs and symptoms and for the range of expected patterns of patient findings. Judicious case-based training may provide the potential for "compacting" such experience within the confines of formal training. In addition, the recognition of oddity, especially the sense of things "not hanging together" in a reasonable way, can be aided by conceptual knowledge, as can the ability to judge whether a potential approach to problem solution is sensible (Davis & McKnight, 1980; Gelman & Meck, 1986; Schoenfeld, 1983).

Absence of Consultation

When consultation with an individual of greater expertise must be delayed, the corpsman must still be able to function in an adequate manner. This places importance on a knowledge base that can support inference and, perhaps, invention, both of which have been shown to be aided by a sound basis in conceptual knowledge (Kieras & Bovair, 1983; Spilich, Visonder, Chiesi, & Voss, 1979). Other sources of the required cognitive flexibility of the corpsman are the invocation of analogy (which in the medical domain includes a repertoire of past cases resembling the current one on various dimensions) and the ability to call forth ("reminding"--Ross, 1984) these potentially relevant past precedents in the course of working with the problem. Both reminding and the use of analogical precedents is facilitated by experience with cases. However, facility in the use of both reminding and analogy requires deliberate attention to the structural similarity between the "current" problem and potential helpful precedents from instruction or experience (Gick & Holyoak, 1983).

The Application of Knowledge

In situations where application environments can be anticipated and are regular, and in which procedures can be linked reliably to these environments (well-structured domains), training can be relatively procedural. However, even in

these circumstances, conceptual knowledge and case-based instruction have a place. The problem features that are to invoke knowledge need to be learned, and knowledge must be elicited by these features; the latter involves an "inverting" of the knowledge base so that it is indexed not by topics, but by features of the environment (Feltovich, 1983). Learning of applicability conditions and the inverted indexing of the knowledge base suggest the utility of case-based instruction. Even when knowledge is indexed appropriately by application context, the knowledge must still be "instantiated" or translated to the particulars of the context of application. This translation of generic knowledge, including procedural knowledge, to the particulars of situations is, again, aided by conceptual knowledge (Schoenfeld, 1986).

Ill-structured Knowledge Domains

In contrast to domains that are well-structured, in circumstances where either the domains of application are variable and irregular or the concepts to be applied are multifaceted and complex (ill-structured problem domains), direct instruction regarding recognition of conditions and procedures to be applied will not suffice (Spiro et al., 1987, 1939). These are, in short, situations that are likely to be difficult or novel, and that call upon the corpsman's ability to assemble and use knowledge flexibly. The variable presentation of problems and the irregularity of application of concepts, including, perhaps, the partial applicability of many concepts, implicates the need for case-based instruction. In this type of instruction, the ranges of the variable presentations of problems and the partial and variable applicability of concepts can be both viewed and explored.

A Firm Basis for Further Learning and Development

There is evidence that conceptual and procedural knowledge "bootstrap" each other in the development of cognitive competence (Baroody & Ginsburg, 1986; Gelman & Meck, 1986; Glaser, 1984). Conceptual knowledge gives meaning to procedures, aids in their recall, and can promote flexibility of application (Chi, Feltovich, & Glaser, 1981; Kieras & Bovair, 1984; Resnick, 1982); at the same time the practice of procedures in contexts of application can yield insights leading to fuller conceptual understanding (Baroody & Ginsburg, 1986). In addition, "comprehension monitoring," the self-judgment of how well problem solving is progressing, the self-assessment of whether one's knowledge base is adequate for a task, and subsequent changes to knowledge--upon detecting inadequacy--that are fundamental rather than being superficial "repairs", appear to be aided by a sound conceptual knowledge base (Bransford, Stein, Shelton, & Owings, 1982; Brown & VanLehn, 1980; VanLehn, 1986).

While sound conceptual knowledge can aid further learning and application, early conceptual understanding for difficult and complex concepts is often faulty (Coulson, Feltovich, & Spiro, 1989; McCloskey, 1983) and can impede the

development of more sophisticated understanding in serious ways; this is often the result of trying to teach and learn complex material by overly simplifying it (Feltovich, Spiro, & Coulson, 1989; Spiro, Feltovich, Coulson, & Anderson, 1989). Introductory learning regarding difficult ideas must occur in a way that facilitates and does not impede further development. This is particularly important in situations where the time for training is short; a realistic balance must be struck between accommodations that are necessary because of the shortness of time and the need for a sound foundation in knowledge that can be built upon.

OBJECTIVES

The broad objectives of this research were to provide information useful to the selection of topics, biomedical concepts, and clinical case environments that are particularly important and difficult for the practicing corpsman to handle (and, hence, may require special effort in instruction) and to determine the kinds of difficulties student IDCs have in learning and understanding in some of these areas. It was intended that this information could provide guidance for focus in the curricula of Submarine Corpsman training and possibly for the development of case-based components of instruction that the Navy may wish to adopt. It was also anticipated that knowledge derived from the studies would be useful in providing direction for the development of other kinds of instructional tools, such as intelligent computer instructional systems, or those employing interactive videodisc technologies. Specific objectives were as follows:

1. (INFORMATIONAL SURVEY) To create a procedure for identifying case environments and biomedical concepts that are important to the practice of the Submarine Corpsman but that are especially difficult for corpsmen to handle. An additional objective was to actually identify and catalogue these case types and concepts as a result of applying this procedure.
2. (INVESTIGATIVE STUDIES) To conduct "laboratory" investigations to gain a better understanding of why some select medical problem areas, and their related topics and biomedical concepts identified through the process, (above) are difficult for student corpsmen to learn, understand, and apply.

Within this framework, the strategy that the project adopted can be outlined as follows:

- 1) Medical problem areas especially relevant for the work of the corpsman (e.g., Appendicitis) were chosen for study by interviewing personnel close to the IDC Corpsman program and by conducting a follow-up formal survey with many individuals associated with this program.
- 2) Selected concepts and topics pertinent to working effectively with these identified medical problem areas were chosen for laboratory studies of corpsman students' learning, understanding and application of the concepts and topics, in order to assess their capabilities with this subject matter.
- 3) Based on these studies, suggestions are to be made in this report about possible changes to the training program program for Submarine Corpsmen and, to a lesser extent, to the operating procedures for corpsmen on boats. These are addressed at the end of this report.

The two main components of our project, the surveying to determine important medical problem areas and the laboratory studies of students' conceptual capabilities are taken up in the next two main sections. These are followed, at the end, by a discussion and consideration of implications.

THE SURVEY TO DETERMINE MEDICAL PROBLEMS AND BIOMEDICAL CONCEPTS

One of the two major parts of the project was the development and administration of a survey questionnaire (OPNAV Control Symbol 6420-1). There were a number of objectives for the survey. One was to determine the kinds of medical conditions a corpsman commonly sees on a boat. The second was to determine medical conditions that, while perhaps not as common, are important (because of potential consequences to the man or the boat) or difficult to deal with (e.g., because useful equipment is not typically available on a boat) when they are seen. The third aim was to determine for these medical problem areas topics of biomedical conceptual knowledge respondents considered to be important to handling each medical condition well and that were also difficult to learn and apply. For both the medical problem areas and the related biomedical conceptual knowledge, a fourth objective was to gain opinions about the degree of preparedness provided by the Submarine IDC training program. Additional objectives pertained to gaining an appraisal of how clinical medical duties fit in with other aspects of the corpsman's job and to solicit opinions about how areas of training or operating procedure might be changed to enable the corpsman to do his work better. In this and the next sections, the development and administration of the survey questionnaire are described, followed by a presentation of the results.

Interviewing in Preparation for Construction of the Questionnaire

Interviews were conducted with individuals associated with the Submarine IDC program to gain background information to be used in the construction of the survey questionnaire and to familiarize the investigators with the submarine IDC program and the submarine corpsman's job.

These interviews were conducted with people with diverse relationships to the submarine IDC program. A total of sixteen individuals were interviewed, including six medical officers, one radiation health officer, one physician's assistant, four enlisted instructors (from NUMI), and four serving corpsmen (including two group/squadron corpsmen supervisors). After specification from the project investigators that the group represented knowledgeable and diverse perspectives on the corpsman program, interviews were arranged for the investigators with the cooperation of personnel at NUMI where all the interviews were conducted. Interviews were conducted by both principal investigators for the project, using a structured interview technique. Individuals were asked to respond in four areas:

- 1) the kinds of medical conditions (e.g., ulcers) the corpsman sees on a boat, including ones that are common, ones that are important (although perhaps not common), and ones that are difficult to handle,

2) basic biomedical science knowledge that is important to dealing with these medical conditions well, but which is also difficult for the corpsman to learn well and apply,

3) general characteristics of the corpsman's job and training, and

4) aspects of the corpsman's job or training that these individuals would expand or change, if they could, to make the corpsman more effective in his job.

Because at the time the the investigators were new to the project and the the Submarine IDC program, considerable leeway was given to the interviewees to discuss the IDC program beyond the structured questions. Interviews were conducted individually and each lasted about one hour. Interviews were not tape recorded; notes were taken by the two investigators.

Because the main objective of the interviewing was to gain some specific information (in particular about the common and difficult conditions a corpsman sees) as well as some general guidance for developing a formal questionnaire, not all aspects of the interviews were analyzed formally. Hence, some specific items from the interview will be reported here, along with some general impressions (better data in relation to these impressions will be reported later in the report, from the results of the formal suveying). The results from the surveying are as follows:

Medical conditions. A total of 80 discernably different (with much overlap, e.g., sprains of "ankles," "knees," "back," "sprains," and "strains," can all be considered as "orthopedic sprains and strains") medical conditions were noted as common, 60 different conditions were noted as important (because of potential consequences to the man or boat), and 23 conditions were identified as difficult (for a variety of reasons, e.g., unavailability of pertinent equipment on a boat).

The topics varied in their nominations from hot abdomen/appendicitis, where 13 (of 17) interviewees mentioned this topic as important, to some conditions that were nominated by only one person in any of the three categories. Twenty-eight conditions were mentioned by four or more (of 17) people as being either common, important, or difficult. These medical conditions are given in Table 1, and were used in constructing the formal survey instrument.

INSERT TABLE 1 ABOUT HERE
(28 med. conds. from interviewing)

Basic science conceptual knowledge. One major intent of this questionning was to identify biomedical science concepts (e.g, oxy-hemoglobin dissociation) that interviewees considered important to being able to handle each medical condition effectively and, within the set of these, to identify pertinent concepts that were

TABLE 1
MEDICAL PROBLEM AREAS for QUESTIONNAIRE

1. CHEST PAIN
2. DIARRHEA
3. OTITIS, EAR INFECTION
4. HIATAL HERNIA
5. GASTROENTERITIS
6. HEAD INJURY
7. PNEUMONIA
8. APPENDICITIS
9. BRONCHITIS
10. HEADACHE
11. RENAL CALCULUS, KIDNEY STONES
12. MYOCARDIAL INFARCTION, HEART ATTACK
13. HEMAFECIA, BLOODY STOOLS
14. FUNGAL INFECTIONS
15. ORTHOPEDIC STRAINS & SPRAINS
16. GASTROINTESTINAL FLU
17. MENINGITIS
18. HEMATURIA
19. HERNIA
20. TORSION TESTICLE
21. ULCER
22. URETHRITIS
23. DERMATITIS, SKIN RASHES
24. ORTHOPEDIC FRACTURES
25. COLDS & VIRUSES
26. PROSTATITIS
27. TRAUMA, LACERATIONS & CONTUSIONS
28. PSYCHOLOGICAL, TRANSIENT SITUATIONAL DISORDERS

judged to be particularly difficult for corpsman students to learn well. When asked, individuals almost universally did not give responses at the level of particular concepts. When responses to the question were given at all, these tended to identify more global fields of knowledge, for example, cardiac physiology, rather than somewhat circumscribed concepts. The investigators took the difficulty in responding to this question as indication of the level of basic science knowledge that could be addressed successfully (that respondents would have some understanding of) in the formal survey, and that, in particular, focus on specific biomedical concepts would not be fruitful.

Change/expansion to training/operating procedure. A total of 28 discernably different (again, with overlap) responses were given to the open question about changes/expansions to training or operating procedure interviewees would like to have happen to make the corpsman more effective in his job. The twenty-eight items fell into four groups, with four items related to administration, three related to radiation health, seven related to continuing education, and fourteen related to medical skills. The number of individuals suggesting a particular item ranged from a high of 6 (of 17) wanting better training in "time management" for the corpsman, to 12 items that were suggested by only one person. Besides time management, other items that were mentioned by three or more people included: organizational skills (4) and resource management (5); radiation health administration (3); better self-directed learning skills (3) and training in the use of reference materials (3); better knowledge of physiology to serve in the recognition of serious illness (4) and improved capabilities for doing differential diagnosis (3).

Development of the Survey Questionnaire

Aided by the results of the interviewing just discussed, a questionnaire addressing similar issues was constructed to be used in an extensive survey of personnel associated with the submarine IDC program. The questionnaire that was ultimately used in the survey had three main kinds of items (in addition to demographic information about the respondent), one type comprising most of the questionnaire, and the other two quite brief.

Questions about medical problem areas or conditions. The largest part of the questionnaire was composed of 28 sheets, one for each of the 28 medical problem areas suggested by interviewing as being particularly common, important, or difficult. One of these sheets, for "diarrhea," is given as Figure 1; sheets for the other 27 conditions have identical form (but different content in one area, to be discussed). Each sheet, in turn, had two major parts. The first part presented five questions about the medical condition itself (termed medical "problem" in the questionnaire), which was targeted on that sheet (e.g., diarrhea). The respondent was asked, in turn, to rate the Commonness of the medical problem (relative to the standards of the boat), the Importance of the the problem (in terms of consequences to the patient or the boat), the Difficulty for a corpsman to handle that type of

problem (with an additional item asking for explanation of why the problem was judged difficult to handle, if the respondent rated it as such), and, finally, how well corpsman training Prepares a corpsman for handling that medical problem. All of these ratings were on a five point scale, with end-points described appropriately for each rating. For example, the scale for "Difficulty" ranged from 1-NOT DIFFICULT to 5-VERY DIFFICULT (see Fig. 1). The second part of each sheet focused on biomedical science conceptual knowledge pertinent to working with the type of problem targeted on the sheet. Three basic science topics were presented for the respondent to rate, each in four ways (see Fig. 1): how Familiar the topic was to the respondent, how Important the topic is for "thorough understanding of the problem area," how Hard the topic is to learn well, and how well corpsman training Prepares people in the topic. In addition to the three basic science topics provided for rating on each sheet, space was provide for the respondent to provide up to three additional ones and to rate these in the same way. Ratings for basic science topics were, again, done on five point scales.

 INSERT FIGURE 1 ABOUT HERE
 (survey sheet)

Basic science topics provided for rating in the questionnaire varied across the 28 medical conditions. For each of these medical problem areas, basic science topics were selected for inclusion in a process involving two components. The first involved input from a physiologist and a physician/surgeon pertinent to the medical problem area under consideration (e.g., an Orthopedic surgeon for "Orthopedic Strains and Sprains" and for "Orthopedic Fractures"), concerning areas of basic science pertinent to being able able to handle the medical problem well (e.g., being able to diagnose and manage well). The second kind of guidance for topics to include came from one part of the piloting that was done on the survey form. After an initial set of topics was chosen by the process just described, the questionnaire was given to an individual knowledgable about medicine and important to the curriculum of the submarine IDC training program (promises to individuals who participated in our project to assure their anonymity prevent more precise characterization of this individual). This person rated all the basic science topics provided at that time for all 28 medical conditions, and for each condition generated at least one additional basic science topic and rated these in the same way. In cases where a newly generated item was rated as more important (to the medical condition) than was a provided item, the items were switched in construction of the final version of the form. Very few (about seven, of 84) items were switched in this way.

The nature of the corpsman's job on the boat. One item in the questionnaire asked for a description of the corpsman's activities on a boat. Based on information gained in interviewing, eight categories of activity were provided for the respondent--including Face-to-face medical care, Clinical recording (logging) of medical care, Radiation health, Immunization, Pharmacy and medicines, Environmental quality, Occupational safety, and Discharge and transfer summaries.

1. PROBLEM OR TOPIC:

CHEST PAIN

2. How common (relative to the standards of the boat) is this type of problem?

NOT COMMON VERY COMMON
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

3. How important (consequences to the patient or the boat) is this type of problem?

NOT IMPORTANT VERY IMPORTANT
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

4. How difficult is it to handle this type of problem?

NOT DIFFICULT VERY DIFFICULT
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

5. If you rated the question above, about difficulty, with either a 4 or 5, tell why it is difficult in the space below.

6. How well does corpsman training prepare for this type of problem?

NOT WELL VERY WELL
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

7. Listed below are three subtopics related to the medical problem area given at the top of the page. Rate each of these subtopics with regard to: I, How **FAMILIAR** you are with the related subtopic; II, How **IMPORTANT** you think the related subtopic is for thorough understanding of the problem area given at the top of the page; III, How **HARD** the related subtopic is to learn well; and IV, How well corpsman training **PREPARES** for this related subtopic. In the blank spaces below suggest up to three more subtopics pertinent to the problem area given at the top of the page, and rate them in the same way.

SPECIFIC TOPICS	I. HOW FAMILIAR?		II. HOW IMPORTANT?		III. HOW HARD?		IV. HOW PREPARED?	
	NOT	VERY	NOT	VERY	NOT	VERY	NOT	VERY
CARDIAC ELECTROPHYSIOLOGY	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5
THORACIC ANATOMY	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5
DIFFERENTIAL DIAGNOSIS	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5
A. _____	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5
B. _____	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5
C. _____	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1	☐ 2 ☐ 3 ☐ 4 ☐ 5

SECTION TWO: PAGE 1

Figure 1. Sample sheet from questionnaire for the problem area of chest pain.

An additional "Other" category was provided for activities not described by those provided. Respondents were requested to "Estimate the percentage of a corpsman's time (in a typical week on a boat) spent on the following activities [those just listed above in this paragraph]. The total should add up to 100."

Suggestions for training and operational procedure. Two open-response questions gave the respondent the opportunity to suggest improvements, one for the training of submarine corpsmen, and the second for operating procedures on the boat:

- 1) "If you could change or expand any three aspects of Submarine IDC training to better prepare the corpsman for what he will actually experience on the job, what would they be? Even though you may have many ideas, please choose the three most important and write them in the box below."
- 2) "If you could change or expand any three aspects of operating procedure for the Submarine IDC to better serve the medical needs of the crew and the boat, what would they be? Even though you may have many ideas, please choose the three most important and write them in the box below."

During development the questionnaire was pilot tested twice with a Group Corpsman, a NUMI Instructor, and a Medical Officer and was also presented at a meeting at the Office of Naval Research attended by Bureau of Medicine personnel. The initial piloted version was, in concept, much like the one that was ultimately used but differed in two substantial ways. It had more questioning about the corpsman's job, and it required respondents themselves to propose areas of basic science pertinent to the 28 medical conditions. Both of these contributed considerably to the time required to complete the survey, and, in the case of the latter, it was not particularly easy for respondents to do. Hence, job-related questions were reduced to the few that remain (described above), and it was decided to provide selected basic science items for each medical condition (rather than requiring respondents to create their own), while also providing respondents the opportunity to generate their own additional ones. A new form was created which was again pilot tested with a Group Corpsman, a NUMI Instructor, and a Medical Officer. The new form was also sent to DMDC for critique. As a result of these actions minor changes were made, mostly involving simplification and clarification of instructions and formats. In addition, minor changes were made (discussed in the last section) to some of the basic science items provided in the questionnaire for medical conditions.

Procedure for Administration of the Questionnaire

It was the intention of the investigators to distribute the questionnaire to all (then) active duty SUBLANT medical officers, all (then) current instructors at NUMI, and all active duty SUBLANT submarine IDC's. Hence, corpsmen themselves, those

who teach corpsmen, and those who supervise corpsmen would be surveyed. A request was made to the Bureau of Personnel to provide mail addresses for this population, and a set was provided.

Two hundred and nineteen surveys were mailed as priority mail on 30 May, 1990. Self-addressed stamped (priority mail) folders were included with the questionnaire for return mailing. Forty-four questionnaires were returned by 28 June, 1990, at which time a follow-up mailing was sent. This included a reminder letter and a return post card. This post card asked the respondent to declare his intentions with regard to the survey, that is, whether, 1) he had already completed and was returning the form (it's in the mail), 2) he had lost the materials and needed new ones (in which case we would send new ones) or, 3) he had no intention of participating in the survey.

Thirty-eight additional questionnaires were returned after the reminder, with the (apparently) last one received on 21 November, 1990. Seven questionnaires that were promised by return post card to be completed and returned have never been received. Nineteen post cards stated the intention not to participate. Hence, at the close of the survey, 82 questionnaires were returned. Seven (of the original 219) people have explicitly informed the investigators that the survey was not applicable to them (i.e., non-corpsman-related jobs). For this reason, the functional original population is at most 212 and likely smaller (surmizing that there might be as many or more non-applicable people who did not bother to inform of this as there were those who did). The overall response rate, then, is $82/(219-7) = .39$, and may be somewhat higher, depending on how many nonrespondents were individuals inappropriate for the survey. Responses were received from 51 corpsmen, 14 medical officers, and 10 instructors. Six other questionnaires were not useably completed by the respondents.

Results of the Survey Concerning Medical Conditions Seen by The Corpsman

In this section, results are presented from that part of the survey concerned with medical conditions a corpsman deals with in his work. Results from other parts of the survey pertaining to the time distribution for activities in the corpsman's job and respondents' suggestions for improving training and job operations will be reported in later sections of the report.

Medical Problem Areas

Commonness. In this section are reported the results of the ratings of Commonness (relative to the standards of presentation of illness in a submarine) for the 28 medical conditions presented in the survey. The mean ratings (and standard deviations) are presented in Table 2. Commonness ratings ranged from a high (high commonness) of 4.83 for Colds and Upper Respiratory Infections to a low (low commonness) of 1.10 for Meningitis. Also rated as quite common were Headache,

Trauma-lacerations and Contusions, Orthopedic Strains and Sprains , and Dermatitis/Skin Rashes. Also rated as quite uncommon were Torsion Testicle, Myocardial Infarction/Heart Attack, Hiatal Hernia, and Fungal Infections/Pulmonary Mycosis.

INSERT TABLE 2 ABOUT HERE
(ratings of common--28 conditions)

There were a number of significant (.05 level) differences among the subgroups of respondents in their ratings of the commonness of the medical conditions. Differences in commonness were present for eleven of the twenty-eight medical conditions. Medical officers rated five conditions (Gastroenteritis, Renal Calculus/Kidney Stones, Gastrointestinal Flu, Psychological Transient Situational Disorders, and Urethritis/ Epididymitis) as being more common than did either the corpsmen or the instructors. Medical officers rated five conditions (Chest Pain, Pneumonia, Bronchitis, Hematuria/Bloody Urine, and Gastrointestinal Ulcer) as being more common than the instructors did, but with no significant difference from the ratings of the corpsmen. One condition (Fungal Infections/Pulmonary Mycosis) was rated higher by the corpsman than the medical officers, but with no difference from the instructors. As reflected above, for ten of the eleven conditions where differences were noted, the pattern of means was that the medical officers rated the conditions as most common, followed by the corpsmen and then the instructors. This trend indicates that the medical officers perceive a number of medical conditions a corpsman sees as being more common than do the corpsmen themselves who work on boats and the people who train them (who usually have had some experience on boats).

Importance. In this section are reported the results of the ratings of Importance (in terms of implications for the man or the mission) for the 28 medical conditions presented in the survey. The mean ratings (and standard deviations) are presented in Table 3. Importance ratings ranged from a high (high importance) of 4.92 for Myocardial Infarction/Heart Attack to a low (low importance) of 2.24 for Dermatitis/Skin Rashes. Also rated as quite important were Appendicitis, Meningitis, Torsion Testicle, and Head Injury. Also rated as quite unimportant were Diarrhea, Otitis/Ear Infections, Hiatal Hernia, and Prostatitis.

INSERT TABLE 3 ABOUT HERE
(ratings of importance for 28 conditions)

There was strong consensus among the subgroups of respondents about the importance of the twenty-eight medical conditions. Only one difference was

TABLE 2
Ratings of Commonness for
Medical Problem Areas
(ascending order of Commonness)

BRIEF CONDITION		COMMON	S.D.
1	MENINGITIS	1.100000	0.34683
2	TORSION TESTICLE	1.217390	0.53878
3	HEART ATTACK	1.239440	0.52002
4	HIATAL HERNIA	1.619720	0.86794
5	APPENDICITIS	1.722222	1.05112
6	FUNGAL INFECTION	1.732390	1.06848
7	CHEST PAIN	1.805560	0.76248
8	BLOODY STOOL	1.928570	1.04009
9	HEAD INJURY	1.958330	1.08040
10	G.I. ULCER	2.057970	0.96838
11	INGUINAL HERNIA	2.112680	0.97906
12	BLOODY URINE	2.114290	0.98603
13	PNEUMONIA	2.166670	1.00702
14	PROSTATITIS	2.183100	1.04622
15	FRACTURES	2.260870	0.94949
16	KIDNEY STONES	2.295770	1.13885
17	PSYCHOLOGICAL	3.000000	1.24212
18	URETHRITIS	3.188410	0.89567
19	BRONCHITIS	3.263890	1.13824
20	G.I. FLU	3.295770	1.19993
21	OTITIS	3.402780	1.01620
22	D'ARRHEA	3.444440	1.07322
23	GASTROENTERITIS	3.788730	1.04082
24	DERMATITIS	4.352110	0.73870
25	SPRAINS	4.485710	0.77540
26	TRAUMA	4.521130	0.69404
27	HEADACHE	4.569440	0.66769
28	COLDS	4.826090	0.41856

TABLE 3
Ratings of Importance for
Medical Problem Areas
(ascending order of Importance)

	BRIEF CONDITION	IMPORTANT	S.D.
1	DERMATITIS	2.23944	1.04833
2	DIARRHEA	2.43056	0.99047
3	OTITIS	2.45833	1.00614
4	COLDS	2.55072	1.07835
5	PROSTATITIS	2.56338	0.85744
6	HIATAL HERNIA	2.60563	1.07543
7	URETHRITIS	2.65714	0.84931
8	HEADACHE	2.83333	1.04814
9	GASTROENTERITIS	2.84507	0.98049
10	G.I. FLU	2.84507	1.00921
11	BRONCHITIS	2.86111	0.89294
12	FUNGAL INFECTION	2.88732	0.97906
13	SPRAINS	2.94286	1.15327
14	INGUINAL HERNIA	3.08959	1.08437
15	TRAUMA	3.19718	1.06395
16	BLOODY STOOL	3.50704	1.11961
17	BLOODY URINE	3.52113	0.99799
18	PNEUMONIA	3.54167	0.93353
19	PSYCHOLOGICAL	3.88732	0.90316
20	FRACTURES	3.90000	0.80127
21	KIDNEY STONES	4.18310	0.88334
22	CHEST PAIN	4.23611	1.08112
23	G.I. ULCER	4.32857	0.81154
24	HEAD INJURY	4.45833	0.80382
25	TORSION TESTICLE	4.64286	0.51177
26	MENINGITIS	4.76056	0.46182
27	APPENDICITIS	4.77778	0.48126
28	HEART ATTACK	4.91549	0.32717

demonstrated, with corpsmen rating Hiatal Hernia as being more important than either the medical officers or the instructors.

Difficulty. In this section are reported the results of the ratings of Difficulty (for various reasons, including training required or facilities available on a boat) for the 28 medical conditions presented in the survey. The mean ratings (and standard errors for each) are presented in Table 4. Difficulty ratings ranged from a high (high difficulty) of 4.76 for Myocardial Infarction/Heart Attack to a low (low difficulty) of 1.69 for Diarrhea. Also rated as quite difficult were Meningitis, Head Injury, Chest Pain, and Torsion Testicle. Also rated as not difficult were Otitis/Ear Infections, Orthopedic Strains and Sprains, Colds and Upper Respiratory Infections, and Urethritis/ Epididymitis.

INSERT TABLE 4 ABOUT HERE
(ratings of difficulty 28 conditions)

There was strong consensus among the subgroups of respondents about the difficulty of medical conditions. Only two differences were demonstrated. Medical officers judged Headache to be more difficult than both the corpsmen and the instructors. Instructors judged Renal Calculus/Kidney Stones to be more difficult than did the medical officers, but with no difference between the instructors and the corpsmen.

Preparedness. In this section are reported the results of the ratings of how well Corpsman training prepares corpsmen for dealing with the 28 medical conditions presented in the survey. The mean ratings (and standard errors for each) are presented in Table 5. Preparedness ratings ranged from a high (high preparedness) of 4.39 for Otitis/Ear Infections to a low (low preparedness) of 2.53 for Myocardial Infarction/Heart Attack. Other conditions for which preparedness was rated very high were Colds and Upper Respiratory Infections, Trauma-lacerations and Contusions, Orthopedic Strains and Sprains, and Diarrhea. Other conditions for which preparedness was rated very low were Fungal Infections/Pulmonary Mycosis, Psychological Transient Situational Disorders, Meningitis, and Chest Pain.

INSERT TABLE 5 ABOUT HERE
(ratings of preparedness 28 conditions)

There were a number of differences among the subgroups regarding preparedness of the corpsman to handle the twenty-eight medical conditions. Differences were demonstrated in four of seven medical conditions. Instructors judged corpsmen to be better prepared than did the medical officers (but not greater than the corpsmen did) for three conditions (Headache, Meningitis, and Myocardial Infarction/Heart Attack). Both the instructors and corpsmen judged

TABLE 4
Ratings of Difficulty for
Medical Problem Areas
(ascending order of Difficulty)

	BRIEF CONDITION	DIFFICULT	S.D.
1	DIARRHEA	1.69444	0.66373
2	OTITIS	1.75000	0.72675
3	SPRAINS	2.07143	0.96791
4	COLDS	2.07246	0.94431
5	G.I. FLU	2.11268	0.80266
6	URETHRITIS	2.14286	0.76681
7	GASTROENTERITIS	2.16901	0.69664
8	TRAUMA	2.30000	1.08146
9	PROSTATITIS	2.31429	0.67121
10	BRONCHITIS	2.31944	0.81925
11	HIATAL HERNIA	2.46479	1.03966
12	HEADACHE	2.48611	0.90372
13	INGUINAL HERNIA	2.55714	0.94233
14	PNEUMONIA	2.69444	0.72460
15	DERMATITIS	2.74648	0.98152
16	BLOODY URINE	2.91429	0.88043
17	FUNGAL INFECTION	2.92754	0.94431
18	KIDNEY STONES	3.18310	0.96080
19	BLOODY STOOL	3.25714	1.07253
20	FRACTURES	3.37143	0.87097
21	G.I. ULCER	3.38571	1.08070
22	PSYCHOLOGICAL	3.57746	0.83942
23	APPENDICITIS	3.77465	1.05826
24	TORSION TESTICLE	3.82857	0.99231
25	CHEST PAIN	3.94444	1.01937
26	HEAD INJURY	3.95833	0.98492
27	MENINGITIS	4.18310	0.89936
28	HEART ATTACK	4.76056	0.54680

TABLE 5
Ratings of Preparedness for
Medical Problem Areas
(ascending order of Preparedness)

	BRIEF CONDITION	PREPARED	S.D.
1	HEART ATTACK	2.44776	1.13195
2	FUNGAL INFECTION	2.55072	1.06462
3	PSYCHOLOGICAL	2.76812	1.07300
4	CHEST PAIN	2.97183	1.02778
5	MENINGITIS	3.01429	1.02848
6	BLOODY STOOL	3.15714	0.91105
7	HIATAL HERNIA	3.19718	0.88833
8	HEAD INJURY	3.22222	1.02397
9	DERMATITIS	3.22535	1.05826
10	TORSION TESTICLE	3.31429	0.95618
11	BLOODY URINE	3.44286	0.71497
12	FRACTURES	3.55714	0.95759
13	PROSTATITIS	3.60563	0.85321
14	INGUINAL HERNIA	3.64789	0.77641
15	G.I. ULCER	3.79104	0.72900
16	PNEUMONIA	3.88889	0.66196
17	HEADACHE	3.90278	0.82496
18	G.I. FLU	3.92857	0.82218
19	BRONCHITIS	3.97222	0.75007
20	URETHRITIS	4.00000	0.72761
21	KIDNEY STONES	4.02857	0.90043
22	GASTROENTERITIS	4.08571	0.69663
23	DIARRHEA	4.16901	0.81040
24	APPENDICITIS	4.17143	0.85077
25	SPRAINS	4.18841	0.86220
26	TRAUMA	4.22535	0.83147
27	COLDS	4.24638	0.82370
28	OTITIS	4.38571	0.68721

preparation for Appendicitis and Fungal Infections/Pulmonary Mycosis to be higher than did the medical officers. Instructors judged the corpsman's preparedness for Hemafecia/Bloody Stools to be greater than did both the medical officers and the corpsmen. Instructors judged preparedness for Gastrointestinal Flu as greater than did the corpsmen (but not greater than the medical officers). The most notable trend appears to be that for all seven medical conditions that showed differences, the instructors rated preparedness to be the greatest.

Importance and difficulty. The number of respondents who rated each of the medical conditions high (4 or 5 on the 5-point scale) on both the dimensions of Importance and Difficulty were also considered. The results of this analysis are given in Table 6. This Table presents each medical condition and the number of respondents who rated it both important and difficult. The conditions range from a high of 73 respondents for Myocardial Infarction/Heart Attack to a low of zero respondents rating Prostatitis, Diarrhea, and Urethritis/ Epididymitis as both important and difficult. The top ten medical conditions as determined in this manner (Importance&Difficulty) were:

- 1) Myocardial Infarction/Heart Attack (73),
- 2) Meningitis (57),
- 3) Torsion Testicle (53),
- 4) Chest Pain (52),
- 5) Head Injury (50),
- 6) Appendicitis (47),
- 7) Psychological Transient Situational Disorders (34),
- 8) Gastrointestinal Ulcer (34),
- 9) Orthopedic Fractures (29), and
- 10) Renal Calculus/Kidney Stones (26).

INSERT TABLE 6 ABOUT HERE
(showing how many rated each of 28 diff and imp)

Preparedness in relation to importance, Difficulty, and Commonness. In addition to the direct rating of preparedness presented above, another measure of Preparedness was created. An Index1 was created to attempt to capture the respondents' perceptions of the corpsman's Preparedness to handle a medical condition, relative to that condition's perceived Commonness, Importance, and Difficulty--how well prepared Corpsmen are for a dealing with a condition, compared to the pervasiveness and impact of the condition. The Index1 that was used for this was the cube root of the ratio of the third power of the mean Preparedness score and the product of the means of Importance, Difficulty, and Commonness, as follows:

TABLE 6
Medical Problem Areas Rated Important & Difficult

No. Rating both
 Important & Difficult

73	MYOCARDIAL INFARCTION/HEART ATTACK
57	MENINGITIS
53	TORSION TESTICLE
52	CHEST PAIN
50	HEAD INJURY
47	APPENDICTIS
34	PSYCHOLOGICAL TRANSIENT SITUATIONAL DISORDERS
34	GASTROINTESTINAL ULCER
29	ORTHOPEDIC FRACTURES
26	RENAL CALCULUS/KIDNEY STONES
19	HEMAFECIA/HEMATOCHEZIA (BLOODY STOOLS)
13	HEMATURIA/BLOODY URINE
9	HERNIA,INGUINAL
9	FUNGAL INFECTIONS/PULMONARY MYCOSIS
8	TRAUMA/LACERATIONS & CONTUSIONS
8	PNEUMONIA
6	HIATAL HERNIA
5	ORTHOPEDIC STRAINS & SPRAINS
3	COLDS & UPPER RESPIRATORY INFECTIONS
2	DERMATITIS/SKIN RASHES
2	GASTROENTERITIS
2	G.I.FLU
1	OTITIS/EAR INFECTIONS
1	HEADACHE
1	BRONCHITIS
0	PROSTATITIS
0	DIARRHEA
0	URETHRITIS/EPIDIDYMITIS

$$\text{Index1} = [\text{Preparedness}^3 / (\text{Commonness} \times \text{Importance} \times \text{Difficulty})]^{1/3}$$

The results of applying this index1 are presented in Table 7. Index1 ratings ranged from a high (high preparedness) of 1.77 for Otitis/Ear Infections to lows (low preparedness) of 0.79 for Psychological Transient Situational Disorders and Myocardial Infarction/Heart Attack (0.82). Other conditions for which preparedness (by the Index1) was rated very high were Diarrhea, Urethritis/ Epididymitis, Prostatitis, Hiatal Hernia, and Colds and Upper Respiratory Infections. The bottom ten conditions for which preparedness was rated low (again, by the index1--and listed in ascending order of Preparedness) were

- 1) Psychological Transient Situational Disorders (least well Prepared),
- 2) Myocardial Infarction/Heart Attack,
- 3) Chest Pain,
- 4) Head Injury,
- 5) Dermatitis/Skin Rashes,
- 6) Fungal Infections/Pulmonary Mycosis,
- 7) Meningitis,
- 8) Hemafecia/Bloody Stools,
- 9) Orthopedic Fractures, and
- 10) Torsion Testicle.

 INSERT TABLE 7 ABOUT HERE
 (preparedness for 28 on index1)

A target set of medical conditions for the training of the corpsman. The union of the ten medical conditions rated both Important and Difficult by the most respondents, and the ten conditions rated least prepared according to the Preparedness Index1 constitute a reasonable set of medical conditions to receive special attention in the training of the corpsman. This set comprises conditions for which Preparedness is judged to be relatively low, in relation to the prevalence and impact of the condition (Index1), plus a few others that are perceived to be critical, independently of degree of prevalence. The set of target conditions, defined in this manner, contains 13 (only 3 items not contained in both groups) medical conditions, listed here in ascending order (ascending order of preparedness) of their score on Index1:

- 1) Psychological Transient Situational Disorders [least well prepared] (.79)
- 2) Myocardial Infarction/Heart Attack (.82)
- 3) Chest Pain (.94)
- 4) Head Injury (1.00)
- 5) Dermatitis/Skin Rashes (1.05)
- 6) Fungal Infections/Pulmonary Mycosis (1.05)
- 7) Meningitis (1.06)

TABLE 7
Ratings of Preparedness in Relation to
Commonness, Importance & Difficulty
(descending order of Preparedness)

CONDITION	P3-INDEX (see text)
1 OTITIS / EAR INFECTIONS	1.765
2 DIARRHEA	1.705
3 URETRITIS / EPIDIDYMITIS	1.525
4 PROSTATITIS	1.504
5 HIATAL HERNIA	1.439
6 COLDS & U.R.I'S	1.439
7 G.I. FLU	1.424
8 GASTROENTERITIS	1.424
9 BRONCHITIS	1.419
10 PNEUMONIA	1.415
11 INGUINAL HERNIA	1.399
12 ORTHOPEDIC STRAINS & SPRAINS	1.391
13 TRAUMA / LACERATIONS & CONTUSIO	1.312
14 APPENDICITIS	1.309
15 RENAL CALCULUS / KIDNEY STONES	1.296
16 HEMATURIA / BLOODY URINE	1.251
17 HEADACHE	1.235
18 GASTROINTESTINAL ULCER	1.229
19 TORSION TESTICLE	1.183
20 ORTOPEDIC FRACTURES	1.172
21 HEMAFECIA / HEMATOCHYZIA (BLOOD	1.140
22 MENINGITIS	1.063
23 FUNGAL INFECTIONS / PULMONARY M	1.050
24 DERMATITIS / SKIN RASHES	1.048
25 HEAD INJURY	1.002
26 CHEST PAIN	0.974
27 MYOCARDIAL INFARCTION / HEART A	0.824
28 PSYCHOLOGICAL TRANSIENT SITUATI	0.794

- 8) Hemafecia/Bloody Stools (1.14)
- 9) Orthopedic Fractures (1.17)
- 10) Torsion Testicle (1.18)
- 11) Gastrointestinal Ulcer (1.23)
- 12) Renal Calculus/Kidney Stones (1.30)
- 13) Appendicitis (1.31)

Basic Science Preparation for the Target Medical Conditions

In addition to rating the Commonness, Importance etc. for each of the medical conditions provided in the survey form, respondents were also asked to rate for each condition (e.g., "Chest Pain") several topics of biomedical science (sometimes clinical science) pertinent to the condition in terms of their Familiarity with the topic, how Important they viewed the topic to being able to deal effectively with the particular medical condition, how Difficult they felt the topic was to learn and understand well, and how well they judged that the training of the corpsman Prepares corpsmen with regard to the topic. Results from these items of the questionnaire are presented in this section. Because of the extensiveness of these data, the presentation will be confined to the thirteen Target medical conditions described directly above.

Table 8 gives the results. One way to view these results is in terms of Preparedness for a topic, relative to the perceived Importance and Difficulty of the topic. An index, Index2, of this relationship was calculated as the square root of the ratio of the square of Preparedness and the product of Importance and Difficulty

$$\text{Index2} = [\text{Preparedness}^2 / (\text{Importance} \times \text{Difficulty})]^{1/2}$$

and is given in the Table. The Table also lists the medical conditions from the last section in ascending order of perceived preparedness of the corpsman for handling this type of condition, also as defined in the last section. Hence, for instance, "Psychological Transient Situational Disorders" are listed first in the Table because this item was the medical condition respondents judged the one for which corpsmen were least well prepared (relative to the Importance and Difficulty of that medical condition). Within this topic, respondents judged that corpsmen were least well prepared in the area of "characteristics of personality disorders," relative to the Importance and Difficulty of this topic in handling "Psychological Transient Situational Disorders." In the medical condition for which respondents judged corpsmen to be second-to-least well prepared, Heart Attack, respondents believed that corpsmen were least well prepared in the biomedical science area of "mechanisms of arrhythmias." By inspecting the rest of Table 8, the reader can see the judged preparedness of corpsmen in key basic science topics associated with each of the thirteen special medical conditions defined in the last section. The information which is captured in Table 8 for the target medical conditions from the last section is given in Appendix 1 for the entire set of 28 medical conditions included

in the survey. Such information should be informative in guiding curricular planning.

INSERT TABLE 8 ABOUT HERE
basic sci. prepared/ imp x diff for target 13 conds.

TABLE 8
Preparedness in Relation to Importance &
Difficulty for Basic Science Topics Pertinent to
13 Selected Medical Problem Areas (see text)
 (higher number indicates higher Preparedness)

	CONDITION	SUB-TOPICS	INDEX (see text)
1	PSYCHOLOGICAL	SYMPTOMS OF DRUG/ALCOHOL ABUSE	0.951
2	PSYCHOLOGICAL	SITUATIONAL ADJUSTMENT REACTION	0.822
3	PSYCHOLOGICAL	CHARACTER OF PERSONALITY DISOR	0.747
4	HEART ATTACK	MYOCARDIAL METABOLISM (ISCHEMIA)	0.728
5	HEART ATTACK	CARDIAC FUNCTION	0.794
6	HEART ATTACK	MECHANISMS OF ARRHYTHMIAS	0.600
7	CHEST PAIN	CARDIAC ELECTROPHYSIOLOGY	0.662
8	CHEST PAIN	THORACIC ANATOMY	1.072
9	CHEST PAIN	DIFFERENTIAL DIAGNOSIS	0.889
10	HEAD INJURY	NEURAL ANATOMY	0.781
11	HEAD INJURY	CEREBRALVASCULAR ANATOMY	0.757
12	HEAD INJURY	OSMOTIC DIURETICS	0.684
13	DERMATITIS	TOPICAL TREATMENTS / DERMATITIS	1.118
14	DERMATITIS	HISTOLOGICAL STRUCTURE OF SKIN	1.258
15	DERMATITIS	NUTRITIONAL INTEGRITY OF SKIN	1.339
16	FUNGAL INFECTION	PULMONARY PHYSIOLOGY	0.961
17	FUNGAL INFECTION	METABOLISM OF LYMPH NODE CALCIF	0.700
18	FUNGAL INFECTION	ANATOMY OF THE LUNGS	1.092
19	MENINGITIS	INFECTIOUS AGENTS & BLOOD-BRAIN	0.916
20	MENINGITIS	MECHANISMS OF NUCLEAL RIGIDITY	0.982
21	MENINGITIS	EXAMINATION OF CRANIAL NERVE FU	0.923
22	BLOODY STOOL	INFECTIOUS AGENTS IN THE G.I. T	1.207
23	BLOODY STOOL	ANATOMY OF THE G.I. TRACT	0.858
24	BLOODY STOOL	DIFFERENTIAL DIAGNOSIS	0.809
25	FRACTURES	INFECTIOUS PROCESSES IN BONE	0.940
26	FRACTURES	SECONDARY PATHOLOGICAL EFFECTS	0.915
27	FRACTURES	PHYSIOLOGY OF BONE GROWTH & KNI	0.951
28	TORSION TESTICLE	UROGENITAL ANATOMY	1.079
29	TORSION TESTICLE	GENITAL-RECTAL EXAMINATION	1.146
30	TORSION TESTICLE	DIFFERENTIAL DIAGNOSIS (EDIDIDY	1.041
31	G.I. ULCER	PHYSIOLOGY OF G.I. SECRETION	0.983
32	G.I. ULCER	DIFFERENTIAL DIAGNOSIS	1.023
33	G.I. ULCER	MECHANISMS OF ULCERATION	0.981
34	KIDNEY STONES	MECHANISMS OF REFERRED PAIN	1.051
35	KIDNEY STONES	DIFFERENTIAL DIAGNOSIS	1.026
36	KIDNEY STONES	UROGENITAL ANATOMY	1.094
37	APPENDICITIS	MECHANISMS OF REFERRED PAIN	1.034
38	APPENDICITIS	ABDOMINAL ANATOMY	1.097
39	APPENDICITIS	NON-SURGICAL TREATMENT OF APPEN	1.111

STUDIES OF BASIC SCIENCE KNOWLEDGE IN RELATION TO CLINICAL REASONING

Directed by the findings of the questionnaire, studies were conducted to determine students' knowledge of basic science pertinent to working with important types of medical Problem Areas a corpsman sees and to determine their ability to apply this knowledge usefully in these types of cases.

Method

Materials

Investigative tools were developed for determining students' understanding and application of the selected biomedical science concepts and topics to clinical problems. A major component of these tools, which we have called a "Probe Set," has been used in similar studies within civilian medicine (e.g., Feltovich, Spiro, & Coulson, 1989). One such Probe Set was developed for each of the four Medical Problem Area we studied (listed later). The Probe Set is a structured set of discussion questions that is derived from a conceptual analysis of the problem area. The four Probe Sets used are given as Appendix B.

The Probe Set has a carefully designed structure which addresses specific features of the students' experience, knowledge, and cognitive behavior. Probe Sets were partitioned into the following categories of questions:

Clinical skills. The first part of a Probe Set begins with a medical clinical case which is progressively described (further elaborated and filled-in as information is progressively presented) in which understanding of a particular problem area and its related topics and concepts are germane to appropriate handling of the case. Performance on these cases by students is used to assess clinical reasoning skills, background knowledge, understanding of basic science relevant to the case, and possible effects of misconceptions students may hold. Several specific stages in the clinical reasoning process (e.g., Barrows & Feltovich, 1987) were assessed:

Hypotheses generation (the ability to assess the clinical situation and to recognize, recall, or formulate a differential diagnosis).

Evaluative assessment (the ability to determine the possible seriousness of the situation).

Self-knowledge assessment (the ability to recognize the limitations of one's knowledge and to determine what has to be learned or further discovered from the case in order to either decide among the medical possibilities or to refine the possible differential).

Clinical appraisal (the ability to evaluate the patient's signs and symptoms in order to recognize the emergence of an unmanageable situation).

Basic science knowledge. The second part of the Probe Set asked the student (or the "subject" more generally) to discuss broadly and deeply biomedical topics/concepts germane to the medical problem area being studied. This was initially done without any prompting, i.e., without any cues or feedback which would aid the student). Follow-up questions become progressively more specific, taking the student from general concepts to specific knowledge about anatomical structures and physiological and biochemical processes relevant to the topic.

Basic science--clinical linkers. The last part of the Probe Set returns to another clinical case scenario dealing with the same type of medical problem area (e.g., a gastrointestinal problem) in which questions about causative or etiological mechanisms were asked in addition to diagnoses (and other information asked under "clinical skills" above). The specific nature of the probing described in the last subsection, Basic Science Knowledge) may have refreshed the students' memories about applicable biomedical knowledge, causing them to recall and apply knowledge that they were unable to use when questioned in the earlier clinical reasoning exercises described above. Finally, subjects were given an explanatory mechanism (e.g., a pathophysiological mechanism, such as the "inability to digest or absorb fats ") for the patient problem and were asked to describe how that mechanism could account for the the patient's given condition (signs and symptoms) or were asked to infer the kinds of signs and symptoms such a pathological mechanism might produce in a patient. At times they were given a diagnosis and asked to explain the biomedical mechanisms involved in a useful treatment.

Groups Studied/Subjects

It was initially planned to study seven students from the IDC population and seven medical students on each of the four medical problem areas selected.

As it turned out, Submarine Independent Duty Corpsmen at various stages in their training program, active duty submarine corpsmen, and former submarine corpsmen acting as enlisted instructors were studied. Submarine Independent Duty Corpsmen come from a wide variety of occupational and training backgrounds but one feature they generally had in common was a fairly broad range of clinical experiences. Because of human subjects anonymity requirements it is not possible to identify individual corpsmen regarding details of their individual training and clinical experience. However their clinical experience was extensive. A typical group of IDC subjects, studied on a particular problem area with a Probe Set, had clinical experience ranging from an average of five to twelve years. This clinical work experience was in addition to particular clinical training courses these men may have had. For various reasons, involving factors such as progress in the NUMI curriculum, more than seven subjects were studied in the IDC groups. As many as fifteen and as few as nine subjects were studied in the IDC groups. Over the course of the project Submarine IDC students from three different NUMI classes, active duty Submarine

corpsmen from commissioned boats, and some enlisted NUMI instructors were studied.

For purposes of comparison, groups of second year medical students from two different Southern Illinois University School of Medicine classes were also studied using the same Probe Sets. Second year medical students generally had received extensive theoretical medical basic science training but very limited clinical experience. Seven medical students were studied in one problem area, with six subjects serving in the other three medical problem areas which were used in the studies.

Medical Problem Areas Studied

Because of the high profile of Gastro-intestinal problems identified in the survey process, two medical problem area Probe Sets were developed from this area: one centered on digestive and absorptive properties; and, one centered on swallowing and aboral food movement properties. Another problem area Probe Set was developed around the phenomenon of chest pain, and one was related to head trauma. Cases were based on real patient cases provided by medical consultants or, in a few instances, from write-ups in medical literature. Inspection of Figure 2,

INSERT FIGURE 2 ABOUT HERE
(Imp-Diff with connections showing coverage of probes)

which gives the Medical Problem Areas and their judged Importance and Difficult from the results of our survey, shows the coverage of these problem areas that the researchers considered to be accomplished by the Probe Sets which were designed. In short, it was believed that the sets used made pertinent contact with the basic science necessary to handle many of the Important/Difficult problem areas well. For descriptive purposes the Probe Sets were coded as follows (it should be noted that although a particular case below may be described only in terms of its ultimate answer, e.g., "Lactase Deficiency," the cases were chosen so that a wide variety of conditions a corpsman sees would be relevant to consider in deciphering each problem--i.e., the cases had "Logical Competitor Sets" [Feltovich, Johnson, Moller, & Swanson, 1984] quite pertinent to the work of the corpsman):

<u>Problem area</u>	<u>Clinical skills case</u>	<u>Basic Science Topics</u>	<u>Mech. /Linker Case</u>
GI-1	Atypical Appendix (retroceal)	Digestion & Absorption	Lactase deficiency (Idiopathic)
NEURO	Intracranial Hematoma	Central Nervous System	Brain tumor (Glioma)

Important & Difficult (80)

MEDICAL AREAS COVERED BY TESTING MATERIAL

No. Rating both
Important & Difficult

73	M. I./HEART ATTACK	ChestPain (Probe Set)
57	MENINGITIS	Head Injury (Probe Set)
53	TORSION TESTICLE	
52	CHEST PAIN	
50	HEAD INJURY	
47	APPENDICTIS	GI 1-2 (Probe Sets)
34	PSYCHOLOGICAL T.S.D.	
34	GASTROINTESTINAL ULCER	
29	ORTHOPEDIC FRACTURES	
26	RENAL CALCULUS/KIDNEY STONES	
19	HEMAFECIA (BLOODY STOOLS)	
13	HEMATURIA/BLOODY URINE	
9	HERNIA,INGUINAL	
9	FUNGAL INFECTIONS/PULMONARY MYCOSIS	
8	TRAUMA/LACERATIONS & CONTUSIONS	
8	PNEUMONIA	
6	HIATAL HERNIA	
5	ORTHOPEDIC STRAINS & SPRAINS	
3	COLDS & UPPER RESPIRATORY INFECTIONS	
2	DERMATITIS/SKIN RASHES	
2	GASTROENTERITIS	
2	G.I. FLU	
1	OTITIS/EAR INFECTIONS	
1	HEADACHE	
1	BRONCHITIS	
0	PROSTATITIS	
0	DIARRHEA	
0	URETHRITIS/EPIDIDYMITIS	

Figure 2. Important and difficult medical problem areas covered by laboratory "Probe Sets" (tests of knowledge).

CHEST PAIN	Pulmonary Embolis	Cardiovascular System	Anxiety neurosis (Non-autonomia)
GI-2	Esophagitis (hematemesis)	Swallowing & Aboral movement	Achalasia (L.E.S. spasm)

Procedure

Subjects, in individual sessions, were given each question of a Probe Set in order (see Appendix B), in writing and directed to answer orally as completely as they could with no time constraints. That is, the subjects were asked to verbalize all their thoughts. They were encouraged, and prompted by the experimentors, to verbalize their thoughts when there were long periods of silence. An experimenter was present to administer the procedure. Sessions lasted from about 45 min. to 1 1/2 hours, depending on the subject. Subjects responses were tape-recorded and transcribed for later scoring and analysis.

Probe Set Keys/ for Scoring and Analysis

Answer keys for the Probe Sets were derived for the four Probe Sets by expert basic scientists pertinent to a problem area (e.g., a cardiovascular physiologist for the area of "chest pain" and general physician clinicians without regard to any performance level that might be expected from subjects taking the tests. In order to perform perfectly a subject would have to have the combined skills of several experts in a variety of disciplines and medical sub-specialties, a level of performance which was never anticipated nor realized. The generation of the answer keys was simply to create the basis for a scoring system so that comparative levels of performance among subjects could be assessed over a range of different knowledge areas.

All subject responses were scored by project investigators using these keys, with consultation with medical professionals and basic biomedical scientists when needed (e.g., to ask whether two responses meant the same thing, or to ask if a response not listed in the key was reasonable).

Results

Method of Analysis

In each of the three main sections of the Probe Sets, Clinical Skills, Basic Science Knowledge, and Basic Science - Clinical Linkers the method of analysis was the same. The scores of all subject groups, IDC Class-1 (NUMI 168 Class), IDC Class-2 (NUMI 172 Class), IDC Class-3 (NUMI 173 Class), Corpsmen (active duty corpsmen from boats in port), Instructors (NUMI Enlisted Instructors), and SIU students (second year medical students from Southern Illinois University) were compared by analysis of variance to determine if there was between group variation that was greater than within group variation at the $p < 0.05$ level of significance. When there was significant differences among the groups, individual comparisons were made among Least Square Means of the different subject groups (also assuming a $p < 0.05$ level of significance).

Clinical Skills

- [1] Hypothesis generation (differential diagnosis) as part of clinical reasoning

Recall that in each of the four Probe Sets subjects were first required to perform differential diagnosis on a clinical case pertinent to the subject of the Probe Set. Table 9 illustrates the results of subjects' performance. There were no significant differences in the scores obtained by subjects from any of the groups on either initial or final diagnosis (recall that on some Probe Sets subjects were asked to give a tentative differential diagnosis after having been presented partial information from a case--initial diagnosis--and again after receiving the remainder of the information about the patient, the final diagnosis) on any of the four Probe Sets. It should be noted that even though the SIU students and Navy personnel did not appear to differ in their diagnostic ability on our exercises, comparison of all subjects mean scores with the total possible scores for each case (given in parentheses within Table 9 e.g, means of about 0-5, when cases had possible scores ranging from 9-22), suggests that none of the groups is exploring the reasonable possible explanations in a particularly rich manner.

INSERT TABLE 9 ABOUT HERE
(subjects on initial case, each probe set)

- [2] Evaluative Assessment (Discriminating seriousness of diagnoses)
- [3] Self-knowledge Assessment (Knowing what knowledge is yet needed to accomplish diagnosis)
- [4] Clinical Assessment (Recognition of the emergence of unmanageability/emergency)

TABLE 9

Clinical Skills: Hypothesis Generation (Differential Diagnosis) (Beginning Section of Probe Sets)

PROBLEM AREA	possible score	IDC Class-1	IDC Class-2	IDC Class-3	Corpsmen	Instructors	SIU students
GI-1	13						
Appendix							
number of subjects		[2]	[5]	[5]	[2]	[1]	[6]
Initial Dx		2.0	2.4	1.8	2.0	1.0	2.5
Final Dx		2.5	2.2	3.6	2.5	3.0	4.2
GI-2	21						
Esophagitis							
number of subjects			[4]	[5]		[2]	[6]
Initial Dx			4.5	3.6		3.5	4.5
Final Dx			1.75	0.6		1.5	2.5
CHEST PAIN	22						
Pulmonary Embolis							
number of subjects				[9]			[7]
Final Dx				2.6			1.9
NEURO	9						
Hematoma							
number of subjects				[9]			[6]
Final Dx				2.0			1.5

Note: There were no significant differences

As part of the clinical case vignettes that subjects encountered at the beginning of each Probe Set, in addition to diagnosis they were required to do three additional things: 1) Of the medical conditions in their differential, to assess the comparative seriousness of the items, 2) To determine what further information about the patient, beyond what was given, would be needed to more firmly establish the diagnosis, and 3) To specify any changes (e.g., newly emerging signs and symptoms) that should be looked for in the patient's condition that would signal that the patient is "going bad," degenerating into an emergency. Table 10 illustrates the results. There were no significant differences in the scores obtained by subjects in any of the groups on any of these items in any of the Probe Sets.

INSERT TABLE 10 ABOUT HERE
(clinical follow-up initial)

There were two clinical cases represented in our Probe Sets that fairly signaled the need to consider great danger for the patient, one involving increased intracranial pressure and the other a case of anxiety neurosis, mimicking many of the indications of Myocardial Infarction (heart attack). Corpsmen subjects were better able to recognize the presence of increased intracranial pressure, more likely to MEDEVAC the patient, and more likely to start appropriate treatment for this emergency situation (see Table 11). Regarding the possible heart attack, Corpsmen and medical students were equally likely to recommend MEDEVAC. Given that the "Heart Attack-looking" case was actually a case of anxiety, it is not clear to the researchers whether suggesting medivac for this case was the optimal thing to do. But, it is clearly a danger-signaling situation, so being cautious is the prudent thing to do (especially since corpsmen have told us that they do not feel well prepared for dealing with psychological disorders).

INSERT TABLE 11 ABOUT HERE
(detecting danger)

Basic Science Knowledge

As has been described in earlier, within each Probe, subject matter tests dealing with the basic biomedical science knowledge pertinent to the topic of the Probe. These were widely ranging over the subject matter, covering levels of knowledge from minute (e.g., cellular) to gross (gross anatomical). Both structural properties (again, anatomy) and processes (e.g., physiology biochemistry) were covered. The results of these assessments are given in the remainder of this section.

GI-1 (Digestion & Absorption)

TABLE 10

Clinical Skills: Evaluative, Self-knowledge, and Clinical Assessment

PROBLEM AREA	possible score	IDC Class-1	IDC Class-2	IDC Class-3	Corpsmen	Instructors	SIU students
GI-1							
Appendix							
number of subjects		[2]	[5]	[5]	[2]	[1]	[6]
Evaluative Assessment	4	1.0	1.6	1.6	2.0	1.0	1.3
Self knowledge	12	2.5	2.6	3.0	1.5	3.0	1.8
Clinical Assessment	4	2.5	2.2	2.4	3.0	1.0	1.3
GI-2							
Esophagitis							
number of subjects			[4]	[5]		[2]	[6]
Evaluative Assessment	2		1.3	1.0		2.0	1.3
Self knowledge	10		4.0	1.4		4.5	3.3
Clinical Assessment	8		1.5	1.2		1.5	2.0
CHEST PAIN							
Pulmonary Embolis							
number of subjects				[9]			[7]
Evaluative Assessment	22			2.1			1.6
Self knowledge	2			0.44			0.43
Clinical Assessment	18			2.3			3.3
NEURO							
Hematoma							
number of subjects				[9]			[6]
Evaluative Assessment	5			0.78			0.83
Self knowledge	3			0.11			0.33
Clinical Assessment	11			1.8			2.8

Note: There were no significant differences

TABLE 11
HANDLING DANGER IN CLINICAL SITUATIONS

	<i>N</i>	Recognize Increased Intracranial Pressure	Would MEDEVAC	Give Osmotic Diuretic
HEMATOMA (<u>INTRACRANIAL</u> <u>PRESSURE</u>)				
IDC-CLASS 3	9	9/10 = 90%	6/9 = 67%	3/9 = 33%
SIU	6	4/6 = 67%	1/6 = 16%	0/6 = 0%
CHEST PAIN (<u>ANXIETY</u>)				
IDC-CLASS 3	9		4/9 = 44%	
SIU	7		3/7 = 43%	

Table 12 illustrates the results. There were no significant differences in the scores obtained by subjects in any of the groups of Navy personnel on any of the topics (Structures, Substances, Cell-types, Transport) assessed in this subject area. However, on every topic the scores obtained by the medical students were dramatically higher.

INSERT TABLE 12 ABOUT HERE
BS--Digest and absorb

GI-2 (Swallowing & Aboral Movement of Food)

Table 13 illustrates the results. There were no significant differences in the scores obtained by subjects in any of the groups of Navy personnel (IDC Class-2, IDC Class-3, and Instructors) on any of the topics (Structures, Substances, Neuro-endo Control, Neural Systems, Innervation, and Contractile) assessed in this subject area. The scores obtained by the medical students were significantly (and greatly) higher than those from all the Navy groups.

INSERT TABLE 13 ABOUT HERE
BS--motility

CHEST PAIN (Heart & Cardiovascular System)

Table 14 illustrates the results. In this subject area nine members from IDC Class-3 (NUMI 173 Class) and seven SIU students were subjects for this Probe Set. Scores obtained by SIU students on all topics (Structures, Substances, Cell-types, Vessel Size) except Compliance were significantly higher than those obtained by the student corpsmen.

INSERT TABLE 14 ABOUT HERE
(BS--chest pain)

NEURO (Central Nervous System)

Table 15 illustrates the results. On these topics, nine members from IDC Class-3 (NUMI 173 Class), different from the nine studied with the CHEST PAIN Probe Set, and seven SIU students, also different from the seven studied with the CHEST PAIN Probe Set, were examined. On every topic studied (Structures, Cranial Nerves, Substances, and Cell-types) the group of SIU students obtained significantly (sometimes greatly) higher scores.

INSERT TABLE 15 ABOUT HERE
BS-head

In the basic science knowledge sections of the four probe sets there were certain topic items (Structures, Substances, and Cell-types) common to three or more of the four Probe Sets (GI-1, GI-2, CHEST PAIN, and NEURO).

TABLE 12

Results of Probe Sets on Basic Science Knowledge: GI-1 (Digestion & Absorption)

SUBJECT AREA	possible score	IDC Class-1	IDC Class-2	IDC Class-3	Corpsmen	Instructors	SIU students
number of subjects		[2]	[5]	[5]	[2]	[1]	[6]
Structures (e.g. villi)	8	1.5	2.4	3.0	1.5	3.0	6.7 * $p < (.0008)$
Substances (e.g. pepsin)	45	7.5	6.4	9.2	4.0	9.0	29.3* $p < (.0001)$
Cell-Types (e.g. goblet)	8	0.5	0.4	0.0	0.0	0.0	6.5 * $p < (.0001)$
Transport (e.g. diffusion)	10	3.5	2.0	1.6	0.0	1.0	7.2 * $p < (.0004)$

Note: * indicates significance

TABLE 13

Results of Probe Sets on Basic Science Knowledge: GI-2 (Swallowing & Aboral Movement)

SUBJECT AREA	possible score	IDC Class-1	IDC Class-2	IDC Class-3	Corpsmen	Instructors	SIU students
number of subjects			[4]	[5]		[2]	[6]
Structures (e.g. esophagus)	30		16.5	16.6		17.5	25.5* $p < (.004)$
Substances (e.g. gastrin)	8		0.5	0.4		1.0	4.0 * $p < (.0001)$
Neuro-endo Control	6		0.5	0.2		0.5	2.2 * $p < (.0008)$
Neural Systems (e.g. myenteric)	11		1.3	0.8		0.0	6.7 * $p < (.0001)$
Innervation (e.g. of muscle)	4		0.25	1.4		1.0	2.7 $p < (.05)$
Contractile (e.g. peristalsis)	13		3.2	2.8		4.5	7.2 * $p < (.005)$

Note: * indicates significance

TABLE 14

Results of Probe Sets on Basic Science Knowledge: CHEST PAIN (Heart & Cardiovascular System)

SUBJECT AREA	possible score	IDC Class-1	IDC Class-2	IDC Class-3	Corpsmen	Instructors	SIU students
number of subjects				[9]			[7]
Structures (e.g. atrium)	17			8.4			12.1* $p < (.003)$
Substances (e.g. epinephrine)	21			2.7			15.1* $p < (.0001)$
Cell-Types (e.g. baroreceptor)	24			6.3			16.1* $p < (.0001)$
Vessel Size (e.g. resistance)	4			0.0			0.9 * $p < (.0001)$
Compliance (e.g. opposition)	3			0.67			1.1

Note: * indicates significance

TABLE 15

Results of Probe Sets on Basic Science Knowledge: NEURO (Central Nervous System)

SUBJECT AREA	possible score	IDC Class-1	IDC Class-2	IDC Class-3	Corpsmen	Instructors	SIU students
number of subjects				[9]			[6]
Structures (e.g. cortex)	36			7.6			20.8* p<(.0001)
Cranial Nerves	48			17.4			29.7* p<(.02)
Substances (e.g. acetylcholine)	17			1.0			8.2 * p<(.0001)
Cell-Types (e.g. nerve axon)	12			1.3			9.2 * p<(.0001)

Note: * indicates significance

Since in every case the mean scores of the SIU students were significantly greater than the mean scores of the groups of navy personnel the ratio of the mean scores of Navy / SIU was calculated. Table 16 illustrates the results. It can be seen by inspection of the Navy / SIU mean score ratios that the performance of the navy personnel was consistently better on topics of a gross anatomical nature (Structures) than on either topics of a physiological and biochemical nature (Substances) or topics of a histological nature (Cell-types). It should be noted that the IDC Class-3 group had not yet taken the the NEURO part of the NUMI course at the time of the study. However, the performance (assessed by mean score ratios) was not noticeably different than on the other subject areas where the formal instruction had occurred prior to our testing. Particularly noteworthy is the fact that the same class, IDC Class-3, had completed their final exam on the G.I. section of the NUMI course the day before they were examined with the Probe Sets GI-1 and GI-2 (see Tables 3 & 4). The one neurology topic, cranial nerves, the Corpsmen students had studied, apparently quite soon before the test, they scored better on.

 INSERT TABLE 16 ABOUT HERE
 (ratio corp/siu BS structures /processes)

Basic Science - Clinical Linkers

On these problems subjects were given pathophysiological descriptions (e.g., breakdown of fat absorption mechanisms) relevant to a patient and were asked to deduce what kind of clinical picture the patient would likely present. Table 17 illustrates the results. In all four problem areas and on all topics studied (GI-1, Absorptive disorders & Lactase Deficiency; GI-2, Motility Disorders; CHEST PAIN, Cardiovascular Disorders; and NEURO, Cranial Lesions, Glioma prior to knowing correct diagnosis, and Glioma after learning the correct diagnosis) SIU students scored significantly higher than all other groups with one exception. On GI-2 the SIU student mean scores on the topic of Motility Disorders was not significantly greater than the mean score of the group of two instructors. However, the instructor group was not significantly different from the other two groups of navy personnel (IDC Class-2 and IDC Class-3), and when the three Navy groups were pooled, the pooled mean score was significantly less than the mean score of the SIU students. This suggests that what the classical first two years of basic science education in medical schools engenders in students is the ability to work "top down," from disease processes to clinical manifestations; the relatively unspectacular performance of the medical school students in generating rich differentials on the clinical cases in our studies suggests that the turning of this knowledge around (Feltovich, 1983), so that it can be elicited by clinical cues, then possibly progresses in the final, clinical years of medical school. The biomedical science knowledge of the corpsmen was such that they had difficulty projecting symptoms from knowledge of pathology.

TABLE 16

Basic Science - Topic items common to two or more Subject Areas
Navy Scores relative to Medical Students Scores.

PROBLEM AREA	Structures	Substances	Cell-types	Cranial Nerves
GI-1				
Digestion				
Navy / SIU	2.3 / 6.7 = .34	7.2 / 29.3 = .24	.18 / 7.2 = .03	
GI-2				
Motility				
Navy / SIU	16.9 / 25.5 = .66	.63 / 4.0 = .16		
CHEST PAIN				
Navy / SIU	8.4 / 12.1 = .69	2.7 / 15.1 = .18	6.3 / 16.1 = .39	
*HEAD INJURY				
Navy / SIU	7.6 / 20.8 = .36	1.0 / 8.2 = .12	1.3 / 9.2 = .14	**17.4 / 29.7 = .59

Note: * indicates a topic for which Navy students had only had partial instruction.

** indicates area of neurology for which Navy students had instruction.

INSERT TABLE 17 ABOUT HERE
BS-clinical linkers

There was another (in addition to those at the beginning of each Probe Set) set of clinical case scenarios attached to the end of the Basic Science - Clinical Linkers section. Subjects were required to do much the same things as with the earlier cases (see "Clinical Skills" section above). In particular, subjects were again tested for generating differential diagnoses. Table 18 illustrates the results. Again there were no significant differences among any of the navy groups. However, the SIU student groups had significantly higher mean scores on two of the four problem areas (GI-1 and GI-2) but were not significantly different from the navy groups on the other two (CHEST PAIN and NEURO). This is in contrast with the differential diagnoses scores found in the earlier section of the study (see "Clinical Skills" section, above, and Table 9) where there were no differences at all between navy groups and the SIU students. This raises the possibility that the exercise of working through the Probe Sets may have refreshed the memories of SIU students in ways beneficial to conducting the clinical exercises.

INSERT TABLE 18 ABOUT HERE
(end probe diagnoses etc.)

TABLE 17

Results of Probe Sets on Basic Science Knowledge: Clinical Linkers (Mechanisms - Signs & Symptoms)

PROBLEM AREA	possible score	IDC Class-1	IDC Class-2	IDC Class-3	Corpsmen	Instructors	SIU students
GI-1							
number of subjects		[2]	[5]	[5]	[2]	[1]	[6]
Absorptive Disorders	10	0.5	0.6	0.6	1.0	0.0	4.8 * $p < (.0001)$
Lactase Deficiency	2	0.0	0.0	0.0	0.0	0.0	1.8 * $p < (.0001)$
GI-2							
number of subjects			[4]	[5]		[2]	[6]
Motility Disorders	12		6.75	4.2		7.5 *	10.0* $p < (.003)$
CHEST PAIN							
number of subjects				[9]			[7]
Cardio-vascular Disorders	10			3.44			7.7 * $p < (.0001)$
NEURO							
number of subjects				[9]			[6]
Cranial Lesions	12			2.89			2.67
Glioma-Initial	15			0.11			2.17* $p < (.0002)$
Glioma-Final	6			0.11			3.5 * $P < (.0001)$

Note: * indicates significance.

TABLE 18

Differential Diagnosis for Cases at the end of Probe Sets

PROBLEM AREA	possible score	IDC Class-1	IDC Class-2	IDC Class-3	Corpsmen	Instructors	SIU students
GI-1	16						
number of subjects		[2]	[5]	[5]	[2]	[1]	[6]
Differential Dx Lactase Deficiency		1.0	1.8	1.4	1.5	3.0	6.2 * $p < (.004)$
GI-2	8						
number of subjects			[4]	[5]		[2]	[6]
Differential Dx Achalasia			1.3	0.4		10.0	2.8 * $p < (.002)$
CHEST PAIN	9						
number of subjects				[9]			[7]
Differential Dx Anxiety Neurosis				2.2			2.4
NEURO	9						
number of subjects				[9]			[6]
Differential Dx Glioma				1.3			1.5

Note: * indicates significance

CHANGES TO THE CORPSMAN PROGRAM SUGGESTED BY SURVEY RESPONDENTS

Several items in the questionnaire gave respondents the opportunity to characterize the corpsman's job and to suggest ways that the Corpsman Program could be improved. Before presenting our own discussion of the results of the survey and some of our resulting recommendations, it is useful to examine the recommendations posed by the respondents themselves. This is done in this section.

The Nature of the Corpsman's Job on the Boat

Eight categories of activity associated with the job of the corpsman were provided for consideration by the respondents--including Face-to-face medical care, Clinical recording (logging) of medical care, Radiation health, Immunization, Pharmacy and medicines, Environmental quality, Occupational safety, and Discharge and transfer summaries. Respondents were requested to estimate the percentage of a corpsman's time (in a typical week on a boat) spent in each of these activities.

INSERT TABLE 19 ABOUT HERE
(% time of corpsman's job estimates)

The results are presented in Table 19. Face-to-face medical care and clinical recording (logging) of this medical care are estimated to account for about 23% of the corpsman's job on a submarine. Duties associated with the radiation health program require an estimated 43% of the corpsman's time. The remaining 34% of the corpsman's time is spread across the five other categories listed above (see Table 19). There were no significant differences among corpsmen, instructors, and medical officers in their estimates.

Suggestions for the Training of the Corpsman

An open-response question gave the respondents the opportunity to suggest improvements for the training of submarine corpsmen: "If you could change or expand any three aspects of Submarine IDC training to better prepare the corpsman for what he will actually experience on the job, what would they be? Even though you may have many ideas, please choose the three most important and write them in the box below (on the survey form)." A synthesis of the responses to this question is given in Table 20.

INSERT TABLE 20 ABOUT HERE
(open suggestions for training changes)

A cluster representing three types of responses was offered by a quite large number of respondents. This included a call for increased clinical/supervised "hands

TABLE 19

THE IDC'S JOB ON THE BOAT

1. EFFORT DISTRIBUTION

Estimate the percentage of the corpsman's time (in a typical week on the boat) spent on the following activities. The percentage should add up to 100.

Face-to-Face Medical Care	%	13.5	($\pm$ 10.2)
Clinical Recording (logging) of Medical Care	%	9.9	($\pm$ 6.2)
Radiation Health	%	42.9	($\pm$ 19.9)
Immunization	%	2.5	($\pm$ 2.2)
Pharmacy and Medicines	%	5.0	($\pm$ 4.7)
Environmental Quality	%	7.4	($\pm$ 5.1)
Occupational Safety	%	6.9	($\pm$ 5.9)
Discharge and Transfer Summaries	%	2.8	($\pm$ 3.2)
Other	%	10.7	($\pm$ 11.9)

TOTAL	100%	*102.6
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*Due to rounding: exact figures give 100%

Notes: (1) No significant differences in estimates among Corpsmen, Instructors, Medical Officers

(2) Face-to-face medical care and logging of care account for about 23% of the Corpsman's job.

TABLE 20

Suggestions for Changes in Training Program

Question #2 If you could change or expand any three aspects of Submarine IDC training to better prepare the corpsman for what he will actually experience on the job, what would they be?

No. Suggesting

- 47 Clinical/supervised "hands-on" experience
- 34 ACLS & ATLS training & certification
- 31 Time/Administrative Management
- 15 On-the-Job training (on boats)
- 11 Psychiatry/Psychology
- 11 Radiation Health/Occ. & Environ. Safety
- 8 Pharmacology/AMAL (more familiarization)
- 5 Computer (Word Proc. & Data Base)
- 4 Stress Management
- 4 Instructions/guides/notices
- 2 Laboratory
- 2 Qualify IDC only after successful sea tour
- 1 Invite CO's & XO's to lecture
- 1 Increase medical training to 2yrs.
- 1 Increase Physiology & disease processes
- 1 Medevac & extrication procedures
- 1 NAV OSH programs
- 1 Preparation for inspections
- 1 Educational Specialist to ensure training quality
- 1 Better training facilities
- 1 Self-auditing procedures
- 1 More emphasis on "SOAP" notes

on" experience with patients during the training process (47 respondents, see Table 20); ACLS and ATLS training and certification (34); and better training in time and administrative management (31).

A second substantial cluster included the recommendation of a program of on-the-job training aboard boats during the training process (15); better preparation for handling psychological/psychiatric disorders (11); and additional emphasis on Radiation Health and Occupational/Environmental Safety (11).

Other less common responses ranged from a recommendation for more familiarization with Pharmacology/AMAL (8), to a number of suggestions raised by single individuals (see Table 20).

Suggestions for Operational Procedure Aboard the Boat

Another open-response question gave the respondents the opportunity to suggest improvements for operating procedures on the boat: "If you could change or expand any three aspects of operating procedure for the Submarine IDC to better serve the medical needs of the crew and the boat, what would they be? Even though you may have many ideas, please choose the three most important and write them in the box below (on the survey form)." A synthesis of the responses to this question is given in Table 21.

INSERT TABLE 21 ABOUT HERE
(open suggestions for operating procedure)

A large group of responses centered on the issue of reducing the work-load of the submarine IDC (65 total responses--see Table 21). Specifics of this took different forms, including a call for a second IDC on the boat (16 responses); reduction in the number and frequency of inspections (14); reduction in the number and frequency of reports (12); general reduction in IDC collateral duties (9); removal of radiation health duties from the IDC (7); removal of atmospheric control duties from the IDC (6); and removal of occupational safety duties from the IDC.

Another frequent response involved a call for increased equipment and space provided for the corpsman on the boat (16). A host of less frequent responses ranged from a fairly prevalent recommendations for more and/or required continuing education (9) and increased utilization of computers (9), to a number of responses given by single individuals (see Table 21).

TABLE 21

Suggestions for Changes in Operating Procedure

Question #3 If you could change or expand any three aspects of operating procedure for the Submarine IDC to better serve the medical needs of the crew and the boat, what would they be?

No. Suggesting

- 65 Reduce IDC Work Load**
 - 16 Additional IDC
 - 14 Reduce number & Frequency of Inspections
 - 12 Reduce number & Frequency of Reports
 - 07 Remove Rad. Health from IDC duties
 - 06 Remove Atmosphere Control Program from IDC duties
 - 01 Remove Occupational Safety Program from IDC duties
 - 09 General reduction in IDC collateral duties
- 16 Changes in Equipment & Space**
- 09 Continuing Medical Education - more/required CME**
- 09 Computer Usage Increased**
- 07 Increased Support**
- 05 More Medicine - less admin./shore experience in clinics**
- 05 Standardize Procedures - boat-to-boat**
- 05 Change Status - higher rank for corpsman**
- 04 Standardize AMAL**
- 02 Job Restrictions - limit #of tours**
- 01 Miscellaneous (8)**
 - 01 "'Tiger Teams' to replenish medical supplies and inventory upon return to port. Too much time expended with limited in port time."
 - 01 "A new submarine IDC graduating from school should be sent to a fully operational boat instead of one in overhaul or new construction."
 - 01 "Personnel should be qualified for sea with all medical up to date ie. physicals, shots, audiograms."
 - 01 "Ban smoking on submarines to decrease incidence of URI's, which constitute much of the IDC's sick call time."
 - 01 "IDC answers only to Commanding Officer and Commanding Officer answers to Squadron."
 - 01 "Standardize treatment requiring for important situations, i.e. head injury, appendicitis, etc."
 - 01 "Review supplies & make requirements realistic in type & quantity."
 - 01 "Semiannual tech assists from tender units/share bases activities."

CONCLUSIONS AND IMPLICATIONS

Tests of clinical problem solving, including the knowledge and application of basic biomedical science knowledge to these problems, were administered to naval personnel (including students in the submarine corpsman training program, active duty corpsmen, and instructors from the corpsman training program) and to second year medical students. On parts of these tests that dealt most exclusively with clinical thinking (e.g., generation of hypotheses about the patient's medical problem, determination of the information further needed to establish what is wrong with the patient) the Navy personnel performed at the same level as the medical students. The Navy groups scored as well, if not better, than the medical students in the recognition of clinically dangerous situations (e.g., increased intracranial pressure) and in the measures that should be instituted immediately to manage them. On the other hand, Navy personnel lagged far behind the medical students on tests of basic biomedical science knowledge pertinent to the clinical cases (e.g., relevant pathophysiology) and the application of this knowledge in some clinically useful ways (e.g., deriving the symptomatology that should accompany a patient, given the presence some aspect of pathophysiology). The notable paucity of pertinent conceptual knowledge among the corpsmen suggests that the basis for the corpsmen's clinical practice is largely procedural (see first section, BACKGROUND AND INTRODUCTION), rather than being grounded in a solid foundation of biomedical science knowledge and concepts. One might expect this to show up in such things as a relative lack of ability in the corpsman to tackle novel problems, to explain and justify his cases to others, to be able to improvise, and so forth. Navy personnel appeared to have a relatively better knowledge of structural aspects of basic science (e.g., anatomy) than they did of processes (e.g., relevant physiology).

Having stated the finding that Navy personnel performed like medical students on the clinical reasoning tasks, it should also be noted that neither group demonstrated very rich consideration of the clinical cases used in the studies. For example, while the diagnostic hypotheses created by both groups were similar in quality (and quantity), these represented a quite small subset of the medical conditions judged by medical consultants to our project to be worthy of investigation in the cases. Despite nearly two years of basic science instruction and the relatively much richer knowledge of basic science demonstrated by the medical students, this did not translate for these students into the ability to think comprehensively and deeply about clinical cases. The Navy subjects, with less overall basic science instruction than the medical students, seemed unable to apply the basic knowledge they had learned and there were indications this knowledge might largely have been forgotten not long after instruction (considering, for example, the results from the gastrointestinal case, GI-2, where students were not able to remember appropriate knowledge, despite having completed there pertinent instruction and final examinations within days prior to participating in our studies).

Both the medical students and the Navy personnel were taught their basic biomedical science mostly by lecture method and largely in isolation from realistic examples of its application in clinical practice, the mode of instruction that has been predominant in medicine for many years. Other studies of students trained in this standard way have indicated, as has the current one, that students have difficulty applying basic science knowledge usefully to clinical tasks (e.g., Myers, Feltovich, Coulson, Adami, & Spiro, 1990; Lesgold, Robinson, Feltovich, Glaser, Klopfer, & Wang, 1988; Patel, Evans, & Groen, 1989; Patel, Kaufmann, & Magder, 1991) and, indeed, that they do not even remember the sciences very well after they have completed the "basic science" years and have entered clinical instruction (e.g., Levin & Forman, 1973). New forms of instruction have been proposed to counter this problem of "inert knowledge," knowledge that people "have" in some sense but cannot productively use. These are "problem-" or "case-" based methods of instruction, in which the curriculum is composed of a set of medical patient cases (e.g., Barrows, 1983). Students learn (often in groups led by a coach or tutor) clinical medicine and the basic biomedical science useful for understanding each type of case in the course of exploring, diagnosing and managing the case. In this way, knowledge is acquired under the goal of using it in practical application, and its organization in the learner should, likewise, be one conducive to use; there is in this kind of instruction an integration of basic science and clinical learning that is not present in medical education which largely separates basic science and clinical learning.

Case-based instruction, such as that just described, may be a useful form of instruction for the submarine corpsman program to adopt, at least in some part. This seems especially attractive since the core set of common and difficult medical conditions a corpsman must deal with can be identified (e.g., the set of 28 medical conditions which formed the basis of our mail survey). These could be the case basis for a case-centered curriculum. In addition to possibly enabling better "linkage" between the basic sciences and clinical application, more guidance might be provided for what areas of basic science (e.g., anatomy, physiology) to cover; that is, students would not be exploring general, encompassing "basic physiology," rather aspects of physiology most pertinent to understanding "chest pain." Further focus within a medical problem area can come from the results of our survey, which asked about important basic science topics/concepts within each medical problem area.

Another notable finding from our studies was that, for the most part, individuals charged with training student corpsmen performed about as well clinically, and in the understanding and application basic science knowledge, as the corpsmen they had trained and the student corpsmen they were training. It is suggested that the possibility of cooperation with a university be explored, such that biomedical science specialists could be involved in the corpsman's education about the basic biomedical sciences and their application in clinical medicine. In addition to its role in the education of the corpsman, such an involvement might be arranged to enable the corpsmen to obtain an academic degree (e.g., an Associate in Arts) or

credit toward a degree, an achievement often expressed by corpsmen to the researchers during the conduct of the project as highly desirable.

A mail survey was also conducted with personnel associated with the submarine corpsman program. In it, respondents were asked to rate 28 medical conditions regarding their Commonness, Importance and Difficulty in a corpsman's job, and the degree of Preparedness the corpsman has for each condition from submarine corpsman training. In rating medical conditions with regard to Importance and Difficulty, there was strong agreement among students, instructors, and medical officers, with only one (of 28 conditions) discrepancy on importance and two on Difficulty. (See the body of the report for description of group differences on judgments of Commonness and Preparedness, where more disagreement was found). Individuals within the Corpsman program appear to agree on what are the tricky conditions a corpsman may see.

Within each medical condition, respondents were also asked to rate several topics of biomedical science pertinent to the condition regarding their familiarity, importance, difficulty, and, again, the degree of preparedness in knowledge of the topic that training provides for the corpsman. There was considerable variability in these ratings across the set of medical conditions and related conceptual topics. These can be used to create various indices which relate items according to their degree of preparedness relative to their importance and difficulty--indices suggesting the need for particular focus on a topic during instruction.

Respondents were also asked to estimate the percent of time corpsmen spend in various kinds of tasks on a boat, a kind of portrait of the corpsman's job. Responses show that the corpsman on a boat clearly is doing many and diverse things, all of considerable responsibility. In particular, it is estimated that only about 23% of the corpsman's job is involved in face-to-face medical care, seeing patients, and recording the results. This was a cause for concern for many respondents, as will be discussed below in presenting the kinds of changes suggested by respondents for the submarine corpsman program.

As noted, respondents were given an opportunity to suggest changes in the training program and in the operating procedures of a boat. Judging from the responses to our survey, the change that respondents, themselves, would most like to have made to the training program is the availability of "more hands-on experience" with patients during this training. There are constraints on how involved with real medical patients corpsmen can be, including regulations restricting what corpsmen can do with patients on land. It would be useful if educational methods could be adopted that would approximate active involvement with real patients. The methods of case- and problem-based instruction suggested above are themselves a significant step in this direction, since all instruction has some centering on a patient case. However, there are developments allied with the growing adoption of case-based methods of instruction that might further satisfy

the need for more active involvement with patients. These involve the use of patient case simulations, sometimes in the form of computer-based or paper-and-pencil representations (Norman, Muzzin, Williams, & Swanson, 1985). Perhaps more germane to the needs of the corpsman is the growing use in medical education of another kind of simulation that involves the use of "patient actors" or "simulated patients." These are individuals who are trained to portray a real patient case (it should be noted that not only items of patient history can be portrayed, but also a surprising range of physical findings). They are sometimes used as the patient focus for sessions of problem-based learning, but they can also be used for many other facets of learning, for example, as a tool for evaluating/testing a student's clinical competence while the student is performing realistic clinical actions with a "patient" (Barrows, Williams, & Moy, 1978). Simulated patients can also provide opportunities for students to practice their clinical skills, without the risks associated with giving students substantial responsibility over patients who are actually ill. They are also transportable to many settings (as opposed to students, for instance, having to work with patients only in hospitals and clinics).

The second most requested change in the training program given by the survey respondents was that ACLS and ATLS training and certification be made available. Providing this training appears to involve no particular conceptual or educational difficulty, just a decision about whether the training is worthwhile. Hence, we will offer no suggestions related to this issue here.

The recommendation for change to training that was given third most often was for time and administrative management. Besides the survey results, this concern was expressed to the researchers numerous during their interactions with corpsman personnel during the conduct of the research project. There is concern that the corpsman on a boat has so much to do that without explicit training about organization and use of time, the corpsman's job is in serious jeopardy when he is placed on a boat for the first time. This is further reflected, we believe, in the call for a component of training to actually be conducted on an an operating boat, the fourth most requested change to training. Simulations of a sort may be helpful in addressing these concerns also. These would take the form of realistic mock experiences of boat-board life, including the practice of the corpsman. In the best of circumstances these would be conducted on a boat. However, simulations of lower fidelity are probably more feasible. The important aspect is that the corpsman be able to experience the multiple responsibilities, demands, and time constraints of working on a boat so he can practice performing them and perhaps start to adjust to them (so his first exposure is not on the first day of his actual job). It should be noted that the development of such training experiences is already progressing at NUMI, the most notable being a training and evaluation exercise called "hell week." It is recommended that such exercises be continued and expanded.

A finding from the survey (regarding proposed changes to the training program) which appears to be somewhat unexpected (judging from the response to

it in forums where results of the survey have been reported) is the magnitude of the call for more training about psychological/psychiatric disorders. It appears that more of this kind of training should be provided in some manner. It can be noted that these kinds of disorders are particularly amenable to "simulated patient" representation, since representation of physical findings are often not crucial or tricky.

The overwhelming majority of suggestions from respondents about desired changes in operating procedures aboard a boat had to do with reduction of the corpsman's workload (although the specific nature of such suggestions varied notably). Again, the researchers cannot make specific suggestions about this issue, except to note the relationship of this request to the calls for increased attention in training to time-management and organizational skills, as discussed earlier in this section.

No matter what, if any, changes are made to the training program of the corpsman or the operating procedures for corpsmen on boats, they are likely to involve choices--what gets kept or dropped, what gets more or different emphasis and what remains the same. With regard to the training component, it is clear that what is desired is that corpsman receive training that will enable him to handle in an appropriate and flexible manner those medical problems he confronts, using in this process knowledge of how the human body and psyche work. What is desired is that the corpsman have a functional, working knowledge of the biomedical science pertinent to the common, and/or important medical problems he faces. Our own research over a number of years suggests that building such knowledge, especially for difficult topics, requires a kind of concerted and resource-consuming effort that cannot feasibly be directed at all the components of a curriculum; there must be ways to determine what is and what is not worth the effort (e.g., Feltovich, Spiro, & Coulson, in press). In this respect, what we have reported should be able to provide a great deal of guidance for curricular focus, in the importance and difficulty of the medical problems a corpsman sees, in the biomedical science knowledge pertinent to these which is felt to be most important and least well mastered, and in the perceptions of personnel associated with the corpsman program, regarding changes that would better prepare the corpsman for his job.

In summary, our recommendations, based on this research project, are as follows:

- 1) Incorporate elements of case- or problem-based instruction into the curriculum, instruction that involves the exploration of how pertinent basic biomedical science concepts apply to and aid in the understanding of these cases.
- 2) Incorporate patient simulations, especially live "simulated patients," in order to give students experiences with clinical problems and their presentations, and in order to enable students to practice their skills.

3) Use environmental simulations, in the ideal case, simulations of the working environment on a boat, to prepare students for the rigors on a real submarine that they will encounter as a working corpsman.

4) In all curricular endeavors that require resource and time commitment decisions, use the research results presented here to guide the decisions to areas of difficulty and importance, relative to commonness in the corpsman's medical practice.

REFERENCES

- Anderson, J.R. (1982). Acquisition of cognitive skill. *Psychological Review*, 18, 396-406.
- Anderson, J.R. (1983). *The architecture of cognition*. Cambridge, MA: Harvard University Press.
- Anderson, J.R., Farrell, R., & Sauers, R. (1984). Learning to program in LISP. *Cognitive Science*, 8, 87-129.
- Anderson, J.R., & Reder, L.M. (1979). An elaborative processing explanation of depth of processing. In L.S. Cermak & F. I. M. Craik (Eds.), *Levels of processing in human memory*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Baddeley, A.D. (1982). Domains of recollection. *Psychological Review*, 89, 708-729.
- Barrows, H.S. (1983). Problem-based, self-directed learning. *JAMA*, 250, 3077-3080.
- Barrows, H. S., & Feltovich, P.J. (1987). The clinical reasoning process. *Medical Education*, 21(2), 86-91.
- Barrows, H.S., Williams, R.G., & Moy, R.H. (1978). A comprehensive performance-based assessment of fourth-year students' clinical skills. *Journal of Medical Education*, 62, 805-809.
- Baroody, A.J., and Ginsburg, H.P. (1986). The relationship between initial meaningful and mechanical knowledge of arithmetic. In J. Harvey (Ed.), *Conceptual and procedural knowledge: The case of mathematics*. Hillsdale, NJ: Lawrence Erlbaum.
- Bransford, J.D., Stein, B.S., Shelton, T.S., and Owings, R.A. (1982). Cognition and adaptation: The importance of learning to learn. In J. Harvey (Ed.), *Cognition, social behavior, and the environment*. Hillsdale, NJ: Lawrence Erlbaum.
- Brown, J.S., and VanLehn, K. (1980). Repair theory: A generative theory of bugs in procedural skills. *Cognitive Science*, 4, 379-426.
- Chi, M.T.H., Feltovich, P.J., and Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science*, 5, 121-152.
- Coulson, R.L., Feltovich, P.J., and Spiro, R.J. (1989). Foundations of a misunderstanding of the ultrastructural basis of myocardial failure: A reciprocating network of oversimplifications. *Journal of medicine and Philosophy*, 14, 109-146.

- Coulson, R.L., Spiro, R.J., and Feltovich, A conceptual blending approach to teaching and assessing the understanding of complex biomedical concepts. Pre-publication manuscript.
- Davis, R.B., and McKnight, C. (1980). The influence of semantic content on algorithmic behavior. *Journal of Mathematical Behavior*, 3, 39-87.
- Duffy, J.C., Ed. (1984). *The ship's medicine chest and medical aid at sea*. Office of the Surgeon General, U.S. Dept. of Health and Human Services, Rockville, MD. U.S. Government Printing Office, Washington, D.C.
- Feltovich, P.J. (1983). Expertise: Reorganizing and refining knowledge for use. *Professions Education Researcher Notes*, 4, 5-9.
- Feltovich, P.J., Johnson, P.E., Moller, J.H., and Swanson, D.B. (1984). LCS: The role and development of medical knowledge in diagnostic expertise. In W.J. Clancey & E.H. Shortliffe (Eds.), *Readings in medical artificial intelligence: The first decade*. Reading, MA: Addison-Wesley.
- Feltovich, P.J., Spiro, R.J., and Coulson, R.L. (1989). The nature of conceptual understanding in biomedicine: The deep structure of complex ideas and the development of misconceptions. In D. Evans & V. Patel (Eds.), *The cognitive sciences in medicine: Biomedical Modeling*. Cambridge, MA: MIT (Bradford) Press.
- Feltovich, P.J., Spiro, R.J., & Coulson, R.L. (in press). Learning, teaching and testing for complex conceptual understanding. In N. Fredericksen, R. Mislevy, & I. Bejar (Eds.), *Test theory for a new generation of tests*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Forbus, K.D. (1985). Qualitative process theory. In D.G. Bobrow (Ed.), *Qualitative reasoning about physical systems*. Cambridge, MA: MIT (Bradford) Press.
- Gelman, R., and Meck, E. (1986). The notion of principle: The case of counting. In J. Hiebert (Ed.), *Conceptual and procedural knowledge: The case of mathematics*. Hillsdale, NJ: Lawrence Erlbaum.
- Gick, M.L., and Holyoak, K.J. (1983). Schema induction and analogical transfer. *Cognitive Psychology*, 15, 371-416.
- Glaser, R. (1984). Education and thinking: The role of knowledge. *American Psychologist*, 39, 93-104.
- Hiebert, J., and Lefevre, P. (1986). Conceptual and procedural knowledge in mathematics: An introductory analysis. In J. Hiebert (Ed.), *Conceptual and*

procedural knowledge: The case of mathematics. Hillsdale, NJ: Lawrence Erlbaum.

- Kieras, D.E., and Bovair, S. (1984). The role of a mental model in learning to operate a device. *Cognitive Science*, 8, 255-273.
- Lesgold, A.M., Feltovich, P.J., Glaser, R., and Wang, Y. (1981). *The acquisition of perceptual diagnostic skill in radiology*. Tech. Rept. No. PDS-1, ONR Contract No. N00014-79-C-0215, NR 157-430. Pittsburgh, PA: Learning Research and Development Center, University of Pittsburgh.
- Lesgold, A.M., Robinson, H., Feltovich, P.J., Glaser, R., Klopfer, D., & Wang, Y. (1988). Expertise in a complex skill: Diagnosing x-ray pictures. In M.T.H. Chi, R. Glaser, & M.J. Farr (Eds.), *The nature of expertise*. Hillsdale, NJ: Lawrence Erlbaum Assoc.
- McCloskey, M. (1983). Naive theories of motion., In D. Gentner & A.L. Stevens (Eds.), *Mental Models*. Hillsdale, NJ: Lawrence Erlbaum.
- Myers, A., Feltovich, P.J., Coulson, R.L., Adami, J.F., & Spiro, R.J. (1990). Reductive biases in the reasoning of medical students: An investigation in the domain of acid-base balance. In B. Bender, A.J.J.A. Scherbier, & R.P. Zwierstra (Eds.), *Teaching and assessing clinical competence*. Groningen, The Netherlands: BoekWerk Publications.
- Norman, G.R., Muzzin, L.J., Williams, R.G., & Swanson, D.B. (1985). Simulations in health sciences education. *Journal of Instructional Development*, 8, 11-17.
- Patel, V.L., Evans, D.A., & Groen, G.J. (1989). Biomedical knowledge and clinical reasoning. In D. Evans & V. Patel (Eds.), *Cognitive science in medicine: Biomedical modeling*. Cambridge, MA: MIT (Bradford) Press.
- Patel, V.L., Kaufman, D.R., & Magder, S. (1991). Causal explanation of complex physiological concepts by medical students. *International Journal of Science Education*, 13(2), 171-185.
- Resnick, L.B. (1982). Syntax and semantics in learning to subtract. In T.P. Carpenter, J.M. Moser, & T.A. Romberg (Eds.), *Addition and subtraction: A cognitive perspective*. Hillsdale, NJ: Lawrence Erlbaum.
- Ross, B.H. (1984). Reminders and their effects in learning a cognitive skill. *Cognitive Psychology*, 14, 1-38.
- Schoenfeld, A.H. (1983). Episodes and executive decisions in mathematical problem solving. In R. Lesh & M. Landau (Eds.), *Acquisition of mathematics concepts and processes*. New York: Academic Press.
- Schoenfeld, A.H. (1986). On having and using geometric knowledge. In J. Hiebert (Ed.), *Conceptual and procedural knowledge: The case of mathematics*. Hillsdale, NJ: Lawrence Erlbaum.

- Spilich, G.J., Vesonder, G.T., Chiesi, H.L., and Voss, J.F. (1979). Text processing of domain related information for individuals with high and low domain knowledge. *Journal of Verbal Learning and Verbal Behavior*, 14, 506-522.
- Spiro, R.J., Vispoel, W.L., Schmitz, J.G., Samarapungavan, A., and Boerger, A.E. (1987). Knowledge acquisition for application: Cognitive flexibility and transfer in complex conceptual domains. In B.C. Britton and S. Lynn (Eds.), *Executive Control Process*. Hillsdale, NJ: Lawrence Erlbaum.
- Spiro, R.J., Feltovich, P.J., Coulson, R.L., and Anderson, D.K. (in press). Multiple analogies for complex concepts: Antidotes for analogy-induced misconceptions in advanced knowledge acquisition. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning*. Cambridge, U.K.: Cambridge University Press.
- VanLehn, K. (1986). Arithmetic procedures are induced from examples. In J. Hiebert (Ed.), *Conceptual and procedural knowledge: The case of mathematics*. Hillsdale, NJ: Lawrence Erlbaum.

APPENDIX A

CONDITION	SUB-TOPICS	INDEX
1 CHEST PAIN	CARDIAC ELECTROPHYSIOLOGY	0.662
2 CHEST PAIN	THORACIC ANATOMY	1.072
3 CHEST PAIN	DIFFERENTIAL DIAGNOSIS	0.889
4 DIARRHEA	G.I. ABSORPTION, SECRETION & MOT	1.077
5 DIARRHEA	CARBOHYDRATE & LIPID METABOLISM	0.845
6 DIARRHEA	MECHANISMS OF INFECTION	1.003
7 OTITIS	VESTIBULAR APPARATUS & EQUILIBR	1.158
8 OTITIS	ANATOMY OF AUDITORY APPARATUS	1.281
9 OTITIS	MECHANISMS OF INFECTION	1.206
10 HIATAL HERNIA	THORACIC & ABDOMINAL PRESSURES	0.944
11 HIATAL HERNIA	PHYSIOLOGY OF ESOPHAGEAL SPHIN	0.965
12 HIATAL HERNIA	INNERVATION OF THE G.I. TRACT	0.912
13 GASTROENTERITIS	ANATOMY OF THE G.I. TRACT	1.235
14 GASTROENTERITIS	FLUID & ELECTROLYTE BALANCE	0.946
15 GASTROENTERITIS	G.I. MOTILITY	1.033
16 HEAD INJURY	NEURAL ANATOMY	0.781
17 HEAD INJURY	CEREBRAL VASCULAR ANATOMY	0.757
18 HEAD INJURY	OSMOTIC DIURETICS	0.684
19 PNEUMONIA	ANATOMY OF THE THORAX	1.137
20 PNEUMONIA	VENTILATION-PERFUSION PHYSIOLOG	0.836
21 PNEUMONIA	GRAM NEGATIVE SEPSIS	0.839
22 BRONCHITIS	PHYSIOLOGY OF MUCUS PRODUCTION	1.054
23 BRONCHITIS	BRONCHIAL HISTOLOGY & ANATOMY	1.019
24 BRONCHITIS	PULMONARY INFECTIOUS AGENTS	0.896
25 HEADACHE	VASOMOTOR PHYSIOLOGY	0.896
26 HEADACHE	ANATOMY OF THE HEAD & NECK	1.048
27 HEADACHE	MECHANISMS OF HEADACHE TYPES	0.978
28 APPENDICITIS	MECHANISMS OF REFERRED PAIN	1.034
29 APPENDICITIS	ABDOMINAL ANATOMY	1.097
30 APPENDICITIS	NON-SURGICAL TREATMENT OF APPEN	1.111
31 KIDNEY STONES	MECHANISMS OF REFERRED PAIN	1.051
32 KIDNEY STONES	DIFFERENTIAL DIAGNOSIS	1.026
33 KIDNEY STONES	UROGENITAL ANATOMY	1.094
34 HEART ATTACK	MYOCARDIAL METABOLISM (ISCHEMIA)	0.728
35 HEART ATTACK	CARDIAC FUNCTION	0.794
36 HEART ATTACK	MECHANISMS OF ARRHYTHMIAS	0.600
37 FUNGAL INFECTION	PULMONARY PHYSIOLOGY	0.961
38 FUNGAL INFECTION	METABOLISM OF LYMPH NODE CALCIF	0.700
39 FUNGAL INFECTION	ANATOMY OF THE LUNGS	1.092
40 SPRAINS	MUSCULOSKELETAL ANATOMY	1.231
41 SPRAINS	MUSCLE SPINDLES & GOLGI ORGAN P	0.950
42 SPRAINS	CONNECTIVE TISSUE MORPHOGENESIS	0.952
43 BLOODY STOOL	INFECTIOUS AGENTS IN THE G.I. T	1.207
44 BLOODY STOOL	ANATOMY OF THE G.I. TRACT	0.858
45 BLOODY STOOL	DIFFERENTIAL DIAGNOSIS	0.809
46 G.I. FLU	G.I. ABSORPTION & SECRETION	1.014
47 G.I. FLU	INFECTIOUS AGENTS OF THE G.I. T	0.990
48 G.I. FLU	FLUID & ELECTROLYTE BALANCE	0.932
49 MENINGITIS	INFECTIOUS AGENTS & BLOOD-BRAIN	0.916
50 MENINGITIS	MECHANISMS OF NUCLEAR RIGIDITY	0.982
51 MENINGITIS	EXAMINATION OF CRANIAL NERVE FU	0.923
52 BLOODY URINE	UROGENITAL ANATOMY	1.090
53 BLOODY URINE	RENAL PHYSIOLOGY	0.956
54 BLOODY URINE	INFECTIOUS AGENTS OF UROGENITAL	0.999
55 INGUINAL HERNIA	MUSCULOSKELETAL ANATOMY	1.108
56 INGUINAL HERNIA	EMBRYOLOGY	0.841

CONDITION	SUB-TOPICS	INDEX
57	INGUINAL HERNIA	MECHANISMS OF REFERRED PAIN 1.007
58	TORSION TESTICLE	UROGENITAL ANATOMY 1.079
59	TORSION TESTICLE	GENITAL-RECTAL EXAMINATION 1.146
60	TORSION TESTICLE	DIFFERENTIAL DIAGNOSIS (EDIDIDY 1.041
61	G.I. ULCER	PHYSIOLOGY OF G.I. SECRETION 0.983
62	G.I. ULCER	DIFFERENTIAL DIAGNOSIS 1.023
63	G.I. ULCER	MECHANISMS OF ULCERATION 0.981
64	URETHRITIS	UROGENITAL PHYSIOLOGY 1.144
65	URETHRITIS	SEXUALLY TRANSMITTED DISEASE PA 1.165
66	URETHRITIS	UROGENITAL ANATOMY 1.175
67	DERMATITIS	TOPICAL TREATMENTS / DERMATITIS 1.118
68	DERMATITIS	HISTOLOGICAL STRUCTURE OF SKIN 1.258
69	DERMATITIS	NUTRITIONAL INTEGRITY OF SKIN 1.339
70	FRACTURES	INFECTIOUS PROCESSES IN BONE 0.940
71	FRACTURES	SECONDARY PATHOLOGICAL EFFECTS 0.915
72	FRACTURES	PHYSIOLOGY OF BONE GROWTH & KNI 0.951
73	COLDS	INFECTIOUS AGENTS IN RESPIRATOR 1.219
74	COLDS	AUSCULTATORY ANATOMY OF THORAX 1.172
75	COLDS	PHYSIOLOGY OF THE LUNG 1.178
76	PROSTATITIS	ANATOMY OF THE UROGENITAL SYSTE 1.154
77	PROSTATITIS	MALE GENITAL-RECTAL EXAM 1.155
78	PROSTATITIS	UROGENITAL INFECTIOUS AGENTS 1.055
79	TRAUMA	PHYSIOLOGY OF WOUND HEALING 1.241
80	TRAUMA	PHYS. OF BLOOD PRESSURE IN SHOC 1.174
81	TRAUMA	MECHANISMS OF INFECTION 1.170
82	PSYCHOLOGICAL	SYMPTOMS OF DRUG/ALCOHOL ABUSE 0.951
83	PSYCHOLOGICAL	SITUATIONAL ADJUSTMENT REACTION 0.822
84	PSYCHOLOGICAL	CHARACTER OF PERSONALITY DISOR 0.747

APPENDIX B

Conceptual Knowledge Research Project
GI Probe Set
12/19/88

PART I

READ THE FOLLOWING CASE PRESENTATION CAREFULLY AND RESPOND OUT LOUD TO THE QUESTION. YOU HAVE A PAD AND PEN AND MAY MAKE NOTES IF YOU WISH BUT SAY EVERYTHING OUT LOUD. IF YOU WRITE SOMETHING DOWN TELL WHAT YOU ARE WRITING AND ALWAYS TRY TO THINK OUT LOUD! PLEASE READ THE QUESTION OUT LOUD BEFORE YOU ATTEMPT TO RESPOND TO IT. YOUR RESPONSES AND YOUR IDENTITY WILL BE KEPT STRICTLY CONFIDENTIAL. YOUR COOPERATION IS GREATLY APPRECIATED.

A Torpedoman from the forward torpedo room has sent a rackmate to fetch you about 21:00 hrs on the tenth day at sea. When you arrive at his rack he is doubled over on his left side in the rack complaining of belly pain. You recall giving him antacids two days before when he complained of mild indigestion which he had claimed to have experienced on previous occasions "after eating chili."

1) At this point give your initial impressions. Tell what possible problems you are considering, no matter how speculative or preliminary your ideas may be.

NOW, RE-READ THE CASE PRESENTATION WITH SOME ADDITIONAL INFORMATION PROVIDED AND ANSWER THE FOLLOWING QUESTIONS OUT LOUD. THE NEW INFORMATION IS HIGHLIGHTED IN BOLD TYPE. AS BEFORE YOU MAY MAKE NOTES IF YOU WISH BUT PLEASE TRY TO THINK OUT LOUD! IF YOU WRITE NOTES OR DRAW DIAGRAMS, OR EVEN JUST DOODLE, PLEASE SAY WHAT YOU ARE DOING. YOU MAY KEEP THE CASE PRESENTATION IN FRONT OF YOU IN THE EVENT THAT YOU MAY WANT TO REFER BACK TO IT AS YOU ANSWER THE QUESTIONS. EACH QUESTION WILL BE PRESENTED TO YOU ON A SEPARATE PAGE. PLEASE READ THE QUESTION OUT LOUD BEFORE YOU ATTEMPT TO RESPOND TO IT. YOUR RESPONSES AND YOUR IDENTITY WILL BE KEPT STRICTLY CONFIDENTIAL. YOUR COOPERATION IS GREATLY APPRECIATED.

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2) What problems are you considering at this time? What is your differential diagnosis? Give your current differential diagnosis for the patient and justify it on the basis of what you know about the patient so far. Also discuss things you may have considered but have already excluded as highly unlikely given the information you have so far, and explain why you have excluded them.

3) Of the problems you are considering which are the most serious for the patient and/or the boat? Which of the possibilities you are considering are the least serious for the patient and/or the boat?

4) Considering the possibilities what further information do you need, or what would you have to understand to best decide among the possible problems (differential diagnoses)?

5) What additional things would you watch for or investigate that would suggest to you that the problem either is serious or is turning into something which is serious?

PART II

IN THIS SECTION, AS BEFORE, YOU MAY MAKE NOTES IF YOU WISH BUT PLEASE TRY TO THINK OUT LOUD! IF YOU WRITE NOTES OR DRAW DIAGRAMS, OR EVEN JUST DOODLE, PLEASE SAY WHAT YOU ARE DOING. EACH QUESTION WILL BE PRESENTED TO YOU ON A SEPARATE PAGE. PLEASE READ THE QUESTION OUT LOUD BEFORE YOU ATTEMPT TO RESPOND TO IT. SOME QUESTIONS MAY SEEM TO REPEAT. WE RECOGNIZE SOME OVERLAP. PLEASE TREAT EACH ITEM SEPARATELY AND DEAL WITH IT AS BEST YOU CAN. YOUR RESPONSES AND YOUR IDENTITY WILL BE KEPT STRICTLY CONFIDENTIAL. YOUR COOPERATION IS GREATLY APPRECIATED.

1) Infection is often described by analogy as a sort of battle between invaders and defenders. When you think of the subject of DIGESTION AND INTESTINAL ABSORPTION are there any analogies, metaphores or models that come to your mind that help you to think about the subject of DIGESTION AND INTESTINAL ABSORPTION? Please explain!

2) Describe as well as you can the process of DIGESTION AND INTESTINAL ABSORPTION.

3) Describe the anatomical organs, structures, and cell-types important in the process of DIGESTION AND INTESTINAL ABSORPTION.

4) Describe the physiological functions and materials or substances that are important in the process of DIGESTION AND INTESTINAL ABSORPTION.

5) Describe how the food that is eaten is broken down by digestion into nutrient forms that may be utilized in INTESTINAL ABSORPTION.

6) Describe the various processes by which nutrients are absorbed from the digestive tract into the body (i.e. the blood or interstitial space).

7) Describe the following structures and tell what they actually do in the process of DIGESTION AND INTESTINAL ABSORPTION:

- a) mucosa;
- b) villi;
- c) microvilli;
- d) crypts of Lieberkuhn.

8) Describe the following cell-types and tell what they actually do in the process of DIGESTION AND INTESTINAL ABSORPTION:

- a) columnar cells;
- b) goblet cells;
- c) enterochromaffin cells;
- d) mucosal tight junctions (not a cell-type).

9) Discuss the following substances and tell what they are, where they come from, and what they do in the process of DIGESTION AND INTESTINAL ABSORPTION:

- a) gastric acid;
- b) pepsin;
- c) amylase;
- d) lipase;
- e) chymotrypsin;
- f) peptidases;
- g) bile salts;
- h) carbohydrates;
- i) proteins;
- j) fats;
- k) mono & di-saccharides;
- l) di & tri-peptides;
- m) amino acids;
- n) monoglycerides;
- o) fatty acids.

10) Describe and explain the distinguishing characteristics of the following modes of transport across the intestinal wall:

- a) active transport;
- b) passive diffusion;
- c) facilitated diffusion;
- d) pinocytosis;
- e) "solute drag."

11) For each of the following nutrient pathways of absorption, discuss:

- a) a pathophysiological mechanism (or more than one if there are alternatives) that could cause inhibition of the pathway; and

b) the effect this inhibition could produce in a patient (i.e. in terms of signs and symptoms a patient might exhibit with the nutrient absorption pathway inhibited).

- i) fats only
- ii) carbohydrates only
- iii) proteins only
- iv) carbohydrates and proteins only
- v) fats, carbohydrates and proteins

12) A 25 year old white male patient presents with diarrhea which has progressively gotten worse over the course of a week and is now explosive. He has not been out of the country. He has no fever or any overt signs of infection although he has lost about 10 lbs. (weight now, 175 lbs.) and shows some signs of dehydration.

a) What are your ideas about what may be causing his problem?

b) What pathophysiological mechanism (or mechanisms) could explain the diarrhea in the case of each of your ideas about what may be causing the problem?

13) The patient (in the previous question) has, in fact, acquired a lactase deficiency which prevents him from splitting the disaccharide lactose. This is sometimes referred to as developing "milk sensitivity" since lactose is milk sugar and milk is the main source of this disaccharide in the diet.

Describe a mechanism by which this lactase deficiency could explain the patient's diarrhea.

Conceptual Knowledge Research Project
Southern Illinois University School of Medicine
Departments of Medical Education and Physiology
for the
Manpower, Personnel, and Training Research and Development Program
Office of Naval Research

GI Probe II

PART I

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A 32-year-old senior Chief, just assigned to your fast attack boat from a boomer, comes to see you while in home port. The MO has suggested you see him first and work him up before taking him up to the clinic where the physician will check him again and discuss your findings.

The Chief complains that he has recently been having trouble swallowing solid food. He says he has "no trouble with liquids" except when he "gulps his beer." The trouble swallowing has been getting worse for about the last three weeks, he has lost about five pounds (weight now 160 lbs., height 5'7") and his "appetite has fallen off." The Chief was once a pharmacist's mate on surface ships and he is afraid he "might have cancer." He has a five year history of heartburn for which he usually takes Tums.

- 1) At this point give your initial impressions. Tell what possible problems you are considering, no matter how speculative or preliminary your ideas may be.

NOW, RE-READ THE CASE PRESENTATION WITH SOME ADDITIONAL INFORMATION PROVIDED AND ANSWER THE QUESTIONS THAT FOLLOW OUT LOUD. THE NEW INFORMATION IS HIGHLIGHTED IN BOLD TYPE. AS BEFORE YOU MAY MAKE NOTES IF YOU WISH BUT PLEASE TRY TO THINK OUT LOUD! IF YOU WRITE NOTES OR DRAW DIAGRAMS, OR EVEN JUST DOODLE, PLEASE SAY WHAT YOU ARE DOING. YOU MAY KEEP THE CASE PRESENTATION IN FRONT OF YOU IN THE EVENT THAT YOU MAY WANT TO REFER BACK TO IT AS YOU ANSWER THE QUESTIONS. EACH QUESTION WILL BE PRESENTED TO YOU ON A SEPARATE PAGE. PLEASE READ THE QUESTION OUT LOUD BEFORE YOU ATTEMPT TO RESPOND TO IT. YOUR RESPONSES AND YOUR IDENTITY WILL BE KEPT STRICTLY CONFIDENTIAL. YOUR COOPERATION IS GREATLY APPRECIATED.

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On taking a history you find he had an episode of bronchitis on his last boomer run, about five months ago. The corpsman gave him tetracycline and it cleared up in a couple of days although he took the antibiotic for "probably eight or nine days." He smokes 2-3 packs a day and has smoked since before he enlisted at eighteen. He drinks a six pack of beer every day or two while in port.

His mother died of stomach cancer last year at age 60. He is an only child who lived in Panama until he was twelve. His father was in the Navy. His 62-year-old father has been diagnosed as having "some kind of swallowing problem." The Chief is not married and never has been. He was told he accidentally swallowed some Drano when he was two years old. Except in the boat, he has not been out of the country within the last two years, except briefly in Scotland when he got off the boomer about 3 months ago. He has vomited a few times in the last month or so "after eating or drinking too much." There was blood in the vomit last week. He complains of chest pain lasting "a few minutes" after "eating too much at one time." He denies melena, diarrhea and constipation.

- 2) What problems are you considering at this time? What is your differential diagnosis? Give your current differential diagnosis for the patient and justify it on the basis of what you know about the patient so far. Also discuss things you may have considered but have already excluded as highly unlikely given the information you have so far, and explain why you have excluded them.
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On physical exam, the Chief is found to have no fever and to have stable vital signs. He is alert with slight slurred speech but in not acute distress.

He is normocephalic with no adenopathy or thyromegaly. His neck is supple, he has an enlarged parotid gland, poor dentition and bad breath.

His lungs are clear to auscultation and percussion with no evidence of consolidation.

His heart rate and rhythm are regular with no murmurs, gallops, or rubs. He has no peripheral edema and has good pulses distally.

His abdomen is tender in the sub-xiphoid area with no visceromegaly. Bowel sounds are normal in all quadrants. Rectal exam reveals trace guaiac positive stools and a normal prostrate.

There is mild muscular weakness proximally and symmetrically.

His skin is warm with some spider angiomas and palmar erythema.

There is possible proximal muscle wasting with hypothenar atrophy.

HCT 35.9
MCV 78 3
CPK 500 U

NL 37-47%
NL 82-95 3
NL 25-90 U/ml

- 5) What problems are you considering at this time? What is your differential diagnosis? Give your current differential diagnosis for the patient and justify it on the basis of what you know about the patient so far. Also discuss things you may have considered but have already excluded as highly unlikely given the information you have so far, and explain why you have excluded them.
- 6) What additional things would you watch for or investigate that would suggest to you that the problem either is serious or is turning into something which is serious?

PART II

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- 1) Infection is often described by analogy as a sort of battle between invaders and defenders. When you think of the subject of swallowing and/or aboral movement of food through the GI tract, are there any analogies, metaphores or models that come to your mind that help you to think about the subject of swallowing and aboral movement of food through the GI tract (aboral movement is the propulsion of the food bolus or chyme through the GI tract, "away from the mouth")?
2. Discuss as much as you can about the process of swallowing and/or aboral movement of food through the GI tract.
3. Describe the anatomical organs, structures and cell types important in the process of swallowing and/or aboral movement of food through the GI tract.
4. Describe the physiological control mechanisms that are important in the process of swallowing and/or aboral movement of food through the GI tract.
5. Describe the types of muscle (contractile) activity in the GI tract and tell what they accomplish in the process of swallowing and/or aboral movement of food through the GI tract.
6. Describe each of the following structures and tell what it actually does in the process of swallowing and/or aboral movement of food through the GI tract.
 - I. a) tongue and oral cavity
 - b) pharynx
 - c) esophagus
 - d) stomach
 - e) duodenum
 - f) jejunum
 - g) ileum
 - h) colon
 - II. a) glottis and epiglottis
 - b) upper esophageal sphincter
 - c) lower esophageal sphincter
 - d) pylorus
 - e) ileocecal valve
 - f) internal anal sphincter
 - g) external anal sphincter
7. Describe the following muscle types including their type of innervation (the kind of nerve supply) and tell what they do in the process of swallowing and/or aboral movement of food through the GI tract.
 - a. skeletal (striated) muscle
 - b. smooth (non-striated) muscle

8. Describe the following mechanisms involved in the control of swallowing and/or aboral movement of food through the GI tract, and discuss the function of each.
 - a. neural control mechanisms
 - b. endocrine control mechanisms
9. Discuss the function of each of the following neural systems involved in the control of swallowing and/or aboral movement of food through the GI tract.
 - a. Somatic (non-autonomic) nervous system including voluntary and involuntary components.
 - b. Autonomic (sympathetic and parasympathetic) nervous system
 - c. Enteric or intrinsic nervous system
 - d. Reflex arcs (discuss each)
 - i. myenteric reflex
 - ii. intestinointestinal inhibitory reflex
 - iii. gastrocolic reflex
 - iv. peristaltic reflex
 - v. gastroileal reflex
 - vi. enterogastric inhibitory reflex
10. Discuss each of the following gastrointestinal hormones and tell where it comes from and what it does in controlling swallowing and/or aboral movement of food through the GI tract.
 - a) gastrin
 - b) cholecystokinin
 - c) secretin
 - d) glucagon
11. Discuss how specific types of muscle (contractile) activity, (i.e., peristalsis, segmentation, migrating motor complex, haustration and mass movement, as applicable) relate to mixing and propulsion of the food bolus or chyme in each of the following regions of the digestive tract.
 - a) pharynx/esophagus
 - b) stomach
 - c) small intestine
 - d) colon
12. In the GI tract, pathological disturbances may interfere with the process of swallowing and/or aboral movement of food through the GI tract. For each of the medical conditions listed below, give:
 - a) a pathophysiological mechanism (if one is known, or more than one if there are alternatives) which could cause interference with the process of swallowing and/or aboral movement; and,

b) the effect this interference could produce in a patient, i.e., signs and symptoms a patient might exhibit.

- i. hiatal hernia
- ii. weak lower esophageal sphincter
- iii. esophageal obstruction
- iv. intestinal strangulation
- v. peritonitis
- vi. obstructive bowel mass

13. A 28-year-old black male has a three week history of progressive dysphagia (difficulty swallowing). Initially, there was only difficulty swallowing solids, but now liquids also pose some difficulty. In the past few days, regular vomiting without nausea and a four-five pound weight loss have occurred without other symptoms. His weight now is 180 lbs., height 5'10". He has not been in any foreign countries and has no other remarkable findings.

a) What are your ideas about what may be causing this problem?

b) What pathophysiological mechanisms could explain this problem in the case of each of your different ideas about the cause of the problem?

14. The patient (in the previous question) was, in fact, initially diagnosed as having distal esophageal carcinoma. However, the problem turned out to be achalasia due to idiopathic spasm of the lower esophageal sphincter which was successfully treated, eliminating the problem.

Describe possible treatments which may have been used, once the true diagnosis was known.

"CHEST PAIN"
CONCEPTUAL KNOWLEDGE RESEARCH PROJECT
SOUTHERN ILLINOIS UNIVERSITY SCHOOL OF MEDICINE
DEPARTMENTS OF MEDICAL EDUCATION AND PHYSIOLOGY
FOR THE
MANPOWER RESEARCH AND DEVELOPMENT PROGRAM
OFFICE OF NAVAL RESEARCH

PART I

READ THE FOLLOWING CASE PRESENTATION CAREFULLY AND RESPOND OUT LOUD TO THE QUESTION. YOU HAVE A PAD AND PEN AND MAY MAKE NOTES IF YOU WISH BUT SAY EVERYTHING OUT LOUD. IF YOU WRITE SOMETHING DOWN TELL WHAT YOU ARE WRITING AND ALWAYS TRY TO THINK OUT LOUD! PLEASE READ THE QUESTION OUT LOUD BEFORE YOU ATTEMPT TO RESPOND TO IT. YOUR RESPONSES AND YOUR IDENTITY WILL BE KEPT STRICTLY CONFIDENTIAL. YOUR COOPERATION IS GREATLY APPRECIATED.

A 28 year old white Torpedoman from the forward torpedo room reports a sudden "stabbing" left-sided pain in his chest accompanied by shortness of breath which came on while moving weapons. The dyspnea (shortness of breath) lasted about 5 minutes while the pain continued for about 30 minutes and is just now subsiding without any intervention.

- 1) At this point give your initial impressions. Tell what possible problems you are considering, no matter how speculative or preliminary your ideas may be.

NOW, RE-READ THE CASE PRESENTATION WITH SOME ADDITIONAL INFORMATION PROVIDED AND ANSWER THE FOLLOWING QUESTIONS OUT LOUD. THE NEW INFORMATION IS HIGHLIGHTED IN BOLD TYPE. AS BEFORE YOU MAY MAKE NOTES IF YOU WISH BUT PLEASE TRY TO THINK OUT LOUD! IF YOU WRITE NOTES OR DRAW DIAGRAMS, OR EVEN JUST DOODLE, PLEASE SAY WHAT YOU ARE DOING. YOU MAY KEEP THE CASE PRESENTATION IN FRONT OF YOU IN THE EVENT THAT YOU MAY WANT TO REFER BACK TO IT AS YOU ANSWER THE QUESTIONS. EACH QUESTION WILL BE PRESENTED TO YOU ON A SEPARATE PAGE. PLEASE READ THE QUESTION OUT LOUD BEFORE YOU ATTEMPT TO RESPOND TO IT. YOUR RESPONSES AND YOUR IDENTITY WILL BE KEPT STRICTLY CONFIDENTIAL. YOUR COOPERATION IS GREATLY APPRECIATED.

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about 5 minutes while the pain continued for about 30 minutes and is just now subsiding without any intervention. He says the pain radiated to his left shoulder but he has not noted palpitations (feeling his own heart beating). He is married to a working civilian nurse and has two daughters aged 10 and 12. His father, a coal miner, died at age 60 from "Black Lung disease." He drinks a six-pack a day while on the beach and smokes "maybe half a pack a day." He is 5' 9" tall, weighs 175 lbs, and his temperature is 37 °C. His blood pressure is 110/65, his heart rate is 90/min, and his respirations are rapid (26/min) and shallow. His lungs are clear to auscultation. There is a possible loud S2 (second heart sound). He had a history of red bloody stools during his last hitch which turned out to be hemorrhoids. He was treated with Preparation-H and has had no problem with bloody stool for the past year but the "piles still act up from time to time."

2) What problems are you considering at this time? What is your differential diagnosis? Give your current differential diagnosis for the patient and justify it on the basis of what you know about the patient so far. Also discuss things you may have considered but have already excluded as highly unlikely given the information you have so far, and explain why you have excluded them.

3) Of the problems you are considering which are the most serious for the patient and/or the boat? Which of the possibilities you are considering are the least serious for the patient and/or the boat?

4) Considering the possibilities what further information do you need, or what would you have to understand to best decide among the possible problems (differential diagnoses)?

5) What additional things would you watch for or investigate that would suggest to you that the problem either is serious or is turning into something which is serious?

PART II

IN THIS SECTION, AS BEFORE, YOU MAY MAKE NOTES IF YOU WISH BUT PLEASE TRY TO THINK OUT LOUD! IF YOU WRITE NOTES OR DRAW DIAGRAMS, OR EVEN JUST DOODLE, PLEASE SAY WHAT YOU ARE DOING. EACH QUESTION WILL BE PRESENTED TO YOU ON A SEPARATE PAGE. PLEASE READ THE QUESTION OUT LOUD BEFORE YOU ATTEMPT TO RESPOND TO IT. SOME QUESTIONS MAY SEEM TO REPEAT. WE RECOGNIZE SOME OVERLAP. PLEASE TREAT EACH ITEM SEPARATELY AND DEAL WITH IT AS BEST YOU CAN. YOUR RESPONSES AND YOUR IDENTITY WILL BE KEPT STRICTLY CONFIDENTIAL. YOUR COOPERATION IS GREATLY APPRECIATED.

1) Infection, for example, is often described by a "clash" of battle between invaders and defender. When you think of the heart and

CARDIOVASCULAR SYSTEM are there any analogies, metaphores or models that come to your mind that help you to think about the subject of **THE HEART AND CARDIOVASCULAR SYSTEM**? Please explain!

- 2) Describe as well as you can the process of **THE CIRCULATION OF THE BLOOD**.
- 3) Describe the anatomical organs, structures, and cell-types important in the process of **THE CIRCULATION OF THE BLOOD**.
- 4) Describe the physiological functions and materials or substances that are important in the process of **THE CIRCULATION OF THE BLOOD**.
- 5) Describe how the blood that is returned to the right atrium of the heart by the great veins is returned to the Aorta by the **HEART**.
- 6) Describe how the blood that is ejected by the heart into the aorta is returned to the heart by the **CARDIOVASCULAR SYSTEM**.
- 7) Describe the role that blood vessel size plays in the opposition to the flow of blood in the **CARDIOVASCULAR SYSTEM**.
- 8) Describe the role that compliance (stretchiness) or lack of compliance (stiffness) of blood vessels plays in the opposition to the flow of blood in the **CARDIOVASCULAR SYSTEM**.
- 9) Describe the following structures and tell what they actually do in **THE HEART AND CARDIOVASCULAR SYSTEM**:
 - a) right atrium;
 - b) right ventricle;
 - c) left atrium;
 - d) left ventricle;
 - e) carotid arteries;
 - f) jugular vein;
 - g) mesenteric artery;
 - h) portal vein;
 - i) hepatic artery;
 - j) renal artery;
 - k) brachial artery;
 - l) femoral vein;
 - m) coronary arteries
- 10) Describe the following cell types or tissues and tell what they actually do in **THE HEART AND CARDIOVASCULAR SYSTEM**

- a) cardiac muscle cell;
- b) bundle of His;
- c) atrio-ventricular node;
- d) vagus nerve;
- e) atrial pacemaker cells;
- f) carotid baroreceptors;
- g) aortic chemoreceptors;
- h) tunica media;
- i) intima
- j) vascular smooth muscle
- k) renal arterial juxtaglomerulus
- l) adrenal chromatin tissue.

11) Discuss the following substances and tell what they are, where they come from, and what they do in the **THE HEART AND CARDIOVASCULAR SYSTEM**:

- a) epinephrine;
- b) norepinephrine;
- c) dopamine;
- d) thyroxine;
- e) acetylcholine;
- f) renin;
- g) angiotensin.

12) For each of the following phenomena, discuss:

- a) the mechanism by which it occurs; and
- b) the effect that it could produce in a patient (ie. in terms of signs and symptoms a patient might exhibit while experiencing the phenomena).

- i) diving reflex;
- ii) orthostatic hypotension;
- iii) fight or flight reflex;
- iv) coronary vasospasm;
- v) sinus tachycardia.

13) A 34 year old white Senior Chief, recently transferred from another Fast Attack Boat, presents with chest pain which he describes as "like a belt tightening around my chest" and lasting for about 30 minutes. He reports a three month history of periodic indigestion occasionally accompanied by hyperventilation, for which his old corpsman gave him antacids. The pain started while he was lying awake in the rack. No change in posture relieved the pain. He drinks a six-pack a day when on the beach and smokes a pack a day. His parents, aged 60, are in good health but his maternal grandmother died of a "heart attack." He has a wife and four kids, two boys aged 10 and 12, and two girls aged 15 and 16 all in good health.

His wife and younger daughter are both pregnant. He has not been off the boat out of the country in over a year. He has no fever nor any overt signs of infection.

His blood pressure is 135/85 mmHg,
his heart rate is 85/min,
his respiration rate is 20/min,
he is 5' 11" tall,
he weighs 200 lbs, and
his lungs are clear to auscultation

- a) What are your different ideas about what may be causing the Chief's problem?
- b) What physiological mechanism (or mechanisms) could explain the chest pain in the case of each of your ideas about what may be causing the problem?
- c) What would be your disposition of this case?
 - i) Would you treat him on the boat? Explain your reasoning.
 - ii) Would you MEDEVAC him? Explain your reasoning.

14) The patient (in the previous question) is, in fact, suffering from an Anxiety Neurosis. He has been upset over his daughter's pregnancy and the fact that his wife is also pregnant has done nothing to relieve his anxiety.

- a) Explain the processes by which this condition could cause his signs and symptoms.
- b) Describe what more you might have done in order to determine the actual diagnosis.
- c) What facilities would you require, that are not available at sea, to have been more certain about your diagnosis?

"HEAD INJURY"
CONCEPTUAL KNOWLEDGE RESEARCH PROJECT
SOUTHERN ILLINOIS UNIVERSITY SCHOOL OF MEDICINE
DEPARTMENTS OF MEDICAL EDUCATION AND PHYSIOLOGY
FOR THE
MANPOWER RESEARCH AND DEVELOPMENT PROGRAM
OFFICE OF NAVAL RESEARCH

PART I

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You are called to the mess at 0630 hours on the tenth day at sea in a Fast Attack boat. A 20 year old black Mess Management Specialist has slipped in the galley and banged the top of his head on a bulkhead. He is unconscious. You are told by others present that "he has been out for about five minutes," and that you were called when they "couldn't bring him around." A cursory examination reveals a slight contusion with a small laceration on the parietal crown of his head just to the left of the sagittal suture line. His eyes are closed and his pupils are equal and equally reactive to light.

1) At this point give your initial impressions. Tell what possible problems you are considering, no matter how speculative or preliminary your ideas may be.

NOW, RE-READ THE CASE PRESENTATION WITH SOME ADDITIONAL INFORMATION PROVIDED AND ANSWER THE FOLLOWING QUESTIONS OUT LOUD. THE NEW INFORMATION IS HIGHLIGHTED IN BOLD TYPE. AS BEFORE YOU MAY MAKE NOTES IF YOU WISH BUT PLEASE TRY TO THINK OUT LOUD! IF YOU WRITE NOTES OR DRAW DIAGRAMS, OR EVEN JUST DOODLE, PLEASE SAY WHAT YOU ARE DOING. YOU MAY KEEP THE CASE PRESENTATION IN FRONT OF YOU IN THE EVENT THAT YOU MAY WANT TO REFER BACK TO IT AS YOU ANSWER THE QUESTIONS. EACH QUESTION WILL BE PRESENTED TO YOU ON A SEPARATE PAGE PLEASE READ THE QUESTION OUT LOUD BEFORE YOU ATTEMPT TO RESPOND TO IT. YOUR RESPONSES AND YOUR IDENTITY WILL BE KEPT STRICTLY CONFIDENTIAL. YOUR COOPERATION IS GREATLY APPRECIATED.

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- 2) What problems are you considering at this time? What is your differential diagnosis? Give your current differential diagnosis for the patient and justify it on the basis of what you know about the patient so far. Also discuss things you may have considered but have already excluded as highly unlikely given the information you have so far, and explain why you have excluded them.
- 3) Of the problems you are considering which are the most serious for the patient and/or the boat? Which of the possibilities you are considering are the least serious for the patient and/or the boat?
- 4) Considering the possibilities what further information do you need, or what would you have to understand to best decide among the possible problems (differential diagnoses)?
- 5) What additional things would you watch for or investigate that would suggest to you that the problem either is serious or is turning into something which is serious?

PART II

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1) Infection, for example, is often described by analogy as a sort of battle between invaders and defenders. When you think of the subject of **THE CENTRAL NERVOUS SYSTEM** are there any analogies, metaphores or models that come to your mind that help you to think about the subject of **THE CENTRAL NERVOUS SYSTEM**? Please explain!

2) Describe as well as you can the vital processes controlled by **THE CENTRAL NERVOUS SYSTEM**.

3) Describe the gross anatomical features of the head, the major structures of the brain, and the cell-types of the **CENTRAL NERVOUS SYSTEM**.

4) Describe as well as you can the **CENTRAL NERVOUS SYSTEM**'s control of respiration and the blood pressure.

5) Describe as well as you can the functions of as many of the cranial nerves as you can.

6) Describe how the blood volume and the extracellular fluid volume of the brain are regulated.

7) Describe the following structures and tell what they are and what they actually do:

- a) occipital bone;
- b) foramen magnum;
- c) ventricles of the brain;
- d) cerebral-spinal fluid;
- e) oculomotor nerve;
- f) carotid artery;
- g) anterior cerebral artery,
- h) cerebral cortex;
- i) pons

- j) sagittal sinus
- k) medulla oblongata
- l) thalamus.

8) Describe the following cell parts, cell-types, or tissues and tell what they actually do in **THE CENTRAL NERVOUS SYSTEM**:

- a) nerve cell bodies;
- b) nerve axons;
- c) nerve dendrites;
- d) glial cells;
- e) choroid plexus;
- f) myelin.

9) Discuss the following substances and tell what they are, where they come from, and what they do in the **THE CENTRAL NERVOUS SYSTEM**:

- a) acetylcholine;
- b) antidiuretic hormone;
- c) dopamine;
- d) osmotic diuretics;
- e) steroids.

10) For each of the following phenomena, discuss:

- a) the mechanism by which it occurs; and
- b) the effect that it could produce in a patient (ie. in terms of signs and symptoms a patient might exhibit while experiencing the phenomena).

- i) subdural hemorrhage;
- ii) epidural hemorrhage;
- iii) intracerebral hemorrhage;
- iv) subarachnoid hemorrhage;
- v) papilledema.

12) A 28 year old white Senior Chief collapses and becomes deeply unconscious while leaning over the sonarman's shoulder. He has complete right hemiparesis (paralysis on right side) and fixed dilated pupils. His record reveals he has a wife and two kids, two boys aged 10 and 12 all in good health. He has not been off the boat out of the country in over a year. He has no fever nor any overt signs of infection.

His blood pressure is 110/65 mmHg,
 his heart rate is 55/min,
 his respiration rate is 10/min,
 he is 5' 11" tall,

he weighs 170 lbs, and
his lungs are clear to auscultation.

a) What are your different ideas about what may be causing the Chief's problem?

b) What patho-physiological mechanism (or mechanisms) could explain the sudden loss of consciousness and the physical signs exhibited by the patient in the case of each of your ideas about what may be causing the problem?

c) What would be your disposition of this case?

i) Would you treat him on the boat? Explain your reasoning.

ii) Would you MEDEVAC him? Explain your reasoning.

13) The patient (in the previous question) was, in fact, suffering from an extensive infiltrating glioma of the left thalamus which had caused an inch of pineal shift to the left side. He had been asymptomatic until the moment he collapsed. He died the day after being MEDEVAC'd.

a) Explain the processes by which this condition could cause his signs and symptoms.

b) Describe what more you might have done in order to determine the actual diagnosis.

c) What facilities would you require, that are not available at sea, to have been more certain about your diagnosis?

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