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CONSTRUCTION OF A COMPREHENSIVE EXAMINATION FOR MEDICAL TECHNOLOGISTS

By

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ABSTRACT

CONSTRUCTION OF A COMPREHENSIVE EXAMINATION
FOR MEDICAL TECHNOLOGISTS

By

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A 200-item examination is the culmination of the certifying process for medical technologists. It is a comprehensive, criterion-referenced examination covering the disciplines of hematology, chemistry, immunohematology, microbiology, body fluid analysis, nuclear medicine and laboratory practice.

Possession of professional certification by an individual is often a deciding factor in decisions regarding employment acquisition, salary and opportunities for advancement. The degree to which an individual represents his professional competence on a certifying examination can, therefore, profoundly affect his professional future.

A comprehensive examination taken before any certification examination would enable an individual to identify his weaknesses with an opportunity for remediation. The Michigan State University Comprehensive Examination (MSU-CE) for medical technologists was developed to give career-entry medical technologists an opportunity to assess their

professional strengths and weaknesses. The exam is of similar content and format as the medical technology certifying examinations. Objectives and items for the examination were contributed by education coordinators and instructors in clinical schools of medical technology.

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INTRODUCTION

To a wide range of professions the credentialing process has become a time-honored tradition. Litigations for malpractice have become so commonplace that many look upon professional certification as a defense mechanism against defamations of an entire profession. Consumers and representatives of the "public interest" look upon certification as a protective mechanism against malpractice. Regardless of their point of view, few people today question the need for assessments of educational and technical achievement.

Standards of achievement and function for individuals in the clinical laboratory sciences have not been nationally formalized or coordinated by any specific agency (Wells, 1977). Five distinct credentialing agencies are in the business of certifying medical technologists. Each agency has established educational and experiential criteria and standards for certification. Once an individual's eligibility has been determined, he must sit for and pass an examination before the agency formally recognizes his professional competence.

Medical technologists trained in accredited hospital-based programs are most often certified by either (or both)

the American Society of Clinical Pathologists (ASCP) or the National Certification Agency for Medical Laboratory Personnel (NCA). Both agencies have stringent eligibility requirements that must be fulfilled before an individual can sit for a certification examination. Certification is awarded to all individuals attaining a passing score on the examination. Both tests are criterion-referenced tests; they reflect the knowledge and skills required of a competent career-entry medical technologist.

Possession of professional certification by an individual is often a deciding factor in decisions regarding employment acquisition, salary and opportunities for advancement. Although the eligibility requirements vary among the 5 credentialing agencies, laboratory directors prefer to employ medical technologists with than without any certification. Therefore, the degree to which an individual represents his proficiency on a certifying examination can profoundly affect his professional future.

Michigan State University (MSU) provides the academic background for roughly one-third of the medical technologists in accredited clinical training programs. As part of their commitment to the profession, the School of Medical Technology sponsored the development of the MSU Comprehensive Examination (MSU-CE) to give career-entry medical technologists an opportunity to assess their professional strengths and weaknesses before sitting for a certification examination. To make the experience as authentic as possible, the MSU-CE was modelled, in content and format, after the ASCP

certification exam (ASCP-CE) and the NCA certification exam (NCA-CE). It is a criterion-referenced test in that it reflects specified knowledge and skills required of a competent career-entry medical technologist.

A REVIEW OF THE LITERATURE

Public accountability in the health professions requires certification that individuals meet the performance criteria essential to quality care. A written proficiency examination is one method for appraisal of minimum basic knowledge and skill competencies.

Demonstration of clinical competence is a function of two factors: 1) prerequisite knowledge and 2) ability to perform in a complex situation (Morgan and Irby, 1978, p. 60). Throughout the course of clinical training in medical technology, both factors are assessed repeatedly. Observational assessments of performances in response to specified stimuli can be complex, expensive and time-consuming. For these reasons, appraisal of competence based upon clinical performance is not a part of the certification process performed by medical technology credentialing agencies. In lieu of observational assessments, credentialing agencies have experiential and/or training requirements for all applicants. An evaluation of prerequisite knowledge, however, is a comparatively easy task and is one of the determining factors in the conferral of medical technology certification.

According to the American Society for Medical Technology (ASMT), five credentialing agencies offer certification in

the generalist category for medical laboratory personnel (ASMT, 1977): 1) American Medical Technologists (AMT), 2) American Society of Clinical Pathologists (ASCP), 3) International Society for Clinical Laboratory Technology (ISCLT), 4) National Certification Agency for Medical Laboratory Personnel (NCA) and 5) United States Department of Health, Education and Welfare (HEW). In a report of medical technology credentialing agencies at the 1979 ASMT National Convention, the first four of these five groups were represented. At this meeting, the educational and experiential requirements were given for each agency (Blume, 1979). In addition to varied experiential prerequisites, all four agencies examine applicants for prerequisite knowledge using a multidisciplinary test composed of multiple-choice items. A "passing" score on their respective credentialing examination is required for certification. Three of these agencies utilize criterion-referenced measurements in that the items reflect clearly defined competency statements. The NCA further utilizes criterion-referenced test score interpretation (NCA, 1979).

There are two basic approaches to evaluation of cognitive achievement: norm-referenced measurement and criterion-referenced measurement. Copious literature has been generated surrounding the two approaches; almost any text on educational evaluation will discuss the pros and cons and describe the on-going debate of their appropriate usage. Clear definitions of the two methods have emerged regarding the interpretation of the test scores. Criterion-referenced

interpretation relates the individual performance to a predetermined standard of proficiency, while norm-referenced interpretation relates the individual performance to the performance of his test group. It is basically a difference between absolute status (criterion-referenced) and relative status (norm-referenced) (Glaser, 1963).

Norm-referencing in the certification process has been criticized because the ability of the test group, as opposed to competency standards, determines acceptable performance. It discriminates against the individual who fails an examination simply because he was tested in a superior group of examinees. Likewise, it unjustly rewards an incompetent individual who passes a test taken with an inferior group of examinees (NCA, 1979).

Criterion-referenced measurement has consequently come to be the preferred approach in the certification process, providing a sounder basis for judging competent individuals. Wilson (1977) has defined a proficiency examination as a "criterion-referenced appraisal of the individual's possession of the performance, knowledge and skill competencies required to execute the role responsibilities of the given practitioner generic position." She stated that the goal of a proficiency exam used in the certification process should be to appraise whether or not the individual should be in practice, that unfortunately, in 1977, many credentialing exams in health fields essentially evaluated knowledge possession only.

While experts in educational measurement have clearly identified the differences between criterion-referenced and norm-referenced test score interpretation, the characteristics of well-constructed exams of both types are less distinctly contrasted. Popham (1978, p. 184) lists six key characteristics of a well-made criterion-referenced test:

1) an unambiguous descriptive scheme
2) an adequate number of items per measured behavior
3) sufficiently limited focus
4) reliability
5) validity
6) comparative test data

The most reliable basis for any well-constructed test (including norm-referenced) is a set of explicit specifications which includes the kinds of tasks represented, the content area sampled, the number and kinds of items to be used and the level and distribution of item difficulty (Ebel, 1979, p. 69). These specifications do not differ markedly from the first two characteristics of a well-constructed criterion-referenced test. Popham, however, argues that although developers of norm-referenced tests are aware of the importance of content consideration, a criterion-referenced test is designed to produce a clearer description of what an examinee can and cannot do (1978, p. 90).

Ebel and others have also described the importance of reliability, validity and comparative test data in all tests. These statistics are the hallmark, in fact, of norm-referenced measurement.

The procedure for planning a test is described in many texts (Thorndike and Hagen, 1969; Mehrens and Lehmann, 1973; Ebel, 1979). The first step is identification of the test domain. For an examination evaluating the proficiency of a medical technologist, step one requires identifying appropriate competencies (McPherson, 1979). Many such lists have been compiled based upon the consensus of professionals with recognized expertise and by task analyses (Beard et al., 1975; Crowley, 1975; Hedrick and Fiene, 1975; ASMT, 1976).

The first attempt to delineate the behaviors required of a career-entry medical technologist was by the ASMT (1973). Their position paper, "Differentiation Among MT, MLT and CLA Expected Capabilities at Career Entry", compared six categories of functions of three levels of workers performing general laboratory procedures:

1) performing analyses
2) solving problems
3) systems control, organization and communication
4) supervision and management
5) teaching others
6) teaching self (continuing education)

The ASCP developed content guidelines for their certification examinations based upon the ASMT position paper (ASCP, 1974).

The ASMT was the first organization to publish detailed statements of competence for clinical laboratory practitioners in response to a scrutiny of the credentialing process. Their "Statements of Competence of Clinical Laboratory Practitioners" were developed through expert consensus in 1976, and refined in 1978 to represent appropriate

competencies for career-entry medical technologists. These statements were the foundation for the content domain of the generalist technologist examinations developed under ASMT sponsorship (Davis, 1978). The NCA purchased the material developed by the ASMT and used it to construct their first certifying examination for clinical laboratory scientists in 1978 (NCA, 1979).

Schumacher et al. (1978) applied the Professional Performance Situation Model (PPSM) to define competencies for the medical technology profession. The unique approach of the PPSM is based upon the viewpoint that the competency of a professional is determined not only by the knowledge and skills he possesses, but additionally by an ability to respond with the appropriate knowledge and skills in a variety of contexts. Skill and knowledge criteria were extrapolated from situations describing competent clinical laboratory practice.

Seibert (1979) developed precise objectives for competence as it was delineated in ASMT's "Career-Entry Statements of Competence, Clinical Laboratory Sciences" (1978). "Real-world" situations under which each of the competencies might be carried out were established. These circumstances, including required accuracy and speed, were verified by career-entry medical technologists and translated into terminal performance objectives. These objectives were integrated into a medical technology curriculum and ultimately used for the basis for competency evaluation.

The ISCLT has based the content domain for their certification examination on task analyses performed by their management consultants visiting clinical laboratories (Blume, 1979). The degree to which the knowledge domain is required in the average workday of a medical technologist is reflected in the content distribution and level of tasks of the test items.

The next step in test construction is determination of number and format of the test items. Test experts are in general agreement as to how to select and write good test items. These processes are described in many books on test construction (Thorndike and Hagen, 1969; Mehrens and Lehmann, 1973; Ebel, 1979). One aspect of the test plan that is difficult is the number of items required to satisfactorily evaluate a given behavior, objective or criterion. Popham (1978, p. 101) suggests that for many educational settings using criterion-referenced tests, between 10 and 20 items should be used for each behavioral domain. Other test experts are not so definitive. Thorndike (1969, p. 45) simply states that the total number of test items should be large enough to adequately sample student behavior across content areas and across levels of cognitive tasks. Ebel (1979, p. 76) and Mehrens and Lehmann (1978, p. 192) agree that no clear-cut formula exists, that the number of test items is determined by a number of factors, including the amount of time available, the purpose of the test and the format of the items included. All four experts agree that because of better sampling, the longer the examination, the more reliable

the test and the scores obtained from it. The medical technology certifying exams are composed of approximately 200 multiple-choice items, and generally four hours are allowed for completion of the test.

The Department of Medical Technology at Wayne State University (WSU) has developed a comprehensive examination for students completing clinical training in medical technology. The purpose of the 200-item test is to provide the students with an opportunity to assess their preparedness for a certifying exam. The test is not criterion-referenced, nor have formal objectives been developed. In lieu of reliance upon objectives, WSU utilizes the content outlines and test blueprints that have been published for the ASCP certification examination (Garza, 1981). The item pool has been developed primarily from contributions made by the education coordinators of training programs whose students take the exam; test developers at WSU have the occasional responsibility of rewording an item or altering its format. Examinees are directly notified of their total score and scores in each of the constituent disciplines: bacteriology, virology, mycology, parasitology, chemistry, immunohematology, serology, urinalysis, nuclear medicine and hematology. Students are additionally given the minimum passing score, the average score of the exam, the total number of items in each discipline and the range of correct responses for each of the disciplines. Provided with these data, the student can identify content areas in need of additional or remedial study.

The Medical Technology Program at the University of Iowa (U of I) has implemented a computer assisted test assembly (CATA) system to produce a comprehensive examination for students at the completion of clinical training (Gleich, 1979). The 200 multiple-choice items that comprise the test are retrieved from the computer test item bank at the U of I. Each item is encoded with a nine-character identifier which is based on objectives categorized into general, intermediate and specific levels. Among the advantages of the CATA system are 1) the conservation of faculty time otherwise devoted to compiling and correcting the test, 2) conservation of secretarial time otherwise required for typing and reproduction of a test, 3) ready availability of item analyses and other test statistics, 4) the computer can randomly select items to fit test specifications, 5) availability of item pool to other health care disciplines for test development and 6) evaluation is directly correlated to instructional objectives. One important application of the CATA system is its potential use for diagnosing learning difficulty. A student can take the test on a computer terminal and have his deficiencies readily identified and, by coded references, generate appropriate study aids for remedial assistance.

Encouraged by the abundant literature written about test development and prompted by a need for such an assessment tool, this project was undertaken to provide those medical technology students in areas not served by WSU with an opportunity to evaluate their readiness for a certifying examination.

PROCEDURE

The first step in the construction of a criterion-referenced test is to identify and specify the competencies or domain that will be evaluated. A few lists of competencies for the medical technology profession have been published. These behaviors have been identified by task analyses and through the consensus of practitioners with recognized expertise. The "Career-Entry Statements of Competence, Clinical Laboratory Sciences" (ASMT, 1978) were used in the development of the MSU-CE. The competencies described in these statements are general but suitable for use in construction of this test.

The second step in the construction of a criterion-referenced test is to develop objectives for learning from the specified competencies. In competency-based education, learning objectives specify what it is that the learner must know or do (the criterion), the conditions under which the knowledge or skill must be demonstrated, and how well the learner must demonstrate the knowledge or skill (standard of performance). In developing the MSU-CE three assumptions with respect to objectives were made:

1) that the examinee will be required to demonstrate cognitive skills only (refers to the criterion)

2) that the examinee will be evaluated by means of a paper-and-pencil test composed of multiple-choice items (refers to the conditions under which the knowledge must be demonstrated)

3) that no judgment of competence will be made on the basis of this test; the MSU-CE is a self-assessment tool (refers to the standard of performance).

Based on these assumptions, development of formal learner objectives was by-passed.

The next step was to specify the cognitive criteria and the levels of learning. The ASCP has published the cognitive criteria and levels of learning, in blueprint or "grid" format, that are tested by their medical technology certifying exam (ASCP, 1974). Since the MSU-CE was intended to be an assessment tool resembling an actual certifying exam, all test items were selected based upon the criteria and levels of learning specified on the ASCP examination grid.

The major content areas in the MSU-CE (as well as the ASCP-CE) were:

1) Microbiology (including parasitology, mycology, virology and bacteriology)

2) Immunology (including serology and immunohematology)

3) Hematology (including coagulation)

4) Chemistry

5) Miscellaneous Topics (including urinalysis, body fluids, analytical principles, management, education, and research and development).

Each major content area was further divided into the components of the discipline. The content outline is seen on the vertical axis of the grid. The horizontal axis shows the levels of learning, which were taken from Bloom's hierarchy of the cognitive domain (Bloom, 1967). The numbers 1, 2, 3, 4 and

6 correspond respectively to Bloom's designations of knowledge, comprehension, application, analysis and evaluation. The numbers seen in the cells at the intersections of subject and level of learning represent the range of the number of items that could possibly appear on the exam. Figure 1 is an example of the grid. Utilization of the grid insured a fair balance of test items with regard to subject and level of learning.

All test items included in the MSU-CE were in the multiple-choice format. This is the format used in the ASCP-CE and the NCA-CE. The item pool consisted of items submitted by:

1) the education coordinators of hospital-based medical technology programs
2) experts in each content area
3) the author of the MSU-CE.

All test items were first reviewed for item quality, grammatical structure, conciseness, clarity, general appearance, quality of distracters, accuracy, completeness and freedom from unintentional clues. Each item was matched to the exam grid based on both cognitive criterion and level of learning. Items that did not match any of the cognitive criteria were discarded. A preliminary selection of test items was made, using the grid as a guide for content distribution.

These preliminary test items were subject to further review by at least two experts in each content area. These experts verified accuracy, completeness and freedom from unintentional clues. They were also asked to comment upon

I. Erythrocytes	Medical Technologist Taxonomy Levels 8-15 1	2	3	4	6
A. Formation	0-1	0-1	0-1	0-1	0-1
1. Bone marrow	0-1	0-1	0-1	0-1	0-1
2. Liver	0-1	0-1	0-1	0-1	0-1
3. Spleen	0-1	0-1	0-1	0-1	0-1
4. Kidney	0-1	0-1	0-1	0-1	0-1
5. Endocrine glands	0-1	0-1	0-1	0-1	0-1
B. Function	0-1	0-1	0-1	0-1	0-1
C. Collection		0-1	0-1		
1. Anticoagulants		0-1	0-1		
2. Venous		0-1	0-1		
3. Capillary		0-1	0-1		
4. Bone marrow		0-1	0-1		
5. Special handling		0-1	0-1		
D. Enumerative Procedures	0-1	0-1	0-1	0-1	0-1
1. Manual count	0-1	0-1	0-1		
2. Automated count	0-1	0-1	0-1	0-1	0-1
3. Reticulocyte	0-1	0-1	0-1	0-1	0-1
4. Indices	0-1	0-1	0-1		
5. Correlation of results		0-1	0-1	0-1	0-1
6. Quality control	0-1	0-1	0-1	0-1	0-1
E. Basic tests	0-2	0-2	0-2	0-2	0-2
1. Sedimentation rate	0-1				
2. Hematocrit	0-1				
3. Fragility	0-1	0-1	0-1	0-1	0-1
4. Sickle cell	0-1	0-1	0-1	0-1	0-1
5. Hemoglobin	0-1	0-1	0-1	0-1	0-1
6. Heinz bodies	0-1	0-1	0-1	0-1	0-1
7. Sugar water test	0-1	0-1	0-1	0-1	0-1
8. Ham test	0-1	0-1	0-1	0-1	0-1
9. Hemoglobin electrophoresis	0-1	0-1	0-1	0-1	0-1
10. Correlation of results	0-2	0-2	0-2	0-2	0-2
11. Quality control	0-1	0-1	0-1	0-1	0-1

Figure 1. An example of the examination content grid.

the suitability of each item for career-entry medical technologists. An expert in educational measurement reviewed all preliminary test items for grammatical structure, conciseness, clarity, quality of distracters and general appearance. A medical technologist in the first year of her career reviewed the preliminary items for their suitability in preparing for certification exams.

The 200 items surviving the above critiques comprised the MSU-CE as it was administered to the graduates of 16 hospital-based medical technology programs. Sealed packets, each containing one examination, one answer sheet and instructions, were mailed to the education coordinators to be given to their students upon completion of their clinical training. The conditions under which the graduates took the test were to be strictly controlled; four undisturbed hours were to be allotted in a comfortable, well-lighted, well-ventilated room. To protect the security of the exam, a proctor was to be present during the entire test period.

Upon completion of the MSU-CE, all test copies and answer sheets, again in a sealed packet, were returned to MSU for scoring. They were scored by computer scanning and reports were generated using the F1600 program. The obtained scores were not corrected for guessing. All items were weighted equally. Each examinee received a report of his performance in each content area and on the total test. A report was sent to each participating education coordinator which gave the scores in each content area and on the total test for all of his graduates. The report forms are

illustrated in Figures 2 and 3. All reports included the range of scores "to date" for each content area and the total test. As the MSU-CE was a self-assessment tool, a minimum passing score was not determined.

NAME:	I.D. NUMBER:												
	CONTENT AREA												
	BACTI	VIRO	PARAS	MYCO	SERO	BLOOD BANK	HEMA	COAG	BODY FLUIDS	ANALYT PRIN	MISC**	CHEM	TOTAL
NUMBER OF QUESTIONS	26	2	6	6	26	14	29	11	20	12	8	40	200
RANGE*													
YOUR SCORE													

* RANGE OF SCORES TO DATE
**INCLUDES EDUCATION, MANAGEMENT, RESEARCH, CYTOGENETICS

Figure 2. Examinee report form, Michigan State University 1980 Comprehensive Examination Results.

INSTITUTION: (DO NOT POST)

NAME OF EXAMINEE	CONTENT AREA												
	BACTI	VIRO	PARAS	MYCO	SERO	BLOOD BANK	HEMA	COAG	BODY FLUIDS	ANALYT PRIN	MISC**	CHEM	TOTAL
NUMBER OF QUESTIONS	26	2	6	6	26	14	29	11	20	12	8	40	200
RANGE*													

*RANGE OF SCORES TO DATE

**INCLUDES EDUCATION, RESEARCH, MANAGEMENT, CYTOGENETICS

Figure 3. Education coordinator report form, Michigan State University 1980 Comprehensive Examination Results.

RESULTS

One hundred thirty-four career-entry medical technologists took the 200-item MSU-CE. Table 1 shows the distribution of the test scores. Table 2 summarizes pertinent exam statistics. The performances of the examinees on each item (item analyses) and in each content area are shown in Tables 3 and 4, respectively.

The indices of difficulty for the 200 items ranged from one to 95 percent. Fifty percent of the indices were between 17 and 64 percent; one-half of the difficulty indices were greater than 50 percent, indicating that the exam was difficult. The difficulty is most likely related to the variance in program curricula. The items submitted by education coordinators may have been "fair" to students of some programs yet "unfair" to students of other programs in which the item content was omitted or unemphasized. Many of the items with a high index of difficulty were of high taxonomic level in Bloom's hierarchy of the cognitive domain.

The indices of discrimination ranged from -.20 to .51. Items with a negative discriminating power (less than 0.00) were items numbered 9, 20, 21, 24, 27, 32, 42, 48, 51, 57, 68, 84, 117, 142, 147, 165, 173 and 184. A review of the quality of these items revealed that the majority could be improved by wording or diagrammatic changes (reducing

ambiguity). A few were extremely difficult (index of difficulty >60 percent). Item number 32 was miskeyed.

Many attempts, both logical and empirical, were made to demonstrate the validity of the MSU-CE. Content validity is an inherent feature of a properly constructed criterion-referenced test; congruity between test items and cognitive criteria or objectives is the premise of criterion-referenced tests. The MSU-CE was a criterion-referenced test in that it was a reflection of the professional expectations at career entry, as defined in ASMT's "Career-Entry Statements of Competence, Clinical Laboratory Sciences." In addition, all test items were matched by cognitive criteria and level of learning to the ASCP-CE grid which is based upon ASMT's "Differentiation Among MT, MLT, and CLA Expected Capabilities at Career Entry."

In order to demonstrate that the domain of knowledge tested was unique to the target population (career-entry medical technologists), the MSU-CE was administered to 22 June 1980 graduates of MSU's undergraduate medical technology program. These individuals had not yet begun their clinical training; otherwise, the two groups of examinees were very similar. A comparison of the exam statistics for the two groups is seen in Table 5. Two notable differences are in the mean scores and the reliability coefficients. Examinees who had completed a year of clinical training scored significantly higher than those examinees without clinical training. This difference suggests that clinical training supplies the knowledge domain necessary for good performance on the MSU-CE.

A highly valid test must also be reliable. The reliability coefficients determined with the Kuder-Richardson formula 21' indicate that the exam had a degree of reliability with both test groups. However, the degree of test reliability was significantly greater with the career-entry medical technologists than with the June 1980 graduates. This suggests that the MSU-CE given after clinical training has more valid use than if given prior to clinical training.

Correlation coefficients were calculated to determine the relationship, if any, between the MSU-CE and other measures of professional competence. The correlation coefficient between the MSU-CE and the ASCP-CE was 0.81, and 0.84 between the MSU-CE and the NCA-CE. The scores used to determine the coefficients of correlation were of the ASCP-CE administered August 1980 (n=88) and the NCA-CE administered July 1980 (n=38). These calculations indicate a strong correlation between the exams, suggesting that the MSU-CE has a valid use in aiding career-entry medical technologists who are preparing for these two certifying exams.

Table 1. Frequency distribution of scores

Score	(* represents one examinee)
196-200	
191-195	
186-190	
181-185	
176-180	
171-175	
166-170	
161-165	
156-160	
151-155	***
146-150	*
141-145	***
136-140	*******
131-135	**********
126-130	**********
121-125	**********
116-120	**********
111-115	**********
106-110	**********
101-105	**********
96-100	********
91-95	****
86-90	**
81-85	
76-80	*
71-75	
66-70	
61-65	
56-60	
51-55	
46-50	
41-45	
36-40	
31-35	
26-30	
21-25	
16-20	
11-15	
6-10	
0-5	

Table 2. Summary of MSU-CE statistics (examinees: graduates of clinical programs)

Range of scores	80-152
Mean	118
Median	117
Standard deviation	14.5
Standard error of measurement	6.2
Reliability coefficient	0.82

Table 3. Item analyses

Item No.	Index of Discrimination	Index of Difficulty	Item No.	Index of Discrimination	Index of Difficulty
1	.29	44	47	.12	33
2	.29	54	48	-.02	40
3	.02	38	49	.10	7
4	.22	16	50	.10	68
5	.07	77	51	-.02	48
6	.27	40	52	.07	70
7	.32	28	53	.20	17
8	.20	22	54	.41	38
9	-.07	16	55	.07	6
10	.07	48	56	.34	37
11	.22	50	57	-.02	70
12	.34	44	58	.41	35
13	.20	29	59	.15	39
14	.15	41	60	.32	28
15	.17	45	61	.07	43
16	.20	41	62	.46	38
17	.27	35	63	.44	54
18	.39	29	64	.27	26
19	.00	2	65	.02	50
20	-.02	77	66	.29	24
21	-.05	12	67	.34	61
22	.02	13	68	-.15	88
23	.17	38	69	.07	11
24	-.02	82	70	.17	16
25	.22	40	71	.10	20
26	.15	73	72	.00	10
27	-.20	32	73	.20	46
28	.34	27	74	.29	61
29	.24	37	75	.12	11
30	.10	61	76	.17	33
31	.10	29	77	.07	6
32	-.07	91	78	.29	34
33	.20	73	79	.00	10
34	.10	12	80	.20	41
35	.34	37	81	.22	33
36	.37	26	82	.39	22
37	.02	21	83	.15	15
38	.15	29	84	-.15	78
39	.05	76	85	.10	73
40	.15	63	86	.32	26
41	.27	57	87	.12	45
42	-.07	96	88	.27	48
43	.22	26	89	.27	18
44	.20	56	90	.41	33
45	.20	15	91	.27	57
46	.27	26	92	.12	13

Table 3 (continued)

Item No.	Index of Discrimination	Index of Difficulty	Item No.	Index of Discrimination	Index of Difficulty
93	.44	61	140	.17	9
94	.12	57	141	.29	41
95	.10	63	142	-.07	79
96	.39	63	143	.07	11
97	.20	46	144	.00	63
98	.10	22	145	.05	88
99	.02	1	146	.22	50
100	.05	83	147	-.20	85
101	.27	26	148	.41	52
102	.29	54	149	.22	18
103	.07	11	150	.00	59
104	.29	27	151	.24	17
105	.22	18	152	.10	7
106	.00	2	153	.44	56
107	.20	44	154	.12	18
108	.32	30	155	.20	51
109	.27	13	156	.39	29
110	.15	12	157	.15	68
111	.37	35	158	.15	41
112	.34	27	159	.15	29
113	.05	37	160	.07	52
114	.32	28	161	.27	50
115	.22	18	162	.34	66
116	.07	26	163	.17	33
117	-.10	56	164	.07	21
118	.34	58	165	-.07	89
119	.12	9	166	.12	62
120	.05	34	167	.05	59
121	.41	38	168	.00	83
122	.05	93	169	.17	62
123	.24	63	170	.24	39
124	.12	23	171	.37	55
125	.02	6	172	.32	50
126	.44	34	173	-.10	51
127	.51	35	174	.22	33
128	.05	66	175	.20	44
129	.15	66	176	.12	40
130	.02	13	177	.20	15
131	.10	37	178	.22	67
132	.12	55	179	.41	67
133	.27	57	180	.32	28
134	.07	6	181	.24	71
135	.00	15	182	.27	33
136	.12	38	183	.22	43
137	.20	46	184	-.20	42
138	.10	24	185	.10	59
139	.05	66	186	.12	65

Table 3 (continued)

Item No.	Index of Discrimination	Index of Difficulty	Item No.	Index of Discrimination	Index of Difficulty
187	.27	50	194	.46	52
188	.15	20	195	.10	54
189	.22	21	196	.12	77
190	.20	63	197	.12	18
191	.34	41	198	.02	6
192	.20	15	199	.24	17
193	.07	74	200	.10	71

Table 4. Performance report by content area

Content Area	Number of Items	Range of Scores	Average Score
Bacteriology	26	7-24	16.1
Virology	2	0-2	1.0
Parasitology	6	0-5	2.8
Mycology	6	1-6	3.5
Serology	26	7-22	15.4
Blood Bank	14	5-14	9.5
Hematology	29	9-25	18.4
Coagulation	11	3-11	7.8
Body Fluids	20	5-18	12.1
Analytical Principles	12	2-11	7.0
Miscellaneous Topics*	40	10-29	20.4

*Includes Education, Management, Research and Development, Cytogenetics.

Table 5. Comparison of statistics by examinee group

	Career-Entry Medical Technologists (n=134)	MSU Graduates June 1980 (n=22)
Range of scores	80-152	66-107
Mean	117.9	88.1
Median	117.0	87.5
Standard deviation	14.5	10.0
Standard error of measurement	6.2	6.3
Reliability coefficient	0.82	0.61

SUMMARY

Certification is a process by which the educational and functional achievements of an individual are measured. A certifying examination is an integral part of this process. Such tests are constructed and administered by representative credentialing agencies. These groups also define the eligibility standards for certification.

The Michigan State University Comprehensive Examination was developed to enable career-entry medical technologists to assess their strengths and weaknesses prior to sitting for certification examination(s). It was based on the philosophy of competency-based education and criterion-referenced testing; the domain tested by the exam reflected knowledge and skills required for competent performance by career-entry medical technologists. To assure the relevance of the MSU-CE, all test items were referenced to both "Differentiation Among MT, MLT, and CLA Expected Capabilities at Career Entry" (ASMT, 1973) and "Career-Entry Statements of Competence, Clinical Laboratory Sciences" (ASMT, 1978).

The examination was taken by 134 students who were completing their clinical training at 16 hospital-based medical technology programs in Michigan. The examinees and their respective education coordinators received reports of

their scores and a summary of the scores of other examinees. These statements included examinee performance in each content area as well as on the total exam. Thus, each student was able to identify any existing areas of weakness prior to sitting for certification examination.

Each test item was analyzed for its degrees of difficulty and discrimination. Items which were extremely difficult (index of difficulty >60 percent) and which discriminated at a level less than zero were reevaluated. These items were either revised for, or omitted for, future use of the test. These amendments should improve the reliability and the mean score by making the exam less difficult and by reducing ambiguity.

The reliability coefficient (0.82), correlation coefficients (0.81 and 0.84) and additional measures indicate that the MSU-CE is a reliable test which correlates well with the two most popular certifying examinations. Use of the MSU-CE by career entry medical technologists is valid.

It would be difficult to prove, either empirically or logically, what actual value the MSU-CE has for improving an individual's performance on certification exams. Some students took the MSU-CE without reviewing the prerequisite material. With only minimal review their scores on subsequent proficiency tests (certifying exams) could certainly increase to a greater degree than the scores of individuals who were well-prepared when sitting for the MSU-CE. Additional learning between the time the MSU-CE is taken and the time a certification exam is

taken affects any attempt to correlate scores between proficiency exams.

As the MSU-CE is improved it may have additional applications. Since it was designed to reflect the skills and knowledge needed by a career-entry medical technologist, it could well be incorporated into a career mobility program. Demonstration of continued competence is an issue of interest to many credentialing agencies. Assessment of continued competence prior to recertification examination is another possible application of the MSU-CE.

Feedback from some examinees and education coordinators has been favorable. They state that the opportunity to prepare for certifying exams in this way is greatly appreciated. Many examinees felt that the exam was difficult but enabled them to identify their weaknesses and to practice pacing themselves through such a lengthy test. Many education coordinators expressed their wish for continued availability of the MSU-CE. Further evaluation of this examination after additional administrations will more clearly define its usefulness.

APPENDIX A

MICHIGAN STATE UNIVERSITY

1980 COMPREHENSIVE EXAMINATION

1. An organism isolated from a vaginal swab is oxidase positive and on gram stain appears to be a gram negative diplococcus. The organism does not ferment glucose. Which of the following organisms could this be?

a. *Acinetobacter calcoaceticus*
b. *Moraxella osloensis*
c. *Neisseria gonorrhoeae*
d. *Pseudomonas aeruginosa*

2-3. Match each organism at left with the appropriate OPTIMAL PRIMARY ISOLATION MEDIUM at right.

2. *Staphylococcus aureus* (from feces)
3. *Bacteroides melaninogenicus*

a. BHI supplemented with yeast extract, hemin, and vitamin K
b. BHI supplemented with yeast extract, horse serum, and penicillin G
c. blood agar
d. mannitol salt agar

4. A 6-year-old child is seen in the emergency room complaining of a sore throat. A throat culture reveals an almost pure culture of gram positive cocci that are catalase negative and display beta hemolysis. A 15 mm zone of inhibition is seen around the bacitracin disc. The organism is most likely:

a. *Streptococcus pneumoniae.*
b. *Streptococcus,* Group A.
c. *Streptococcus,* Group B.
d. unidentifiable without further testing.

5. Culture isolation and identification of *Clostridium botulinum* from a food source is insufficient evidence to definitely cite it as the cause of food poisoning. Which of the following statements support this fact?

I. not all strains of *Clostridium botulinum* produce an active toxin
II. *Clostridium botulinum* cannot be distinguished readily from non-pathogenic species culturally
III. not all types of botulinus toxin cause human disease

a. III only
b. I and II only
c. II and III only
d. I, II and III

6. A request is made for a culture for diphtheria. The specimen should be inoculated to blood agar and:

   a. Bordet-Gengou medium.
   b. cystine-tellurite blood agar.
   c. Lowenstein-Jensen agar.
   d. McBrides' medium.

7. A pregnant woman developed "flu-like" symptoms, low grade fever and diarrhea, which resulted in abortion. A placental specimen was sent to the laboratory for culture. Colonies on blood agar exhibited beta hemolysis, and on clear tryptose agar the colonies gave a characteristic blue-green color when viewed with oblique light. A gram stain showed gram positive small coccobacilli. What organism is most likely involved?

   a. *Brucella abortus*
   b. *Hemophilus vaginalis*
   c. *Listeria monocytogenes*
   d. *Erysipelothrix rhusiopathiae*

8. A small gram negative bacillus is isolated from an eye; the organism grows on chocolate agar but not on blood agar. It produces satellite growth around *Staphylococcus aureus* on blood agar but not on plain agar. This reaction indicates that the organism requires:

   a. X factor only.
   b. V factor only.
   c. both X and V factors.
   d. neither X nor V factor.

9. A gram negative bacillus has been isolated from a wound; it grows on MacConkey's agar and is oxidase positive. Other biochemical tests done do not fit the pattern for any known organism. The next step is to:

   a. do a sensitivity study.
   b. repeat the biochemical tests using controls on the media.
   c. send the culture to a reference laboratory.
   d. subculture the organism to see if the culture is pure.

10. From a urine specimen a gram negative bacillus, found to be oxidase negative, was plated on differential media. On blood agar the colonies were large, grayish and spreading with no hemolysis. On MacConkey agar the colonies were medium sized and colorless. Biochemical tests were then done on an isolated colony from MacConkey agar. These results were obtained:

motility	positive
indole	positive
ornithine	negative
urease	bright pink throughout tube
citrate	bright blue
LIA	red slant/yellow butt
TSI	yellow slant/yellow butt, no gas
H_2S	positive

Select the species of *Proteus* that has been identified:

a. *mirabilis*
b. *morganii*
c. *rettgeri*
d. *vulgaris*

11. A flat colorless colony is isolated from feces on MacConkey and EMB agars. The biochemical profile of the organism is shown below.

H_2S	slight positive
glucose	fermented, no gas
lactose	not fermented
citrate	negative
lysine	decarboxylated
phenylalanine	not deaminated
motility	positive
indole	not produced

The technologist should perform:

a. malonate utilization and ONPG tests to rule out *Arizona* sp.
b. serological typing to confirm *Salmonella* sp.
c. serological typing to confirm *Shigella* sp.
d. the urease test to rule out the possibility of an atypical *Proteus* sp.

12. Which of the following statements does NOT apply to the *Rickettsia* species?

a. bacilloid
b. gram positive
c. pleomorphic
d. intracellular

13. On a smear stained with crystal violet a technologist observes spirochetes with 4 or 5 loose spirals and fusiform bacilli with tapered ends. These findings are consistent with:

a. rat bite fever.
b. syphilis.
c. Vincent's angina.
d. whooping cough.

14. An acid fast gram positive bacillus has been grown in a dark incubator for 6 weeks. When it is exposed to a light source, nothing happens. This organism can belong to Runyoun Groups:

a. II and IV.
b. III and IV.
c. I and IV.
d. II and V.

15. A physician has sent an oropharyngeal specimen to the laboratory to be cultured for *Mycoplasma pneumoniae*. To ensure isolation, the specimen should be inoculated to and incubated:

a. in selective broth containing a bacterial inhibitor, at 36°C, in 5% CO_2.
b. in thioglycollate broth, at 36°C, in 95% N and 5% O_2.
c. on brain heart infusion agar, at 35°C, anaerobically.
d. on Lowenstein-Jensen slants, at 35°C, after digestion and decontamination of the specimen.

16. A purulent sputum specimen is submitted to the laboratory for culture and acid-fast staining. Acid-fast bacilli are noted on a smear. After 4 weeks at 37°C on Lowenstein-Jensen agar, rough buff-colored granular colonies develop. Additional testing on this organism will show:

I. strong niacin production.
II. catalase activity.
III. orange pigmented colonies when grown in the dark.

a. I only
b. I and III only
c. II and III only
d. III only

17. In the nitrate reduction test, a red color develops only after addition of zinc dust. This reaction indicates that the organism:

a. failed to reduce nitrate to nitrite.
b. produced nitrogen gas.
c. reduced nitrate to nitrite.
d. reduced nitrite to nitrate.

18. A set of stock cultures is maintained in the laboratory to check all media and reagents. To check media and reagents for positive and negative reactions, which of the following combinations is appropriate?

a. bile solubility: *Streptococcus pneumoniae*, *Streptococcus pyogenes*
b. catalase: *Staphylococcus aureus*, *Bacillus subtilis*
c. fermentation of monosaccharides: *Clostridium botulinum*, *Staphylococcus aureus*
d. hydrogen sulfide production: *Salmonella typhi*, *Proteus mirabilis*

19. You are setting up a small bacteriology laboratory on a limited budget. In addition to stains and differentiation discs, which of the following groups of media will enable you to isolate and presumptively identify the greatest number of species?

a. chocolate agar, MacConkey agar, triple sugar iron agar, urease medium, thioglycollate broth
b. chocolate agar, SS broth/agar, thioglycollate broth, indole broth, citrate agar
c. Loeffler medium, eosin methylene blue agar, mannitol broth, brain heart infusion broth
d. tetrathionate broth, Seller medium, phenylethyl alcohol agar, citrate agar

20. Directions: Each question below consists of an assertion (statement) ir the left-hand column and a reason in the right-hand column. Select:

a. if both the assertion and reason are true statements and the reason is a correct explanation of the assertion.
b. if both assertion and reason are true statements but the reason is NOT a correct explanation of the assertion.
c. if the assertion is false but the reason is a true statement.
d. if both assertion and reason are false statements.

STATEMENT		REASON
The correct temperature for incubation of Kirby-Bauer sensitivity plates is 35°C.	BECAUSE	Methicillin-resistant *Staphylococcus aureus* is detectable at 35°C. Incubation at 37°C may result in false large zones of inhibition.

21. Directions: The following pair of phrases describes conditions or quantities that may or may not be related. Select:

a. if increase in the first is accompanied by increase in the second, or if decrease in the first is accompanied by decrease in the second.
b. if increase in the first is accompanied by decrease in the second, or if decrease in the first is accompanied by increase in the second.
c. if changes in the first are not necessarily accompanied by changes in the second.

QUESTION:

I. zone size in a properly controlled Kirby-Bauer susceptibility procedure
II. relative susceptibility of the organism to the particular antibiotic

22. A swine farmer who occasionally slaughters a hog for personal use is seen in the hospital with anorexia, chills and a diurnal fever. No infectious foci are apparent. The most likely causative agent is:

a. *Brucella suis.*
b. *Francisella tularensis.*
c. *Listeria monocytogenes.*
d. *Streptobacillus moniliformis.*

23. After six weeks with a low grade fever a patient develops petechia on his lower legs. He reports increasing dyspnea and weakness upon exertion. A blood culture is positive and lancet-shaped gram positive cocci are isolated. This patient is suffering with:

a. acute bacterial endocarditis.
b. subacute bacterial endocarditis.
c. pneumonia.
d. rheumatic fever.

24. The skin commensal *Propionibacterium acnes* appears to be capable of retarding skin colonization with *Staphylococcus aureus* and *Streptococcus pyogenes* through the production of:

a. acetone.
b. deconjugated bile salts.
c. lipids.
d. peroxidase.

25. A patient was admitted to the hospital and acquired a disease while in the institution. It was thought by the infection control committee that he could have acquired the disease from the hospital drinking fountain. Upon culturing the water, yellow colonies of gram negative bacilli were isolated. What is the most likely causative organism?

a. *Escherichia coli*
b. *Flavobacterium* sp.
c. *Proteus mirabilis*
d. *Pseudomonas aeruginosa*

26. The optimal specimen for isolation of the poliomyelitis virus is:

a. blood.
b. feces.
c. cerebrospinal fluid.
d. transtracheal aspirate.

27. If material for viral culture cannot be processed immediately it should be held at:

a. 4°C.
b. room temperature.
c. 35°C.
d. 42°C.

28. Quality control checks on the autoclave indicate that the sterilization process is not effective. An examination of the settings reveals a temperature of 112°C and pressure at 15 lbs. What correction(s) should be made?

a. decrease the pressure to 12 lbs.
b. increase the pressure to 21 lbs.
c. increase the temperature to 121°C.
d. increase the temperature to 115°C and the pressure to 21 lbs.

29. A patient has a 48 hour cycle of chills, fever, and sweating. Blood films stained with Giemsa show enlarged pale erythrocytes containing light red dots overlying 15-20 dark red dots in each infected cell. The stage that is being observed is the:

a. early trophozoite of *Plasmodium falciparum.*
b. early trophozoite of *Plasmodium malariae.*
c. schizont of *Plasmodium ovale.*
d. schizont of *Plasmodium vivax.*

30. Directions: The following paired statements describe two entities that are to be compared quantitatively. Select:

a. if (1) is greater than (2).
b. if (2) is greater than (1).
c. if the two are equal or very nearly equal.

(1) the diameter of the cyst of *Entamoeba coli*
(2) the diameter of the cyst of *Entamoeba histolytica*

31. When a human is infected with *Paragonimus westermani*, ova will most readily be found in the:

a. blood.
b. duodenal aspirate.
c. feces.
d. sputum.

32. The insect vector of African trypanosomiasis is the:

a. *Anopheles* mosquito.
b. reduviid bug.
c. sand fly.
d. tsetse fly.

33. A medical technologist is placed in charge of a military laboratory. She needs to screen the personnel for malaria in a non-endemic area. The tests that are best suited for this purpose are:

a. blood cultures.
b. indirect fluorescent antibody and indirect hemagglutination.
c. thick and thin peripheral blood smears.
d. osmotic fragility and heat instability.

34. A patient who has travelled extensively in the last year (including visits to Cuba and Latin America countries) complains of digestive disturbances, a stabbing, radiating substernal pain, and fever. Upon examination abdominal tenderness and hepatomegaly are noted. SGOT (AST), SGPT (ALT), and LDH (LD) are all elevated; eosinophilia is also noted. A fecal specimen examined for ova and parasites contains a large operculated egg. The patient is most likely infected with:

a. *Diphyllobothrium latum.*
b. *Fasciola hepatica.*
c. *Fasciolopsis buski.*
d. *Schistosoma japonicum.*

35. The nitrogen source for fungal growth in culture is usually:

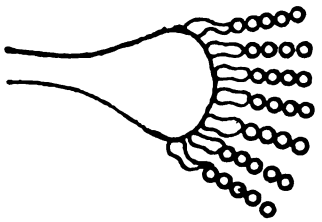
a. ammonia.
b. histidine.
c. nitrate.
d. peptone.

36. Fill in the blank: Symptoms of allergy to *Alternaria* sp. are due primarily to the activity of _____ antibodies.

a. IgA.
b. IgD.
c. IgE.
d. IgG.

37. Bluish-green fungal colonies were isolated from the sputum of a tubercular patient who had an old resolved cavity lesion. The microscopic appearance of the organism is pictured at right. The fungus is most likely:

a. *Aspergillus fumigatus.*
b. *Aspergillus niger.*
c. *Penicillium notatum.*
d. *Rhizopus arrhizus.*



38. An 8-year-old male with apparent *tinea capitis* entered the out-patient clinic. Under a Wood's lamp his hair showed green fluorescence. Culture of the hair yielded a fungus which showed, microscopically, mycelia with very rare microconidia or macroconidia. The fungus is most likely:

a. *Epidermophyton floccosum.*
b. *Microsporum audouinii.*
c. *Microsporum canis.*
d. *Trichophyton rubrum.*

39. To make a diagnosis of histoplasmosis, the best specimens to request are:

a. lymph node biopsy and cerebrospinal fluid.
b. splenic biopsy and transtracheal aspirate.
c. sputum (early A.M.) and bone marrow buffy coat.
d. sputum (early A.M.) and gastric washings.

40. A sputum from a patient with pneumonia was cultured on blood agar at 37°C. After 48 hours, small, creamy colonies appeared which proved to be small, oval, budding yeast cells when gram stained. The germ tube was negative and the biochemical reactions did not fit any of the patterns for organisms listed by the yeast kit. Daily examination of the original culture held at room temperature showed that the yeast colonies were becoming filamentous at the edges. What should be done next to identify or rule out *Histoplasma capsulatum?*

a. transfer colony to BHI agar, incubate at 30°C, and examine for chlamydospores.
b. transfer colony to BHI agar, incubate at 37°C, and examine for tuberculate aleuriospores.
c. transfer colony to Smith's medium, incubate at 30°C, and examine for tuberculate aleuriospores.
d. transfer colony to Smith's medium, incubate at 37°C, and examine for chlamydospores.

41. The most common antibody produced by patients with rheumatoid arthritis:

I. damages heart valves.
II. is an anti-IgG.
III. is an anti-nuclear antibody.

a. I only
b. II only
c. III only
d. I and II only

42. Select the statement that best describes the Classic and Alternate (properdin) complement pathways:

a. the activators are the same but the end results are different
b. the activators are different but the end results are identical
c. the activators and the end results are completely different but they use the same components
d. they cannot be compared in any of the ways stated above

43. Which of the following is a characteristic of delayed hypersensitivity?

a. cell mediated response.
b. humoral response.
c. precipitated Ag-Ab complexes.
d. soluble Ag-Ab complexes.

44. A chronic rejection reaction to a tissue transplant is:

a. a humoral response.
b. both humoral and cell-mediated.
c. cell-mediated.

45. IgG antibodies:

a. account for most of the adult gamma globulins in serum.
b. are the first antibodies formed against new antigens.
c. migrate faster than the other immunoglobulins in electrophoresis.
d. have a molecular weight of approximately 900,000.

46. In the radial immunodiffusion technique:

I. the size of the precipitation zone is proportional to the immunoglobulin concentration.
II. immunoglobulins are measured qualitatively.
III. IgG and IgM are the only immunoglobulins measured accurately.
IV. a precipitation ring is formed when antigen and antiserum are at optimal proportions.
V. the immunoglobulin is the antigen.

a. I. II and IV only
b. I, III and V only
c. I, IV and V only
d. I, II, III, IV and V

47. A woman in the first trimester of pregnancy is exposed to a child with rubella. Five days after her exposure, a blood specimen is collected and tested for rubella antibody by a hemagglutination inhibition test. The titer is 1:64. How should these data be interpreted?

a. beginning rise in antibody titer of the infected woman
b. compatible with immunity existing prior to womans exposure
c. compatible with rubella infection; no cause for immediate concern
d. woman infected and termination of pregnancy is a major consideration

48. Immunization is an example of disease control by:

a. anamnestic response to infection.
b. breaking the host-parasite connection.
c. decreasing the virulence of the parasite.
d. increasing the resistance of the host.

49. While testing a patient's serum with a latex fixation test, the 1:20 dilution appears negative but the 1:40 dilution appears positive. This most likely is an example of:

a. a delayed reaction.
b. a normal occurrence.
c. the post-zone phenomenon.
d. the prozone phenomenon.

50. A positive complement fixation test results when the patient has:

I. a specific antibody to the antigen tested.
II. adequate complement.
III. anticomplementary factor in her serum.
IV. sheep erythrocyte hemolysins.

a. II only
b. I and II only
c. I and III only
d. I, II and IV only

51. Which of the following results in a <u>false</u> negative interpretation of hemagglutination tests?

a. cross-reacting antigens
b. bacterial contamination
c. inadequate antibody in serum
d. rouleaux formation

52. Neutralization testing:

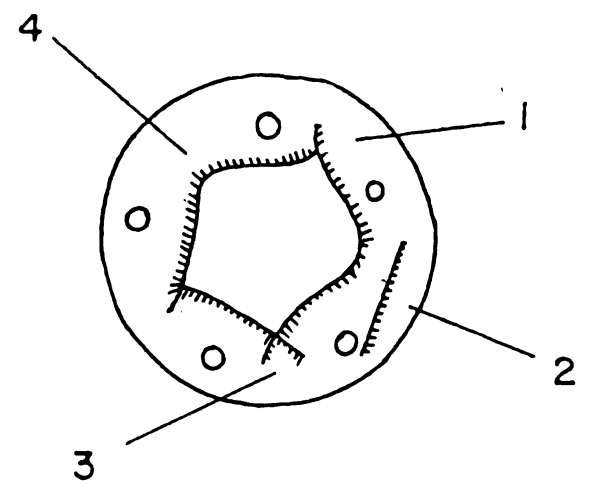
I. can assist in typing viruses.
II. requires animal injection or cell culture inoculation with a mixture of known hyperimmune antisera and antigen.
III. is done routinely in most viral studies.

a. II only
b. I and III only
c. II and III only
d. I, II and III

53. <u>Situation</u>: A clotted specimen is received in the blood bank with a request to do a direct AHG test. The specimen was refrigerated for 24 hours prior to receipt in the laboratory. This sample is <u>unsatisfactory</u> because:

a. the antigenic receptor sites are covered.
b. the calcium was depleted in the clotting process.
c. clinically insignificant "cold" agglutinins may have bound complement.
d. the clot traps antibody-antigen complexes, therefore the activation of the complement system has been prevented.

54. Illustrated below is an Ouchterlony agar-gel immunodiffusion plate. Which of the numbered reactions demonstrates the relationship of "identity"?



a. 1
b. 2
c. 3
d. 4

55. The practical application of the immunologic test for pregnancy (chorionic gonadotropin in urine) depends upon:

a. agglutination of latex particles.
b. agglutination of sensitized spores.
c. chemical precipitation.
d. non-specific protein reactions.

56. When a patient with syphilis is diagnosed in the primary stage and adequately treated, the reagin antibody detectable by the VDRL test should:

a. decline over the years to a low and persistent level.
b. gradually decline and eventually disappear.
c. fluctuate in titer over the years.
d. persist for life at a high titer.

57. Which of the following tests is most specific for the diagnosis of syphilis?

a. Kahn
b. Mazzine
c. RPCF
d. VDRL

58. Based on the reactions indicated, which of the following individuals probably has syphilis?

a. 30-year-old male; weakly reactive VDRL, nonreactive FTA-ABS, negative darkfield
b. 70-year-old female; nonreactive VDRL, nonreactive FTA-ABS.
c. 16-year-old female; nonreactive VDRL, FTA-ABS nonreactive, culture for *Neisseria gonorrhoeae* positive
d. 25-year-old male; nonreactive VDRL, positive darkfield, clinically diagnosed to have lupus erythematosus

59. The Widal test is used for the detection of antibodies in a patient with:

a. a *Proteus vulgaris* infection.
b. Q fever.
c. typhoid fever.
d. typhus fever.

60. The serum of a patient reacts with *Proteus* OX2 and OX19 antigens (the Weil-Felix reaction). A presumptive diagnosis for this patient is:

a. Q fever.
b. Rocky Mountain Spotted Fever.
c. scrub typhus.
d. trench fever.

61. An antibody titer of 1:80 against *Salmonella typhosa* flagellar antigen strongly suggests that the patient:

a. has a *Salmonella* infection other than *S. typhii*.
b. has been exposed to *S. typhii*, or an organism closely related, at some indeterminable time.
c. has had a vaccination recently.
d. may have typhoid fever.

62. While performing a cold agglutinin test, agglutination in the 1:64 dilution is shown to disappear after warming to 37°C. Without further testing, this indicates that the patient may have:

a. infectious mononucleosis; confirm by heterophile antibody determination.
b. *Mycoplasma pneumoniae* infection; confirm by culture or serological tests.
c. Paroxysmal Cold Hemoglobinuria; perform Donath Landsteiner Test.
d. viral pneumonia; confirm with viral studies.

63. To test for rheumatoid factor, a reagent commonly used is latex particles coated with:

a. antihuman globulin.
b. anti-rheumatoid factor.
c. IgG.
d. IgM.

64. An ASO titer of 666 units in the serum of a 6-year-old child is:

a. inconclusive; an anti-DNAse B titration should also be performed.
b. inconclusive; the test should be done on another serum specimen drawn after 10 days.
c. not significant.
d. significant.

65. In the fluorescent antinuclear antibody test a nucleolar pattern is:

a. found in certain collagen diseases other than SLE.
b. produced by antibodies to saline-soluble nuclear proteins.
c. produced by antibodies to particulate DNA histone.
d. typical of acute SLE with renal involvement.

66. The following results were obtained when a serum was tested for heterophile antibodies:

presumptive titer	1:448
differential titer (guinea pig kidney absorption)	1:224
(beef heart absorption)	negative

The best interpretation is:

a. positive for infectious mononucleosis
b. negative for infectious mononucleosis
c. positive for serum sickness
d. negative for serum sickness

67. Of the following, who is an acceptable blood donor?

a. 23-year-old healthy sailor who was tattooed in Spain 2½ months ago
b. 49-year-old woman with a slight cold and a temperature of 99.4°F
c. 21-year-old healthy medical technology student immunized against smallpox 5 days ago
d. 22-year-old healthy male who had 4 impacted wisdom teeth removed 1 week ago

68. Fill in the blank: It is generally accepted that the available methods for HBsAg testing in donor blood will detect the hepatitis associated antigen in up to _____% of the cases.

a. 15
b. 25
c. 50
d. 80

69. These facts apply to which blood component listed below:

I. separated from whole blood within 4 hours of collection
II. frozen and stored at -18°C or colder
III. contains all of the plasma clotting factors

a. cryoprecipitate
b. factor 2-10 complex
c. fresh frozen plasma
d. leukopheresis unit

70. When compared with ACD, with storage CPD maintains more favorable levels of:

a. 2, 3 - DPG.
b. dextrose.
c. factor VIII.
d. potassium.

71. A 32-year-old female comes into the emergency room hemorrhaging severely. The physician orders 2 units "priority 2" (transfuse as soon as possible) and 4 units "on hold" pending possible surgery. The patient is blood group type B, Rh negative. The blood inventory is

UNITS	NUMBER
O positive	25
O negative	7
B positive	12
B negative	3
AB positive	6
AB negative	1

Neither neighboring hospitals nor the American Red Cross have additional B negative units available immediately. Which units should be tested for compatibility with this patient?

a. 6 O negative units to be given as packed cells only
b. 3 B negative units and 3 B positive units
c. 3 B negative units and 3 O negative units (as packed cells only)
d. 3 B negative units; wait for ARC to draw and send additional B negative units

72. Situation: An EDTA blood sample is received in the blood bank laboratory with a request for an indirect AHG test to be performed on it. This sample is unsatisfactory because EDTA:

a. covers the antigenic receptor sites.
b. prevents magnesium from adding C2 to the C4 complex.
c. chelates with the Ag-Ab complexes preventing their agglutination
d. binds the calcium which is needed to add complement to sensitized erythrocytes.

73. Patient M. D. G., who has autoimmune hemolytic anemia, is blood group B, R^1R^1 (CDe/CDe). He has a negative antibody screening test (indirect antihuman globulin test) but a positive direct antihuman globulin test (AHG). Upon elution the antibody is identified as anti-hr" (anti-e). Which of the following blood types would be the best choice for compatibility testing and subsequent transfusion into the patient?

a. group B, r^1R^1
b. group B, r^oR2
c. group O, r^1R2
d. group O, R^2R^2

74. Which of the following groups tends to react least strongly with H antisera?

a. A_1
b. O_h
c. A_2
d. A_2B

75. The results of a routine Rh typing on an adult were:

anti-Rh_o(D) modified tube typing serum	positive
albumin control	positive

The next step is to:

a. check serum of patient for anti-Rh_o(D) antibodies.
b. confirm Rh typing with saline anti-Rh_o(D) typing serum.
c. interpret the results as Rh_o(D) positive.
d. interpret the results as Rh_o(D) negative.

76. Situation: Early in her pregnancy, the blood of L. S. was tested as part of a prenatal work-up. Her blood was found to be type B, Rh_o(D) negative, D^u negative, with a negative antibody screening test. The day after the birth of her child, the blood of L. S. and her child were tested as part of the routine neonatal work-up. The results were:

L. S.	group B, D^u positive, antibody screen negative
Baby S.	group O, Rh_o(D) positive, direct AHG test negative

From the list below, choose the one statement that CANNOT be a cause of the above inconsistency.

a. Baby S. is suffering from hemolytic disease of the newborn due to ABO imcompatibility
b. Baby S. has bled into his mother (fetal-maternal bleed) approximately 35 ml or more
c. L. S. is actually D^u positive; a mistake was made on the original typing
d. L.S. has developed an auto-antibody which was detected in the D^u test

77. Select the phenotype that best fits the pattern given below for W. R.

ANTIGENS PRESENT IN SECRETIONS	ANTIGENS PRESENT ON ERYTHROCYTES
H	H
Le^a (weak +)	
Le^b	Le^b

a. Se, Le, H
b. Se, Le, h
c. se, Le, H
d. se, le, H

78. Given the following reactions with antisera, which genotype listed below is NOT possible?

ANTISERUM	REACTION
C	+
D	+
E	+
c	+
e	+

a. R_1R_2
b. R_or^y
c. R_2r'
d. R_or

79. In a disputed paternity suit, typings for M, N and S antigens are performed to supplement ABO and Rh typings since the alleged father, the mother and the baby are all B, Rh positive. The results are:

	M	N	S
alleged father	-	4+	-
mother	-	3+	3+
child	2+	3+	3+

Is this man the father of the child?

a. definitely yes
b. definitely no
c. possibly yes; additional testing should be done

80. Blood from a neighboring hospital is received in your blood bank in a styrofoam container holding ice that is floating in cold water. The blood has been in transit for approximately 45 minutes. The water temperature is 6°C. A thermometer sandwiched between 2 bags of blood in the container reads 12°C. According to AABB you should:

a. quarantine the blood.
b. return the blood.
c. use the blood.
d. use the blood, but only as packed cells.

81. Select the disease state from the list below that is most consistent with the following data:

hemoglobin	9.5 gm/dl
hematocrit	28.5%
hemoglobin electrophoresis	A_2 = 3.5%
	F = 3.5%
	A = 94.0%
erythrocyte morphology	hypochromia, microcytosis, anisocytosis, poikilocytosis, leptocytosis, polychromasia

a. hemoglobin H disease
b. hemoglobin Lepore disorder
c. hereditary persistence of fetal hemoglobin
d. heterozygous beta thalassemia

82. Following, in random order, are the steps in the formation of an L.E. cell. Select the lettered response which corresponds to the correct ordering of the steps.

1. phagocyte ingests altered nucleus
2. anti-DNP alters the chromatin of the nucleus
3. altered nucleus attracts phagocyte
4. leukocytes are traumatized

a. 4, 2, 3, 1
b. 3, 1, 4, 2
c. 2, 4, 3, 1
d. 1, 2, 3, 4

83. Listed below, in random order, are the cells of the erythroid series. Select the lettered response which corresponds to the correct order of the normal maturation sequence.

1. basophilic normoblast
2. polychromatophilic normoblast
3. orthochromatic normoblast
4. pronormoblast
5. reticulocyte
6. erythrocyte

a. 1, 2, 3, 4, 5, 6
b. 2, 1, 4, 3, 5, 6
c. 4, 3, 2, 1, 5, 6
d. 4, 1, 2, 3, 5, 6

84. Directions: The paired statements below describe two entities that are to be compared quantitatively.

(1) the red blood cell count in capillary blood specimens
(2) the red blood cell count in venous blood specimens

Select:

a. if (1) is greater than (2).
b. if (2) is greater than (1).
c. if the two are equal.

85. The corrected reticulocyte count for a patient with 20% counted reticulocytes and a 30% hematocrit is:

a. 13.3%
b. 15.0%
c. 20.0%
d. 30.0%

86. From the table below, select the values that you would expect to find in the serum of a patient with MCV = 66.6 fl, MCH = 20.2 pg and MCHC = 30.3 gm/dl.

	SERUM IRON (ug/dl)	TIBC (ug/dl)	TRANSFERRIN SATURATION (%)	MARROW IRON STORES
a.	30	200	15	3+
b.	200	250	80	4+
c.	20	400	8	0
d.	115	340	35	2+

87. One of the reagents in the SickleDex test for sickle cell screening is sodium dithionite. What is its function?

a. buffer
b. lysing agent
c. oxidizing agent
d. reducing agent

88. In an osmotic fragility test, hemolysis begins at 0.68% NaCl and is complete at 0.46% NaCl. On the smear one would expect to see:

a. drepanocytes.
b. elliptocytes.
c. normal erythrocytes.
d. spherocytes.

89. Siderotic granules are differentiated from basophilic stippling and Heinz bodies in that siderotic granules stain positively with:

a. new methylene blue.
b. nitroblue tetrazolium.
c. periodic acid Schiff.
d. Prussian blue.

90. The following results were obtained on a Schilling test:

1. 1% of labelled vitamin B_{12} was recovered in the patient's urine when administered alone (normal recovery = 7% or greater).
2. When administered with intrinsic factor, 1% of labelled vitamin B_{12} was recovered in the patient's urine.

These results indicate:

a. malabsorption.
b. folic acid deficiency.
c. pernicious anemia.
d. nothing abnormal.

91. The reducing compounds in the erythrocyte that serve to protect hemoglobin iron from oxidation are generated in the:

a. Embden-Meyerhoff pathway.
b. Krebs cycle.
c. mitochondria.
d. pentose-phosphate shunt.

92. Erythrocytes deficient in a certain enzyme undergo hemolysis when exposed to acetylphenylhydrazine or similar drugs. This deficient enzyme is:

a. galactose-1-phosphate uridyl transferase.
b. glucose-6-phosphate dehydrogenase.
c. glutathione reductase.
d. pyruvate kinase.

Which of the disease states listed below is most consistent with the following data:

RBC = $6.0 \times 10^{12}/l$	platelets = adequate
hgb = 18 gm/dl	LAP = normal
hct = 54%	bone marrow = erythroid hyperplasia
WBC = $9.5 \times 10^{9}/l$	differential and RBC morphology = unremarkable

a. hemoconcentration due to dehydration
b. polycythemia vera
c. relative polycythemia
d. secondary polycythemia

On a peripheral blood smear that is made too slowly, or with undue pressure, when performing a differential one would expect to find an increased percentage of:

a. neutrophilic bands.
b. segmented neutrophils.
c. lymphocytes.
d. monocytes.

In a white blood cell diluting pipette, blood is drawn to the 0.4 mark; the diluting fluid is drawn to the 11 mark. Using an improved Neubauer counting chamber, 26, 21, 22 and 29 cells are counted in the corner squares. The total WBC count per cubic mm is:

a. 6,125.
b. 6,737.
c. 61,250.
d. none of the above.

To perform a Thorn test, the patient is given ACTH. Normal results would show a(an):

a. decrease in eosinophils.
b. increase in eosinophils.
c. decrease in total WBCs.
d. increase in total WBCs.

Sudan Black stains:

a. lipids and usually correlates closely with the peroxidase stain.
b. lipids and usually correlates closely with the periodic acid stain.
c. glycogen and usually correlates closely with the peroxidase stain.
d. glycogen and usually correlates closely with the periodic acid stain.

Aleukemic leukemia differs from other leukemias in that the peripheral blood in this disease has:

a. agranular granulocytes.
b. increased mature forms.
c. normal or decreased WBC count.
d. blast forms found only in the peripheral blood.

99. Toxic granulation in neutrophils is usually caused by:

a. bleeding.
b. chronic anemia.
c. hemolysis.
d. infection.

100. The atypical lymphocyte may be the predominant cell type in:

1. infectious hepatitis.
2. measles.
3. infectious mononucleosis.
4. toxoplasmosis.

a. 3 only.
b. 1 and 3 only.
c. 1, 2 and 3 only.
d. 1, 2, 3 and 4.

101. Fill in the blank: The Philadelphia chromosome is most commonly seen in _____ leukemia.

a. acute lymphoblastic
b. acute myelogenous
c. chronic lymphocytic
d. chronic myelogenous

102. Hematological data reveal:

hemoglobin	= 10.8 gm/dl	differential:	73% segs
hematocrit	= 31%		11% stabs (bands)
RBC	= 3.3×10^{12}/l		9% lymphocytes
WBC	= 13.0×10^{9}/l		2% monocytes
platelets	= 350×10^{9}/l		4% blasts (some with Auer rods)
			1% myelocytes

The patient is a 63-year-old white female. The most probable diagnosis, without further studies is:

a. chronic myelogenous leukemia.
b. chronic lymphocytic leukemia.
c. early acute myelogenous leukemia.
d. early acute lymphocytic leukemia.

103. Pelger-Huet anomaly shows:

a. normal differential, hypochromia, increased leukocyte count.
b. normal leukocyte count, increased number of hyposegmented neutrophils.
c. increased leukocyte count, increased number of hyposegmented neutrophils.
d. normal differential, increased leukocyte count, azurophilic granulation of neutrophils.

104. An elderly patient presents with a WBC count of 70.0 x 10^9/l, hemoglobin 10.5 gm/dl, and platelet count of 175 x 10^9/l. The patient's peripheral blood smear shows 90% lymphocytes and numerous smudge cells. The patient probably has:

a. acute lymphocytic leukemia.
b. chronic lymphocytic leukemia.
c. myelomonocytic leukemia.
d. infectious mononucleosis.

105. A cerebrospinal fluid with 1,200 WBC/cumm, 90% polymorphonuclear leukocytes, and glucose of 25 mg/dl is suggestive of:

a. a normal newborn.
b. bacterial meningitis.
c. myelogenous leukemia.
d. viral meningitis.

106. "A suspension of blood cells is passed through a small orifice simultaneously with an electric current. The individual cells introduce an impedence change in the orifice determined by the size of the cell." This is a statement of the principle of the:

a. Autocytometer.
b. Coulter Counter.
c. Hemalog.
d. SMA 7.

107. What is indicated by an MCV of 140 fl, hemoglobin of 14.0 gm/dl, RBC count of 3.10 x 10^{12}/l, WBC count of 3.0 x 10^9/l, and hematocrit of 43% as determined by a Coulter S?

a. a patient with leukemia
b. cold agglutinins present
c. lysing reagent is not being dispersed
d. the aperature tube is plugged

108. Pancytopenia can occur after exposure to a specific toxin, such as an organic solvent or drug. In this disorder the marrow is generally:

a. hypocellular.
b. normocellular.
c. hypercellular.

109. A useful "battery" of tests for differentiating the acute leukemias would include all of the following EXCEPT:

a. PAS.
b. peroxidase.
c. Prussian blue.
d. specific esterase.

110. DIRECTIONS: In this item, factors 1 and 5 are in a logical sequence, i.e., the first and last to occur. Indicate the order in which the middle three factors should appear, according to the following key:

KEY: a. 2 second, 3 third, 4 fourth
b. 4 second, 3 third, 2 fourth
c. 4 second, 2 third, 3 fourth
d. 2 second, 4 third, 3 fourth

1. a workman skinned his knuckle causing bleeding to occur
2. fibrin was formed from fibrinogen
3. thrombin was produced
4. platelets were activated
5. bleeding eventually stopped after a clot had formed

111. The factor that is required for coagulation *in vitro* but not *in vivo* is factor:

a. II.
b. X.
c. XI.
d. XII.

112. In the extrinsic coagulation pathway, the test of choice to detect abnormalities is the:

a. activated partial thromboplastin time.
b. prothrombin consumption time.
c. prothrombin time.
d. thromboplastin generation test.

113. There is a four-hour delay before you can perform a prothrombin time. The resulting test time would be:

a. shortened due to increased glass contact.
b. shortened due to the breakdown of platelets.
c. prolonged due to the loss of factor V.
d. prolonged due to the loss of factor VII.

114. A patient specimen has a normal prothrombin time and a prolonged partial thromboplastin time. After mixing normal plasma with the patient's plasma, the partial thromboplastin time is still prolonged. The most probable cause is:

a. a deficiency of factor VIII.
b. a deficiency of factor IX.
c. circulating anticoagulants.
d. hypocalcemia.

115. A 47-year-old man who has been drinking heavily comes to the emergency room with severe hematemesis. Prothrombin time and partial thromboplastin time are both prolonged (20 and 82 seconds, respectively), platelet count is 120 x 10^9/l, and plasma fibrinogen is 300 mg/dl. Fibrinogen split products (protamine sulfate) is negative. These results are consistent with which of the following disorders:

a. disseminated intravascular coagulation.
b. liver damage.
c. hemophilia.
d. primary fibrinolysis.

116. Which of the following conditions would NOT be likely to precipitate disseminated intravascular coagulation?

a. anemia
b. gram negative septicemia
c. incomplete abortion
d. liver disease

117. With great difficulty, the technologist has obtained 2 ml of blood from a patient whose physician has ordered a platelet count, hemoglobin, hematocrit and blood glucose. In order to perform all these tests on this specimen, the tube into which he puts the blood should contain:

a. EDTA.
b. heparin.
c. sodium fluoride.
d. sodium oxalate.

118. Platelet counts performed on automated counters may be falsely decreased in the presence of:

1. platelet satellitism.
2. platelet antibodies.
3. megathrombocytes.
4. megakaryocyte fragments.

a. 1 and 4 only.
b. 2 and 3 only.
c. 2 only.
d. 1, 3 and 4 only.

119. In a thrombocytopenic patient, which results would be expected:

a. prolonged Ivy bleeding time, delayed clot retraction, normal activated partial thromboplastin time
b. prolonged activated partial thromboplastin time, prolonged prothrombin time, normal Lee-White clotting time
c. normal Ivy bleeding time, prolonged thrombin time
d. normal Ivy bleeding time, prolonged Lee-White clotting time, prolonged prothrombin time

120. The preferred method of specimen collection for studies of platelet function is using:

a. capillary blood obtained by skin puncture.
b. the 2-syringe technique (glass syringes).
c. the 2-syringe technique (plastic syringes).
d. the Vacutainer system (second tube drawn).

121. In renal tubular acidosis the urine may be alkaline in the presence of metabolic acidosis because of:

a. a high urinary pH.
b. inability of the kidneys to excrete acid.
c. the presence of alkaline reacting substances in the urine.
d. excess tubular reabsorption of anions.

122. Using the data below, calculate the free water clearance.

serum osmolality	284 mOsm/kg
urine osmolality	427 mOsm/kg
urine volume	1440 ml/24 hrs

a. -0.5 ml/min
b. +0.5 ml/min
c. -1.5 ml/min
d. +1.5 ml/min

123. A urine, at temperature 11°C, yields a reading of 1.015 on the urinometer. What is the true specific gravity, if room temperature is 20°C?

a. 1.011
b. 1.012
c. 1.013
d. 1.020

124. Which of the following tests and reagents is most sensitive in the detection of urine bilirubin:

a. Bili-lab Stix
b. Ictotest
c. nitroprusside test
d. 10% ferric chloride

125. A positive Clinitest and a negative glucose oxidase test are demonstated in a urine specimen. These results indicate the presence of:

a. a large quantity of ketones.
b. an interfering drug.
c. glucose as the only sugar.
d. reducing substances.

126. The urinalysis on a 3-month-old female yields an unremarkable dipstick and microscopic examination of the sediment. An additional test which would complete the recommended routine analysis of this urine is:

a. Benedict's.
b. diazo.
c. Ehrlich's
d. Watson-Schwartz.

127. Incomplete oxidation of fatty acids which results in their appearance in urine is called:

a. glycosuria.
b. hyperlipidemia.
c. ketosis.
d. proteinuria.

128. An out-patient delivers to the laboratory a urine specimen that had been collected 3 hours prior to her arrival. The test requested for this specimen is the Watson-Schwartz test. A technologist performs the test and observes a pink-orange color with the addition of Erlich's reagent. After several chloroform extractions (until the chloroform layer is colorless), the aqueous layer remains slightly pink-orange. The test:

a. is negative and should be reported out as such.
b. is probably positive for urobilinogen and should be repeated on a fresh specimen.
c. is probably positive for both urobilinogen and porphobilinogen but further extraction is needed as well as a fresh specimen.
d. results are inconclusive and should be reported out as such, allowing the physician to decide whether the test should be repeated.

129. Which of the following crystals would be found in acid urine:

a. ammonium biurate and uric acid
b. ammonium phosphate and cystine
c. calcium carbonate and sulfanilimide
d. hippuric acid and tyrosine

130. Pyuria and bacteriuria without proteinuria suggest:

a. upper urinary tract infection.
b. lower urinary tract infection.
c. outside contaminant.
d. technical error.

131. The presence in urine of many erythrocytes, a large amount of protein, and an occasional RBC cast is most suggestive of:

a. acute glomerulonephritis.
b. nephrotic syndrome.
c. pyelonephritis.
d. trauma.

152. A kidney stone is pulverized and heated with 10% NaOH. The solution is reheated after crystals of lead acetate are added, and a heavy black precipitate forms. This indicates the presence of:

a. cholesterol.
b. cystine.
c. sulfonamides.
d. xanthine.

153. When a urinary filtrate is reacted with ferric chloride a green color develops, which shortly afterward fades to yellow. Which of the following inborn errors of metabolism should be suspected?

a. alkaptonuria
b. cystinuria
c. maple-syrup urine disease
d. phenylketonuria

154. A patient's urine specimen is brought to the lab immediately after collection and tested promptly. The results include:

pH	acid
glucose	3+
bacteria	occasional

After sitting at room temperature for 4 hours, repeat testing on the same specimen would show:

a. no change.
b. pH -acid; glucose - 3+; bacteria - many.
c. pH - alkaline; glucose - 1+; bacteria - many.
d. pH - alkaline; glucose - 3+; bacteria - many.

155. Darkening of reagent areas on a dipstick may result when the:

I. container top is not replaced.
II. product use has expired.
III. dipsticks are exposed to heat.

a. I only
b. II only
c. I and II only
d. I, II, and III

156. Cerebrospinal fluid may be xanthochromic due to:

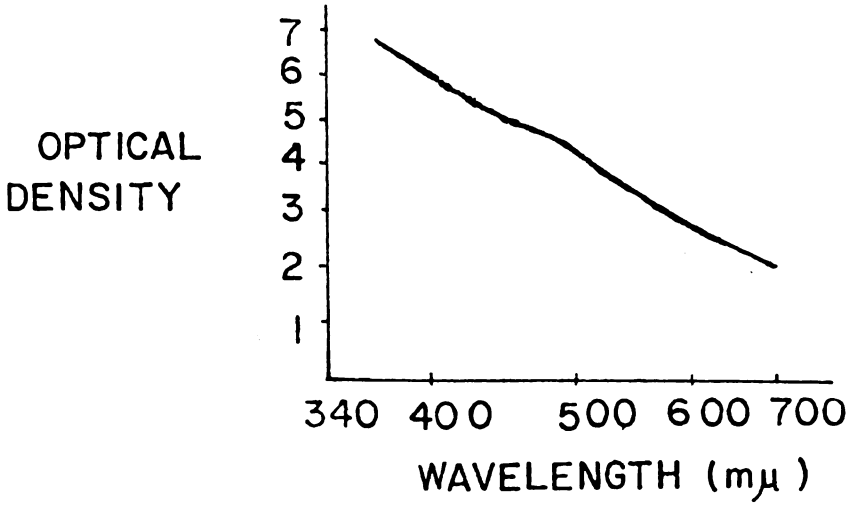
I. bilirubin.
II. hemoglobin pigments.
III. a bloody tap.

a. I only
b. II only
c. I and II only
d. I and III only

137. An appropriate stimulant for a tubeless gastric analysis contains:

a. alcohol.
b. Azure A dye.
c. Diagnex blue.
d. caffeine.

138. Below is a spectral curve of amniotic fluid obtained at term.



This curve indicates that the:

a. amniotic fluid is contaminated with meconium.
b. infant is normal.
c. infant is severly affected by hemolytic disease of the newborn.
d. specimen has deteriorated as a result of a delay in processing.

139. Which of the data below, obtained by examination of seminal fluid, is ABNORMAL:

a. motility: 85% progressive motility
b. sperm count: 100 million/ml
c. viscosity: coagulum present immediately, liquefies after 10 minutes
d. volume: 7.0 ml

140. Steatorrhea is a condition in which there is a pathological increase in fecal:

a. blood.
b. fats.
c. mucus.
d. pus.

141. Which of the following sequences correctly order the human needs according to Maslow's hierarchy, from the most basic to the highest level?

1. affectional
2. self-actualization
3. physiological
4. safety and security
5. self-esteem and independence

a. 1, 2, 3, 4, 5
b. 3, 4, 1, 5, 2
c. 4, 3, 1, 2, 5
d. 2, 5, 1, 4, 3

142. You have been assigned to make a 10N H_2SO_4 solution. While measuring the acid the bottle fell to the floor, splattering on you. Your options are:

1. get under a safety shower
2. call for help
3. put bicarbonate on the acid
4. go to the emergency room

The order of priorities that would minimize damage to you and others is:

a. 1, 3, 4
b. 1, 2, 4, 3
c. 3, 1, 2
d. 2, 1, 3, 4

143. As a laboratory supervisor, you make purchase decisions on new equipment. While examining a new piece of equipment some factors to consider are:

1. company service record
2. cost of reagents, standards and supplies
3. effectiveness of sales personnel
4. instrument life span
5. where the instrument is manufactured

a. 1, 2, and 5
b. 1, 2, and 4
c. 1, 3, and 4
d. 2, 4, and 5

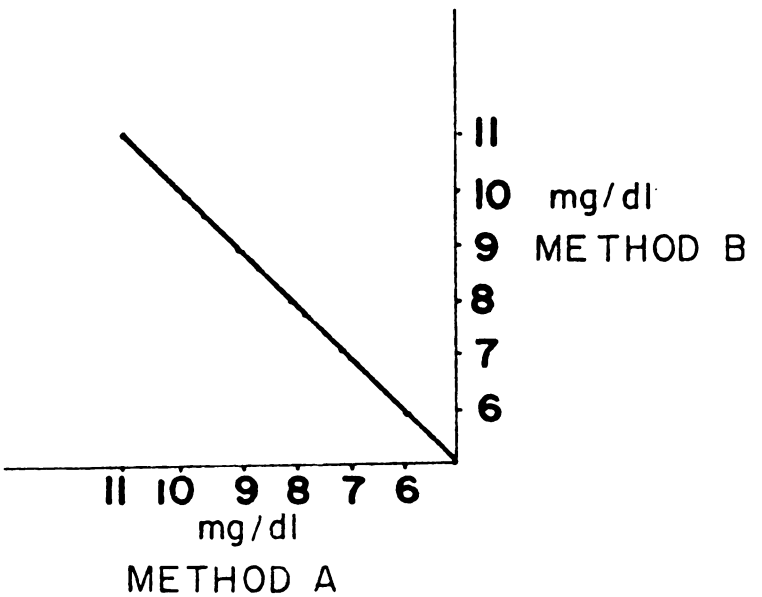
144. Which of the following correctly states the <u>BEHAVIOR</u> sought by a behavioral objective:

a. "...given the appropriate raw data..."
b. "...the student will be able to..."
c. "...derive a standard deviation..."
d. "...within a range of 10-20 ml..."

145. In which format is compatibility testing best taught?

a. group discussion
b. lecture with demonstration
c. lecture with audiovisual aids
d. strictly lecture

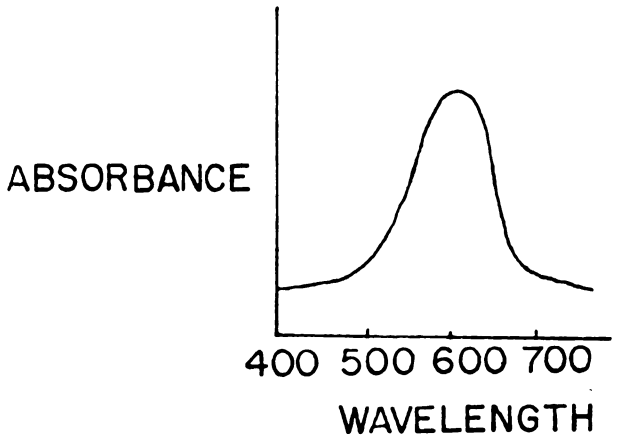
146. Below is a graphic representation of the correlation between Method A. and Method B for the analysis of calcium.

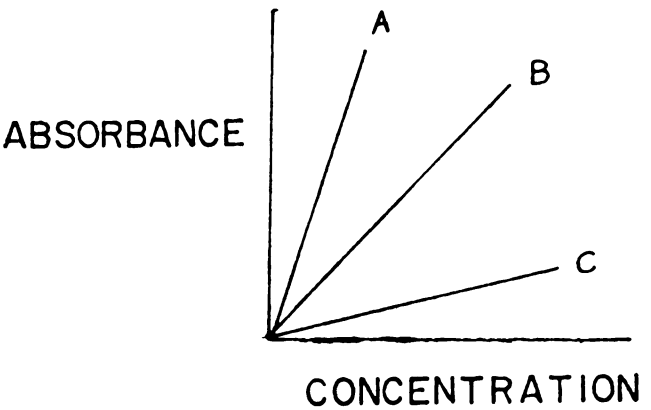


The correlation between the two methods is:

a. -1.0.
b. 0.0.
c. +1.0.

147. A spectral absorbance curve of a colored solution was prepared (graph at left). In addition, a graph of absorbance vs. concentration was prepared and read at several wavelengths (graph at right).





Based on these data, the best match of wavelength with standard line is:

a. 550 nm, line A.
b. 600 nm, line A.
c. 600 nm, line B.
d. 650 nm, line C.

148. What is the molarity of an HNO_3 solution with the following specifications on its bottle:

specific gravity	1.420
purity assay	70%
M.W. of HNO_3	63 gm

a. 1.6
b. 3.2
c. 16
d. 32

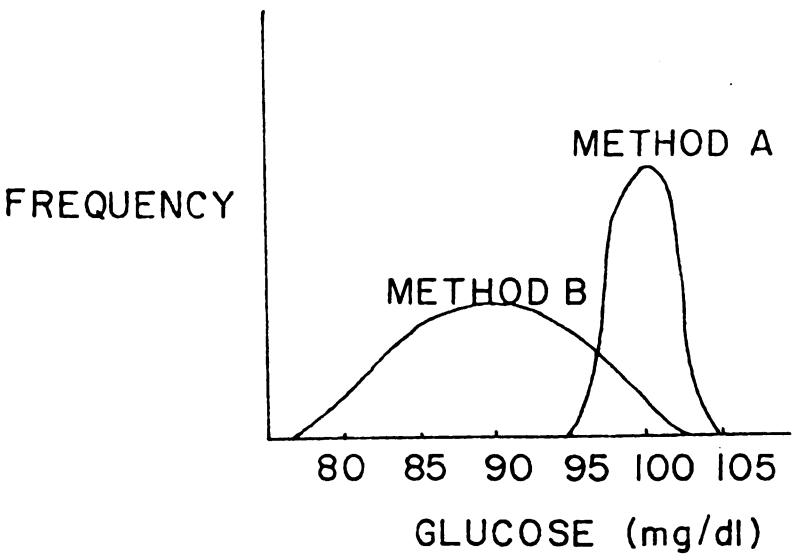
149. The equivalent weight of calcium is 20. Convert 4.5 mEq/L of calcium to mg/dl. (M.W. of calcium = 40)

a. 8.5
b. 9.0
c. 6.4
d. 4.5

150. A serial dilution is made of 0.3 ml of serum, with 0.6 ml of saline in each tube. Each transfer involves 0.3 ml. If 0.2 ml of a 10% suspension of sheep erythrocytes is then added to each tube, what would be the final dilution of the serum in tube #5?

a. 1:108
b. 1:243
c. 1:324
d. 1:1215

151. Shown below is a graphic representation of the results obtained by two methods for glucose. The known value of the test solution is 90 mg/dl.



Method A shows:

a. good accuracy and good precision.
b. good accuracy and poor precision.
c. poor accuracy and good precision.
d. poor accuracy and poor precision.

152. The following values (mg/dl) were obtained for the glucose control in one week:

102	101	99
92	102	99
95	100	100
102	101	102
103	102	

What is the mean value?

a. 99
b. 100
c. 101
d. 102

153. The 95% confidence limits for calcium determinations on control sera were established as 9.4 to 10.2 mg/dl. The standard deviation for this determination is:

a. 0.1.
b. 0.2.
c. 0.4.
d. 0.8.

154. The Henderson -Hasselbach equation is

$$pH = pK + \log \frac{A^-}{HA}.$$

Clinically, the compounds of interest that are represented, respectively, by A^- and HA are:

a. CO_2^- and HCO_3.
b. CO_2^{2-} and H_2CO_3.
c. HCO_3^- and H_2CO_3.
d. $H_2CO_3^-$ and HCO_3.

155. Fill in the blank: The mean value for a sodium standard, obtained by Method XX, is 140 mEq/L with a standard deviation of 1.4 mEq/L when 20 samples are run. The coefficient of variation for Method XX is _____%.

a. 1.0
b. 2.8
c. 5.0
d. 10.0

156. If the hydrogen ion concentration of a solution is 0.000001M, the pOH is:

a. 6.0.
b. 7.0.
c. 8.0.
d. 9.0.

157. In darkfield miscroscopy:

1. the object appears luminous against a dark background.
2. reflected light rays are used.
3. small objects are visible that cannot be seen with bright light microscopy.
4. the limit of resolution is increased over bright light microscopy.

a. 1 and 2 only
b. 2 and 3 only
c. 1, 2 and 3 only
d. 2, 3 and 4 only

158. Fill in the blank: An atom of Co^{60}_{27} has _____ neutrons in the nucleus.

a. 27
b. 33
c. 60
d. 87

159. "Drumsticks" found on the nuclei of polymorphonuclear leukocytes is generally correlated with the:

a. autosome pair #1.
b. Philadelphia chromosome.
c. X chromosome.
d. Y chromosome.

160. The function of phytohemagglutinin (PHA) in tissue culture medium is to:

a. arrest cell division.
b. indicate the presence of red cell antigens.
c. prevent culture infection with bacteria.
d. stimulate mitoses.

161. In atomic absorption procedures for calcium, lanthanum chloride is used as a diluent to prevent:

a. chemical interference.
b. spectral interference.
c. protein interference.
d. self-emission.

162. When performing Iontophoresis, a falsely elevated result would be obtained if the:

a. patient has had an abnormally high intake of salt in the previous 24 hours.
b. patient is dehydrated.
c. patient sweats excessively.
d. site was cleansed excessively in test preparation.

163. Centrifugal analyzers operate by:

a. mixing samples and reagents by centrifugal force and making simultaneous photometric measurements on a series of samples.
b. performing several different tests simultaneously on a single specimen in which the serum and cells have been separated by centrifugal force.
c. separating constituents from interfering substances by centrifugal force and analyzing the supernatants photometrically.
d. taking only a single photometric measurement on a sample in which cells and serum have been separated by centrifugal force.

164. If, after running several blood pH determinations, erratic results are obtained, the most likely problem is:

a. faulty electrode.
b. faulty meter.
c. protein fouling up the electrode.
d. static electricity.

165. While making a CO_2 analysis with a single channel autoanalyzer, you find that you are unable to adjust the water baseline to below 100% transmission with the 100%T potentiometer. What action should be taken?

a. change the lamp
b. insert a larger aperature
c. refocus the flow cell
d. replace the 15 mm flow cell with a smaller flow cell

166. A blood glucose that rises slowly and only slightly above normal in the first two hours of a glucose tolerance test suggests that the patient has:

a. decreased insulin secretion.
b. excess insulin.
c. malabsorption syndrome.
d. hyperthyroidism.

167. You have reported a fasting blood sugar as 140 mg/dl. The doctor calls after receiving the report and asks you if this patient has diabetes. You should:

a. refer him to the pathologist.
b. suggest that there are other possible causes for the high result.
c. tell him that the patient probably has mild diabetes.
d. tell him that the patient probably has mild diabetes but further testing is required.

168. Of the following, the best way to diagnose galactosemia is to measure:

a. RBC content of galactose-1-PO_4 uridyl transferase activity.
b. serum galactose.
c. serum galactose-1-PO_4.
d. serum galactose-1-PO_4 uridyl transferase activity.

169. Arterial blood with a higher-than-normal HCO_3^- may be indicative of:

a. compensatory respiratory acidosis.
b. metabolic acidosis.
c. respiratory acidosis.
d. respiratory alkalosis.

170. A blood specimen containing potassium oxalate as an anticoagulant would be unsuitable for assays of:

a. BUN.
b. Ca^{++}.
c. glucose.
d. Na^{+}.

171. All of the following are consequences of hypercalcemia EXCEPT:

a. kidney stones.
b. loss of appetite.
c. muscle hypotonicity.
d. tetany.

172. Four "normal" serum specimens were analyzed with the four sets of results listed below. The set of results most likely in error is:

	BICARBONATE(mEq/l)	CHLORIDE(mEq/l)	SODIUM(mEq/l)
a.	18	103	135
b.	25	100	140
c.	27	105	130
d.	35	90	138

173. Which of the following chemical principles is responsible for the color production of a phosphorous determination?

a. oxidation of phosphomolybdic acid
b. oxidation of phosphotungstic acid
c. reduction of phosphomolybdic acid
d. reduction of phosphotungstic acid

174. Laboratory data reveal pH 7.5, increased $^{p}CO_2$, and increased total CO_2 content. Potassium and chloride ions are decreased. The most likely clinical condition is:

a. metabolic acidosis.
b. metabolic alkalosis.
c. respiratory acidosis.
d. respiratory alkalosis.

175. Given that the barometric pressure is 740 mmHg and that the CO_2 in the analyzed gas for blood gas analysis is 5%, calculate the partial pressure of CO_2 in mmHg.

a. 35.3
b. 35.9
c. 36.8 (water vapor pressure at 24°C = 22)
d. 39.5

176. When collecting a specimen for capillary blood gases, excess exposure to air results in:

a. increased CO_2 content; decreased P_{CO_2} and pH.

b. increased CO_2 content and P_{CO_2}; decreased pH.

c. decreased CO_2 content; increased P_{CO_2} and pH.

d. decreased CO_2 content and P_{CO_2}; increased pH.

177. Elevations in the two fastest moving (most anodic) LDH (LD) isoenzymes (LDH_1 and LDH_2) suggests damage to the:

a. heart.
b. kidney.
c. liver.
d. skeletal muscle.

178. A certain enzyme reaction is measured by reading the absorbance of the test solution at 340nm to kinetically monitor the conversion of NADH to NAD. A sample from a patient who has just entered the emergency room has a very low initial absorbance and there is minimal change in the absorbance for the 10 minute incubation time. What action should be taken?

a. calculate and report the result as soon as possible
b. check the controls to be sure that the system is working, then calculate the results as usual
c. dilute the specimen and repeat the test
d. request a fresh specimen

179. The major disadvantage to total protein determination with the Folin-Ciocalteau reagent is that:

a. it is 5-10 times less sensitive than the other reagents for protein quantitation (i.e., biuret).
b. the determination is affected by protein concentration of tyrosine, tryptophan, and histidine.
c. the protein molecules must be at least tripeptides.
d. the reaction does not follow the Beer-Lambert Law.

180. Calculate an uncorrected creatinine clearance (ml/min) using the data below:

BUN	50.0 mg/dl
serum creatinine	4.0 mg/dl
urine creatinine	150.0 mg/dl
volume of 24-hr urine	800.0 ml

a. 10
b. 20
c. 100
d. 200

181. All of the following conditions are consistent with an elevated uric acid EXCEPT:

a. gout.
b. leukemia.
c. Fanconi's syndrome.
d. starvation.

182. In a patient with advanced obstructive jaundice, all of the following will be elevated EXCEPT:

a. direct serum bilirubin.
b. indirect serum bilirubin.
c. urine bilirubin.
d. urine urobilinogen.

183. A stat bilirubin determination was performed on the serum of a 12 year-old male, along with a control serum and a standard bilirubin solution containing 5 mg/dl. The results obtained were:

standard absorbance	0.392
control absorbance	0.229
patient absorbance	0.179
bilirubin control assay value	3.5 mg/dl
acceptable limits (one standard deviation)	0.2 mg/dl

Which of the following best describes the correct interpretation of this data?

a. the patient value is normal, the control value is within limits and the patient's value can be reported to the physician
b. the patient value is normal, the control value is outside acceptable limits, and the patient's value cannot be reported to the physician
c. the patient value is abnormal, the control value is within limits, and the patient's value can be reported to the physician
d. the patient value is abnormal, the control value is outside acceptable limits, and the patient's value cannot be reported to the physician

184. Red blood cell protoporphyrin is elevated in:

a. lead poisoning, but not porphyria.
b. porphyria, but not lead poisoning.
c. both lead poisoning and porphyria.
d. neither lead poisoning nor porphyria.

185. An obese adult with premature arteriosclerosis is seen in the clinic. When her serum is tested, no chylomicra are present, LDL are normal, and VLDL are increased. There is an increase in triglycerides and a slight increase in cholesterol. Lipoprotein electrophoresis reveals a heavy pre-beta band. She has no skin rash, and uric acid is increased. This patient has a hyperlipoproteinemia, most likely type:

a. II.
b. III.
c. IV.
d. V.

186. The expected test results in primary hypothyroidism are:

a. decreased T_4, decreased T_3 resin uptake (RT_3U), increased TSH.
b. decreased T_4, increased T_3 resin uptake (RT_3U), decreased TSH.
c. decreased T_4, increased T_3 resin uptake (RT_3U), increased TSH.
d. increased T_4, increased T_3 resin uptake (RT_3U), decreased TSH.

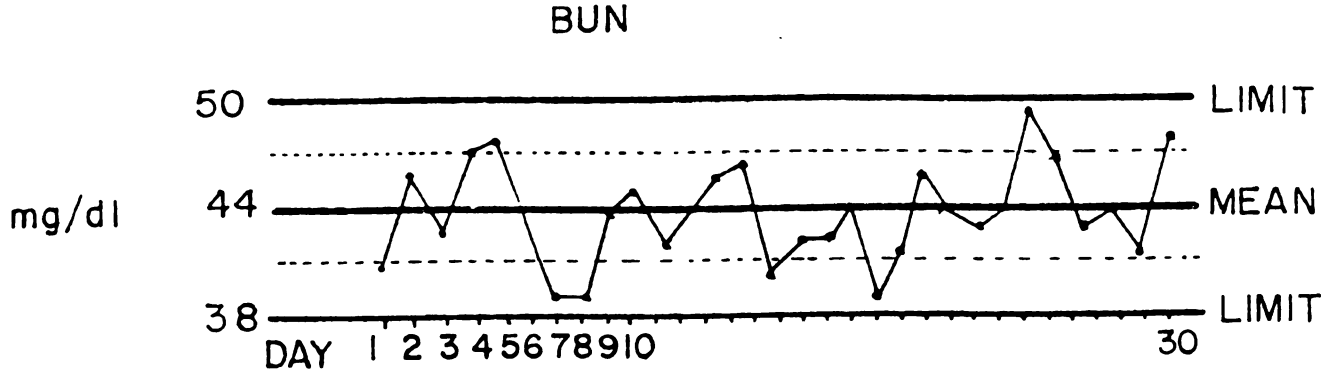
187. A person having an abnormally low 17-hydroxycorticosteroid baseline is given ACTH. A subsequent 17-hydroxycorticosteroid measurement taken after the ACTH shows no change in the level. The most probable diagnosis for this patient is:

a. Addison's disease.
b. adrenocortical tumor.
c. Cushing's disease.
d. hypopituitarism (Simmond's disease).

188. A pheochromocytoma will result in an increased excretion of urinary:

a. androgens.
b. catecholamines.
c. glucocorticoids.
d. mineralocorticoids.

189. The accompanying figure represents a quality control chart for BUN based on 95% confidence limits.



Inspection of the chart reveals a(an):

a. normal control chart with no deviant pattern.
b. shift beginning on day 6.
c. upward shift beginning on day 11.
d. upward trend beginning on day 3.

190. If blood that is drawn for an ammonia assay is left at room temperature the test result will be falsely:

a. decreased due to continued cell glycolysis.
b. decreased due to evaporation.
c. increased due to continued cellular production of urea.
d. increased due to continued enzymatic deamination of labile amides.

191. A clinical chemist requires 95% control limits for serum cholesterol determinations. From previous data, it has been shown that the mean of the daily control serum is 210 mg/dl with a variance of 81 mg/dl. (The standard deviation squared is equal to the variance.)

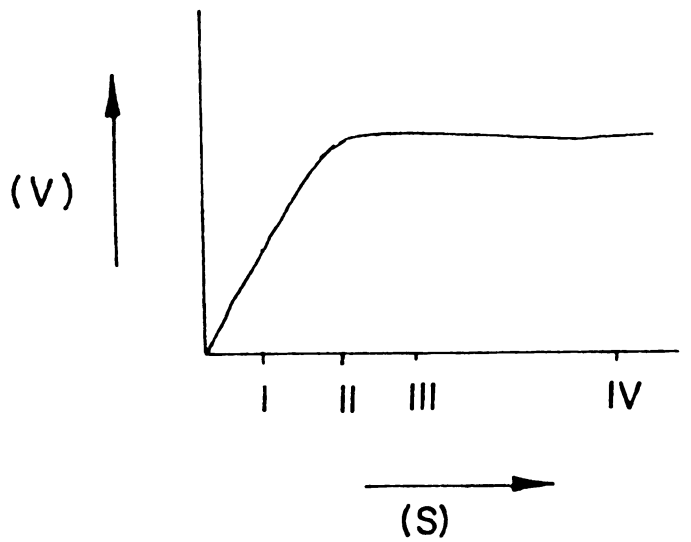
What would you conclude if today you obtain a value of 195 mg/dl for the control serum?

a. the result is outside the limits of acceptance
b. the result is within the limits of acceptance
c. the result is unacceptable 95% of the time
d. not enough data has been presented to draw any conclusion

192. Fill in the blank: To verify that a urine specimen, for quantitative estrogen determination, has been completely collected over a 24-hr period _____ should be assayed.

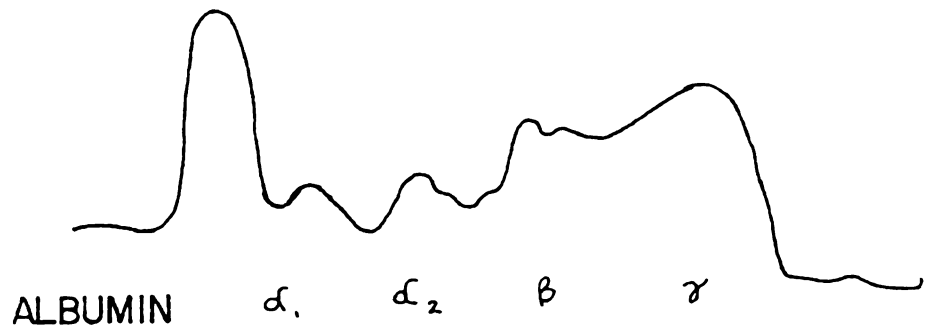
a. another steroid
b. creatinine
c. total protein
d. urea nitrogen

193. Shown below is a graph of initial velocity (v) of an enzyme reaction vs. initial substrate concentration (s). In designing a method to measure the activity of this enzyme, which concentration of substrate should be used?



a. I
b. II
c. III
d. IV

194. Illustrated below is a protein electrophoresis scan.



This pattern suggests that the patient has:

a. chronic liver disease.
b. monoclonal gammopathy.
c. nephrotic syndrome.
d. no protein abnormality.

195. Normal serum amylase, elevated urinary amylase and elevated serum lipase levels together suggests:

a. acute pancreatitis.
b. pancreatic carcinoma.
c. severe renal disease.
d. inconsistent values.

196. Repeated freezing and thawing of pooled sera will have what effect on its albumin assays?

a. falsely increase values
b. falsely decrease values
c. no appreciable effect

197. Methods for the assay of this substance include enzymatic, colorimetric and fluorometric procedures. All three procedures are based on a determination of glycerol, after controlling interfering substances. What substance is assayed by these methods?

a. cholesterol
b. lipoprotein
c. phospholipid
d. triglyceride

198. Venous blood is characteristically bright cherry-red when an individual is poisoned with:

a. barbiturates.
b. carbon monoxide.
c. lead.
d. methanol.

199. A patient in the emergency room has the following signs: comatose, tremors, convulsions and vomiting. The laboratory tests ordered have these results:

sodium	132 mEq/L	(emission flame photometry)
potassium	3.1 mEq/L	(emission flame photometry)
chloride	102 mEq/L	(coulometry)
glucose	85 mg/dl	(hexokinase)
drug screen	negative	(TLC and GLC)

An increased deflection of the lithium response meter is noted when performing the sodium and potassium analyses on this patient's sample, but not on other samples or controls. The electrolytes are repeated, using ion-selective electrodes with the following results:

sodium	142 mEq/L
potassium	4.0 mEq/L
chloride	101 mEq/L

Which of the following statements describes the most appropriate action the technologist should take?

a. report the flame photometry results and recommend that a blood alcohol analysis be performed
b. report the ion-selective electrode results and recommend that a blood alcohol analysis be performed
c. report the ion-selective electrode results and recommend that a serum lithium analysis be performed
d. report the flame photometry results and recommend that serum lead, BUN and arterial blood gas analyses be performed

200. A toxicology screen is ordered on a comatose patient in the emergency room. The thin layer chromatography screen is negative, but the ethanol assay using alcohol dehydrogenase (ADH) gives a value of 65 mg/dl). This value is well below the toxic level for ethanol (greater than 200 mg/dl). Gas-liquid chromatography is performed and no ethanol peak is observed. How can this discrepancy be explained?

a. the value for ethanol by enzyme assay was due to the presence of methanol
b. the value for ethanol by enzyme assay was due to isopropyl alcohol
c. the patient's serum contains abnormal levels of NADH
d. the patient's carboxyhemoglobin level is highly elevated

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