Designing and Writing Multiple Choice Questions

by

Peter Flanagan
Module Objectives

1. Summarize the importance of learning objectives
2. Define “assessment”, “evaluation”
3. Develop an “assessment gradient” for a personal teaching area
4. Summarize the value of multiple choice questions (MCQs)
5. Define the “stem”, “option”, “key”, “distractor” in regard to MCQs
6. List some common flaws in MCQs
7. Explain the characteristics a good MCQ stem will have
8. Write appropriate options for a MCQ
9. Summarize approaches to assessing higher cognitive processes than rudimentary memory recall

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### Gagne: Learned Capabilities – how to test?

<table>
<thead>
<tr>
<th><strong>Intellectual Skills</strong></th>
<th>• Problem solving, discriminations, concepts, principles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitive Strategy</strong></td>
<td>• Meta-cognition - strategies for problem solving and thinking</td>
</tr>
<tr>
<td><strong>Verbal Information</strong></td>
<td>• Facts of knowledge</td>
</tr>
<tr>
<td><strong>Attitude</strong></td>
<td>• Actions that a person chooses to complete</td>
</tr>
<tr>
<td><strong>Motor Skills</strong></td>
<td>• Behavioral physical skills</td>
</tr>
</tbody>
</table>

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Western
Assessment Gradient

Easy of Assessment

High

MCQ

Diagram, Concept Map, Quantitative response

SAQ

Essay, Report, Research paper

Oral interview

Low

Potential Assessment of Learning

Low

High

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Test Yourself: why is this MCQ flawed?¹

The Stanley Cup

A. Is made of cheese
B. Was made in England
*C. Has been under the control of the National Hockey League since 1946, when there were only six teams in the league
D. All of the above

¹ Answers to “Flawed Questions” can be found on the last slide
Test Yourself: why is this MCQ flawed?

The Republic of Ireland, which is about 80% of the area of the island

A. has a largely agricultural economy.
B. is comprised of 32 counties.
C. imports its oil from Canada.
*D. does not contain any snakes.*
Module Section

- Why test?
- The importance of objectives
- Assessment terminology
- Flawed multiple choice questions (MCQs)
- Writing good MCQs
- Item templates and item sets
- Testing higher levels of learning

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Why are multiple choice questions used?

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Perhaps because…

- They are a common selected-response format
- They permit broad coverage of material
- They are practical even with large classes
- They can have very good reliability and validity

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However...

- Constructing good MCQ questions takes time, effort and insight.
- Too often MCQs are used to test what students remember about factual detail.
- Higher levels of cognition and understanding are often not tested.

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Module Section

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**Tip 1: test your objectives**

- Have a clear idea of what you want your students to be able to do!
- Your written learning objectives must be clear, directed to your learning goal - and assessable!
- Be guided by Bloom’s Taxonomy
Bloom’s Taxonomy

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Poor objectives

- Students will be expected to learn the difference(s) between anabolism and catabolism

- On completing this course, the student will understand the principles of oxygen binding to hemoglobin
Legitimate objectives?

❌ Understand the appearance of pneumothorax on a supine chest radiograph.

✔️ Describe five findings of pneumothorax that can be seen on a supine chest radiograph.
Tip 2: use **testable** verbs

- **Knowledge:** “define, state, list”
- **Comprehension:** “recognize, explain”
- **Application:** “choose, demonstrate”
- **Analysis:** “compare, criticize”
- **Synthesis:** “create, develop”
- **Evaluation:** “assess, predict”
Tip 3: teach and test your important stuff!

BIG IDEA

- “nice to know”
- foundational knowledge and skill
- “Big Ideas” worth exploring and understanding in depth

important to know and do

worth being familiar with
Module Section

- Why test?
- The importance of objectives
- **Assessment terminology**
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Assessment: some terms

- **Assessment** - testing students
- **Evaluation** - measuring course effectiveness
- **MCQ stem** = introduction
- **MCQ Options** = multiple choices
- **MCQ Key** = correct answer
- **MCQ Distractor** = incorrect answer
- **Correct answer, best answer?**
More terms

- **Test validity** - appropriately tests the subject area (learning objective) in the students tested
- **Test reliability** - appropriately consistent for students who have similar ability and knowledge levels
- **Item difficulty** - the proportion of students who correctly answered the test question
- **Point biserial** - demonstrates discrimination between students doing well or doing poorly on the test
- **Criterion-referenced test** - measures how well students achieve a learning objective
- **Norm-referenced test** - measures a student’s placement with respect to classmates

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Tip 4: check your MCQs for flaws

Use of flawed multiple-choice items by the New England Journal of Medicine for continuing medical education

ALEX S. STAGNARO-GREEN¹ & STEVEN M. DOWNING²

¹UMDNJ-New Jersey Medical School, USA; ²University of Illinois at Chicago, College of Medicine, USA
Table 1. Item Flaws in 40 *NEJM* CME test items.

<table>
<thead>
<tr>
<th>Type of flaw</th>
<th>Number of flaws</th>
<th>Percentage of 40 items flawed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Verbatim text</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>2. Unfocused stem</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>3. Window dressing</td>
<td>29</td>
<td>73</td>
</tr>
<tr>
<td>4. Unequal option length</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>5. Negative options</td>
<td>14</td>
<td>35</td>
</tr>
<tr>
<td>6. Clues to correct answer</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td>7. Negative stem</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>8. Heterogeneous options</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>203</td>
<td></td>
</tr>
</tbody>
</table>

**Verbatim text flaw:** MCQ text repeated from article

**Unfocused stem flaw:** no question posed by stem

**Window dressing flaw:** excessive / irrelevant information

**Unequal option length flaw:** correct option is appreciably longer

**Negative options flaw:** options contain negative words

**Clues-to-correct answer flaw:** use of ‘always’, ‘never’ or ‘absolutely’

**Negative-stem flaw:** stem includes negatives

**Heterogeneous-options flaw:** non-homogenous content and/or grammatical structure

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Why Flawed?

Which of the following SSRIs has an active metabolite and the longest half-life?
A. Citalopram
B. Fluvoxamine
C. Paroxetine
D. Fluoxetine
E. Sertraline

A 10-year-old boy with attention-deficit/hyperactivity disorder and Tourette’s syndrome is started on methylphenidate. Which of the following effects would methylphenidate be expected to have on the symptoms of the Tourette’s syndrome?

A. Increase the frequency of tics  
B. Decrease the frequency of tics  
C. Reduce coprolalia  
D. Induce choreiform movements  
E. Prevent tic attenuation during sleep
**Why Flawed?**

The parents of a 2-year-old boy reported that he shows in toeing when walking. On examination, the child exhibits femoral anteversion. The most appropriate treatment is:

A. reassuring the parents that the condition usually corrects itself as the child grows older.

B. referral to an orthopedist.

C. referral to a physical therapist.

D. bracing to correct internal rotation of the femurs.
Why Flawed?

A 60-year-old man is brought to the emergency department by the police, who found him lying unconscious on the sidewalk. After ascertaining that the airway is open, the first step in management should be intravenous administration of

A. examination of cerebrospinal fluid  
B. glucose with vitamin B1 (thiamine)  
C. CT scan of the head  
D. phenytoin  
E. diazepam
An OK MCQ
(but tests only memorization!)

Acute intermittent porphyria is the result of a defect in the biosynthetic pathway for
A. collagen.
B. corticosteroid.
C. fatty acid.
D. glucose.
*E. heme.
F. thyroxine (T4).

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A Better MCQ

An otherwise healthy 33-year-old man has mild weakness and occasional episodes of steady, severe abdominal pain with some cramping but no diarrhea. One aunt and a cousin have had similar episodes. During an episode, his abdomen is distended, and bowel sounds are decreased. Neurologic examination shows mild weakness in the upper arms. These findings suggest a defect in the biosynthetic pathway for

A. collagen.
B. corticosteroid.
C. fatty acid.
D. glucose.
* E. heme.
F. thyroxine (T4).

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Module Section

- Why test?
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Blue slides belong to:

David DiBattista, Ph.D.
Brock University
Psychology Department

University of Western Ontario
November, 2008
Tips for MC Item Construction

- The stem should present the issue under consideration *clearly* and contain as much information as possible.
- Do not include irrelevant information in the stem unless it plays a role in the assessment procedure.
Tips for MC Item Construction

- Check carefully for spelling errors, giving special attention to distractors.
- If you use sentence-completion format, check carefully for grammatical consistency of stem and alternatives.
Tips for MC Item Construction

Whenever possible, avoid negative wording in the stem, and be sure to emphasize it when it does occur.
Tips for MC Item Construction

- All distractors should be plausible.
- Four alternatives will usually be quite adequate, but the number used is best determined by the number of plausible distractors you can supply.
Tips for MC Item Construction

➢ To generate plausible distractors

- Use students’ most common errors on constructed-response tests.
- Use distractors that are similar to the correct answer in content, length, and complexity.
- Use words that sound important or have associations to the stem.
- Use distractors that are true, but do not correctly answer the question.
Tips for MC Item Construction

➢ Do not use “none of the above.”
Which of these terms is associated with Sigmund Freud?
A. superego
B. repression
C. latent content
D. all of the above
I never heard of *latent content*, but *superego* and *repression* are both definitely Freudian terms, so it must be “all of the above.”
Which of these terms is associated with Sigmund Freud?
A. superego ✓
B. repression ✓
C. latent content ???
D. all of the above

When all-of-the-above is the keyed response, a student with partial knowledge can still earn full marks!
Also better
Which of these terms is associated with Sigmund Freud?
A. superego
B. latent content
C. both of the above
How many options?

"MC items should consist of three options, one correct option and two plausible distractors. Using more options does little to improve item and test score statistics and typically results in implausible distractors."

Advice: use more than two distractors only if additional ones are plausible!

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Item shape

An appropriately shaped item includes as much of the item as possible in the stem; the stem should be relatively long and the options should be relatively short. The stem should include all relevant facts; no additional data should be provided in the options.

Appropriately Shaped Item:

Long Stem

A.
B.
C. Short Options
D.
E.
A 33-year-old woman, gravida 1, para 1, spontaneously delivers a 2460g (5 lb 7oz) female newborn at 38 weeks’ gestation. The newborn has hepatosplenomegaly, patent ductus arteriosus, and cataracts. At 8 weeks’ gestation, the mother developed a maculopapular rash, enlarged cervical lymph nodes, sore throat, and arthralgias that spontaneously resolved in 1 week. The subsequent prenatal course was uncomplicated. Which of the following tests during pregnancy is most likely to have predicted the findings in the fetus?

A. Amniocentesis to determine karyotype
B. Culture for herpes simplex virus
*C. Serial rubella titers
D. Urinalysis
A 52-year-old man has had increasing dyspnea and cough productive of purulent sputum for 2 days. He has smoked one pack of cigarettes daily for 30 years. His temperature is 37.2 C (99 F). Breath sounds are distant with a few rhonchi and wheezes. His leukocyte count is 9000/mm3 with a normal differential. Gram’s stain of sputum shows numerous neutrophils and gram-negative diplococci. X-ray films of the chest show hyperinflation. Which of the following is the most likely diagnosis?

A. Asthma
B. Bronchiectasis
*C. Bronchitis
D. Pulmonary embolism
E. Streptococcal pneumonia
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Many basic science questions can be presented within the context of a patient vignette. The patient vignettes may include some or all of the following components:

**Age, Gender** (eg, A 45-year-old man) **Site of Care** (eg, comes to the emergency department) **Presenting Complaint** (eg, because of a headache) **Duration** (eg, that has continued for 2 days). **Patient History** (with Family History ?)

**Physical Findings**

+- Results of Diagnostic Studies

+- Initial Treatment, Subsequent Findings, etc.
A 34-year-old woman has had severe watery diarrhea for the past four days. Two months earlier she had infectious mononucleosis. She abuses drugs intravenously and has antibodies to HIV in her blood. Physical examination shows dehydration and marked muscle weakness.

1. Laboratory studies are most likely to show
   A. decreased serum $K^+$ concentration
   B. decreased serum $Ca^{2+}$ concentration
   C. increased serum $HCO_3^-$ concentration
   *D. increased serum $Na^+$ concentration
   E. increased serum pH

2. In evaluating the cause of the diarrhea, which of the following is most appropriate?
   A. Colonic biopsy to identify Giardia lamblia
   B. Culture of the oral cavity for Candida albicans
   C. Duodenal biopsy to identify Entamoeba histolytica
   D. Gastric aspirate to identify Mycobacterium avium-intracellulare
   *E. Stool specimen to identify Cryptosporidium

3. Further studies to evaluate her HIV infection show the ratio of helper T lymphocytes to suppressor T lymphocytes to be 0.3. This occurs because HIV
   A. induces proliferation of helper T lymphocytes
   B. induces proliferation of suppressor T lymphocytes
   *C. infects cells with CD4 receptors
   D. infects macrophages
   E. stimulates the synthesis of leukotriene
An unresponsive 58-year-old woman is brought to the emergency department after collapsing at a local shopping mall. Her family reports that she felt well that morning but developed a headache that progressively worsened while she was shopping. She has had hypertension and atrial fibrillation and is taking an antihypertensive medication and an oral anticoagulant. Her blood pressure is 220/130 mm Hg and her respiratory pattern is one of apnea alternating with hyperpnea. She responds only to noxious stimuli with extensor posturing involving the right arm and leg. Fundoscopic examination reveals papilledema involving the left optic disc. Pupils are 3.0/7.0 (R/L) with no reaction to light on the left. There is a left gaze preference. There is diffuse hyperreflexia (R > L) and Babinski’s sign is present bilaterally.

1. The dilated, unreactive left pupil is most consistent with injury to the left
   
   A. optic nerve  
   B. optic tract  
   *C. oculomotor nerve  
   D. lateral geniculate nucleus  
   E. superior colliculus  

2. The extensor posturing on the right is most consistent with injury to the left
   
   A. telencephalon  
   B. diencephalon  
   *C. midbrain  
   D. pons  
   E. medulla  

3. Her respiratory pattern is best described as
   
   A. normal  
   *B. Cheyne-Stokes  
   C. central neurogenic hyperventilation  
   D. apneustic  
   E. ataxic  

4. Which of the following herniation syndromes is most consistent with her clinical presentation?
   
   A. Cingulate gyrus beneath the falx  
   *B. Temporal lobe uncus across the tentorium  
   C. Diencephalon through the tentorial notch  
   D. Brain stem through the tentorial notch  
   E. Cerebellar tonsils through the foramen magnum
Item sets

Beware!

- **Cueing:** student gets clues by reading ahead
- **Hinging:** student must know answer to one question in order to answer subsequent ones
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“If assessment tasks are to tap higher-order cognitive processes, they must require that students cannot answer them correctly by relying on memory alone.”

—Anderson and Krathwohl, 2001, page 71
Bloom: Analysis

Place your finger in the middle of your forehead, and then move it straight back along the middle of your head and down the back of your head. Your finger started out near your frontal lobe and ended up near your cerebellum. Which parts of your brain did it come near along the way?

A. first the parietal lobes, then the temporal lobes
*B. first the parietal lobes, then the occipital lobes
C. first the temporal lobes, then the parietal lobes
D. first the temporal lobes, then the occipital lobes
Bloom: Evaluation

Dr. Brennan wants to compare the effectiveness of two training methods that are commonly used to teach people to juggle. He obtains a group of volunteers who have never juggled and randomly assigns each person to one of the two training methods. He sets alpha at 0.05 and determines that the power of his statistical test is 0.40. Which of the following is a valid criticism of Dr. Brennan’s research study?

*A. Power is much too low; it should be at least 0.80.
B. Alpha is much too high; it should be no larger than 0.01.
C. A placebo group should be included in the research design.
D. Participants should be allowed to select the training method they will have.
### Assertion / Reason MCQ

<table>
<thead>
<tr>
<th>Assertion</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>In a small open economy, if the prevailing world price of a good is lower than the domestic price, the quantity supplied by the domestic producer will be greater than the domestic quantity demanded, increasing domestic producer surplus.</td>
<td><strong>BECAUSE</strong> In a small, open economy, any surplus in the domestic market will be absorbed by the rest of the world. This increases domestic consumer surplus.</td>
</tr>
</tbody>
</table>

(a) True; True; Correct reason  
(b) True; True; Incorrect reason  
(c) True; False  
(d) False; True  
(e) False; False  

(The correct answer is (d).)
Two-Tier MCQ

During what phase of the learning cycle are students given the opportunity to organize the concept that they have just learned with other phenomena related to this concept?

A. Phase One  
B. Phase Two  
*C. Phase Three  
D. This is true for more than just one phase.

The educational reason for my answer is because:

A. After the information is given to the students, they are given the opportunity to make connections to new concepts.  
B. After the teacher explains the new concept, the students must be given time for free exploration.  
*C. After the concept is presented, appropriate activities are provided to apply the concept to a new situation.  
D. The new learning cycle is all inclusive and develops new concepts during each phase.
Immediate Feedback Assessment Technique

Upon completion, students can score the test according to whatever point system the teacher decides. They leave the test knowing what their score is, as well as the correct answer for EVERY question. Their misunderstandings are IMMEDIATELY replaced with knowledge and the chance of repeating mistakes in the future is decreased.
IFAT technique

- "correct" box has a star, all other boxes are blank
- all boxes are covered by wax - student scratches off the coating
- continues scratching boxes until the star is found
- final choice is always the correct answer
- students get full marks for getting a star on the first attempt
- earn progressively less credit for answering correctly on the second and third attempts
IFAT advantages

1. provides immediate feedback for every item
2. feedback provided by the IFAT is corrective
3. students learn the correct answer to every item immediately
4. students can receive partial credit
5. students are rewarded for their proximate knowledge
6. students can determine their total mark by the end of the test
### Student Response to IFAT

#### TABLE 4. Responses to Questionnaire 3 (n = 141)

<table>
<thead>
<tr>
<th>Item</th>
<th>% Disagree (1–3)</th>
<th>% Agree (5–7)</th>
<th>M</th>
<th>SE</th>
<th>One-sample t test&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>I like the fact that the IFAT lets me know the right answer to every question.</td>
<td>1.4</td>
<td>97.2</td>
<td>6.39</td>
<td>0.08</td>
<td>31.8**</td>
</tr>
<tr>
<td>The IFAT allowed me to learn from my mistakes.</td>
<td>2.8</td>
<td>92.9</td>
<td>6.06</td>
<td>0.09</td>
<td>23.6**</td>
</tr>
<tr>
<td>I think that the IFAT is fairer than an ordinary response form for multiple-choice tests.</td>
<td>13.5</td>
<td>56.7</td>
<td>4.83</td>
<td>0.11</td>
<td>7.45**</td>
</tr>
<tr>
<td>I would like it if I could use the IFAT in all of my courses that have multiple-choice tests.</td>
<td>17.0</td>
<td>69.1</td>
<td>5.18</td>
<td>0.14</td>
<td>8.50**</td>
</tr>
</tbody>
</table>

<sup>a</sup>One-sample t tests (two-tailed) compared the mean score for each item to a test value of 4 (neither agree nor disagree). ES = effect size = (M–4)/SD. **p < .001.

Note. The response scale for each item was 1 (disagree strongly), 4 (neither agree nor disagree), 7 (agree strongly). IFAT = immediate feedback assessment technique.
http://www.epsteineducation.com/home/

Epstein Educational Enterprises has developed a unique multiple-choice learning and assessment system called the Immediate Feedback Assessment Technique, ("IF-AT"). The IF-AT is ideally suited for classroom assessment, textbook and test prep publishers, learning centers, as well as corporate & professional training organizations committed to providing innovative, state-of-the-art learning and teaching tools.

We encourage you to explore our website to learn more about the IF-AT. We have statistically proven at all levels that using the IF-AT can help increase both learning and retention of subject material!

Featured Articles: Suggested Uses  Key Benefits  Team Based Learning

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Additional Resources:

Medical Council of Canada
Clinical Decision Making problems
National Board of Medical Examiners
A rich source of information on MCQs
The Medical Council of Canada / Le Conseil médical du Canada

CLINICAL DECISION MAKING (CDM) EXAM
(Online demonstration version)

This is the demonstration version of the CDM component MCC's Qualifying Exam Part I in a computer based format. You must be using Firefox (version 3 or later) or Microsoft Internet Explorer (version 6 or later) in order to try out this exam. In addition, your browser must have Java and JavaScript enabled. Click your 'Back' button to return to the MCC's main web site if you do not want to try the exam or if your browser version is incorrect.

PRISE DE DÉCISIONS CLINIQUES (PDC)
(Version de démonstration)

L'examen qui suit est une version de démonstration de la composante PDC de la Partie I de l'Examen d'aptitude du CMC dans un format informatisé. Cet examen a été conçu pour être utilisé de concert avec Firefox (version 3 ou plus récent) ou Internet Explorer de Microsoft (version 6 ou plus récent). De plus, les langages Java et JavaScript devraient être initialisés. Si vous n'avez pas la bonne version de navigateur ou que vous ne voulez pas essayer l'examen en ce moment, veuillez cliquer sur le bouton 'Back' afin de retourner au site du CMC.

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Start/Commencer
A 55-year-old male company vice-president presents in your office with a copy of his recent executive physical. His personal health history and family history are negative. He is a non-smoker. As part of the evaluation, he had a random serum cholesterol done, which is reported as 7.00 mmol/L. Serum triglycerides, liver function indices and a resting electrocardiogram are all within normal limits. Examination reveals a rather obese middle-aged man: height 190 cm; weight 98 kg; body mass index (BMI) 30.2; blood pressure 140/88 mm Hg. The rest of the physical examination is unremarkable.

Use the information above to answer the following questions.

**Question 1 (Case 1)**
Which additional investigations, if any, would you do at this time?

Select as many as are appropriate or select #24. No investigations, if none is indicated. (N.B. There are 24 options.)

1. ☐ Alanine aminotransferase (SGPT)
2. ☐ Albumin
3. ☐ Alkaline phosphatase
4. ☐ Aspartate aminotransferase (SGOT)
5. ☐ Complete blood count
6. ☐ Coronary angiogram
7. ☐ Electrocardiogram
8. ☐ Electrolytes
9. ☐ Exercise stress test (treadmill)
10. ☐ Fasting blood sugar
11. ☐ Fasting serum amylase
12. ☐ Fasting serum cholesterol
13. ☐ Glucose tolerance test
14. ☐ Thallium scan
15. ☐ Thyroid-stimulating hormone
16. ☐ Thyroxine (T4)
17. ☐ Total protein
18. ☐ Triglycerides
19. ☐ Triiodothyronine (T3) uptake
20. ☐ Ultrasound gall bladder
21. ☐ Urinalysis (urine microscopy)
22. ☐ 24-hour Holter monitoring
23. ☐ 24-hour urine for total protein
24. ☐ No investigations
Question 2 (Case 1)

Considering the information provided to you in the stem above, what would you recommend to this patient?

*List up to three.*

<p>| | |</p>
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Item Writing Manual

Download the Item Writing Manual in Portable Document Format (PDF)

You can download the manual in its entirety by clicking on the first selection below or you can download it section by section by clicking on the index and the individual sections as shown below. The sections are also available in Spanish and Russian translations (see below).

English:

- Entire Item Writing Guide
- Item Writing Guide Index
- Section I
- Section II
- Section III
- Section IV
- Appendix

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Answers to Questions on Slides

Slide 5: option A is not plausible; option D should be used with caution; option C is longer and more detailed = the likely correct answer

Slide 6: the stem contains unnecessary information (80% etc); while option D may be correct, the options are all “random facts”

Slide 24: the stem asks two questions, both having the same answer

Slide 25: options A and B are mutually exclusive and students will guess between them

Slide 26: option A is longer and more detailed = the likely correct answer

Slide 27: disconnect between stem and options A and C