

## LEARNING FROM STRUCTURALLY DEFECTIVE PHYSIOLOGY MCQS

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**ABSTRACT** On review of approximately 500 physiology MCQs obtained from the internet, about 10% were found to be structurally invalid. Such high percentage of invalid MCQs casts doubt on the reliability of an examination. The structural defects were more common in the stem, although the alternative options were also often defective. By analyzing 50 defective MCQs, this paper highlights the common pitfalls in the construction of valid MCQs.

**Key Words:** MCQs. Structural defects. Validity.

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### Introduction

A multiple choice question consists of a problem, known as the stem, and a list of suggested solutions, known as alternatives. The alternatives consist of one correct or best alternative, which is the answer, and 3-4 incorrect alternatives. The function of the incorrect alternatives is to serve as distractors, which would be selected by students who did not achieve the learning outcome.

MCQs are being used to test the eligibility of medical graduates for admission to postgraduate courses in India. All subjects of MBBS course are tested in about 200 MCQs. Because of high stakes for the examinees, it is imperative that the validity of MCQs is assured. Defective MCQs in postgraduate entrance tests is a matter of great concern. Although guidelines for construction of MCQs are widely known<sup>1,2,3</sup>, it is very difficult to frame structurally sound and valid questions. This paper highlights various structural defects possible in MCQs. By highlighting those defects, the author wishes to create awareness of various pitfalls in framing valid MCQs.

### Material and Methods

The author reviewed 500 Physiology MCQs taken from the internet. The MCQs were evaluated on the basis of the rules that are widely accepted for framing valid MCQs.<sup>1,2,3</sup> Out of about 500 questions, 50 invalid MCQs were selected for comments on the various flaws that occur in the construction of MCQs.

### Rules for construction of valid MCQs

- # 1. Make the Stem a Question or Partial Sentence. The stem should be meaningful by itself and should present a definite problem.
- # 2. The stem should not contain irrelevant material, which can decrease the reliability and the validity of the test scores.
- # 3. The stem should be negatively stated only when significant learning outcomes requires it. The negative element should be emphasized with italics or capitalization.
- # 4. All alternatives should be plausible.
- # 5. Alternatives should be stated clearly and concisely. Lengthy items should be avoided.
- # 6. Alternatives should be mutually exclusive, not overlapping.
- # 7. Alternatives should be homogenous in content.
- # 8. Alternatives should be free from clues about which response is correct, such as differences in grammar, length, formatting, and language choice in the alternatives.
- # 9. The alternatives "all of the above" and "none of the above" should not be used.
- # 10. The alternatives should be presented in a logical order (e.g., alphabetical or numerical) e.g. (a) Active transport, (b) Exocytosis, (c) Facilitated diffusion, (d) Phagocytosis. Or in case of numbers: (a) 40, (b) 400, (c) 4000, (d) 40,000.
- # 11. The stem should be grammatically consistent with the alternatives.
- # 12. Abbreviations or acronyms should not be used.

**Observations/ Discussion**

The various types of defects that were detected are discussed below:

1. When V/Q is infinity, means:

- a). Partial pressure of O<sub>2</sub> becomes 0
- b). No exchange of O<sub>2</sub> and CO<sub>2</sub>
- c). Partial pressure of CO<sub>2</sub> becomes 0
- d). Partial pressure of both CO<sub>2</sub> and O<sub>2</sub> becomes 0.

**Comment:** Rules 1 and 7 violated. The stem is meaningless. There are three options with partial pressure, but where: It could be in alveolar air, pulmonary arterial blood or pulmonary venous blood. Moreover, option (b) is meaningless: No exchange of gases, where?

2. Plasma osmolality is :

- a). 85-95 mOsm/l
- b). 185-195 mOsm/l
- c). 285-295 mOsm/l
- d). 385-395 mOsm/l

**Comment:** Rule # 1 violated. The stem is vague. The stem should have been written as : *Normal* plasma osmolality is:

3. Which of the following is a membrane protein?

- a). GPI
- b). Sec A protein
- c). TRAP
- d). None of the above

**Comment:** Rules # 9 and # 12 violated. In option (d) "None of above" should be avoided. Abbreviations have been used.

4. Not a cell adhesion molecule:

- a). Integrin
- b). Selectin
- c). Catherin
- d). Spectrin

**Comment:** Rule # 1 violated. The stem could have been written as "One of the following is not a cell adhesion molecule:

5. Intracellular concentration of K<sup>+</sup> ion is 10mM and extracellular concentration is 100 mM. Calculate the equilibrium potential of K<sup>+</sup> based on Nernst equation:

- a). +10 mV
- b). + 61 mV
- c). -10 mV
- d). -61 mV

**Comment:** Rules # 10 violated. The alternatives could be written as (a)-61, (b) -10, (c) +10, (d) +60. Moreover concentrations of K<sup>+</sup> in ICF and ECF are reverse of values found in mammalian tissues. Just playing tricks with the examinees.

6. Magnitude of action potential is determined by:

- a). Na<sup>+</sup>
- b). Mg<sup>++</sup>
- c). K<sup>+</sup>
- d). Ca<sup>++</sup>

**Comment:** Rule # 1 violated. All these ions are present in intracellular as well as extracellular fluid. Stem could have been written as "Magnitude of action potential is determined by extracellular concentration of :"

7. Neurapraxia is a type of:

- a). Physiological conduction block
- b). Axonal disruption
- c). Endoneurial disruption
- d). Nerve trunk disruption

**Comment:** Rules # 7 and 10 violated. Options a, b, c, d could have been written in alphabetic order, e. g, (a) Axonal disruption, (b) Endoneurial disruption, (c) Nerve trunk disruption, (d) Physiological conduction block. Moreover, the alternatives are not homogeneous. Three options have disruption, fourth does not.

8. Depolarization of human ventricular muscle starts from:

- a). Posterobasal part of ventricle
- b). Left side of interventricular septum
- c). Uppermost part of interventricular septum.
- d). Basal part of ventricle.

**Comment:** Rule # 6 violated. Both options (b) and (c) are correct. After all, upper part of septum also has left and right sides.

9. True statement about instantaneous means vector

- a). Equal and same as QRS vector
- b). It is drawn through the center of vector in a direction from base towards apex.
- c). Summated vector of generator potential at particular instant caused by inflowing septal depolarization.
- d). When a vector is exactly horizontal directed towards the patient's left side, the

vector is said to extend in the direction of 0 degree.

**Comment:** Rules # 1 and 6 violated. There cannot be an instantaneous, as well as mean, vector. The stem could have been "One of the following statements is true about mean vector. Too long and convoluted alternatives.

10. Ventricular contraction lasts from:

- a). Beginning of Q wave to end of S wave.
- b). Beginning of Q wave to end of S wave.
- c). Beginning of P wave to end of T wave.
- d). Beginning of R wave to end of T wave, if Q wave is absent.
- e). Beginning of P wave to end of S wave.

**Comment:** Rule # 5 violated. By using the word "beginning of" in the stem, its repetition in every alternative can be avoided.

11. Clamping of the carotid arteries above the carotid sinus results in:

- a). Increase in blood pressure and increase in heart rate.
- b). Increase in blood pressure and decrease in heart rate.
- c). Decrease in blood pressure and increase in heart rate.
- d). Decrease in blood pressure and decrease in heart rate.

**Comment:** Rule # 6 violated. Alternatives are confusing.

12. True regarding myocardial O<sub>2</sub> demand:

- a). Inversely related to heart rate.
- b). Has constant relation to external cardiac work.
- c). Directly proportionate to duration of systole.
- d). Is negligible at rest.

**Comment:** Rules # 1 and # 10 violated. The stem could have been written as: Myocardial O<sub>2</sub> demand is----. Alternatives are not homogeneous.

13. Increased airway resistance is/are caused by:

- a). Forced expiration.
- b). Denser air.
- c). Low lung volume.
- d). High lung volume.

**Comment:** Rule # 1 and 10 violated. In the stem, "resistance is" is more appropriate than "resistance is/are". The alternative could have been written in alphabetic order: (a) dense

air, (b) forced expiration, (c) high lung volume, (d). low lung volume.

14. Intrapleural pressure is negative because:

- a). Chest wall and lungs recoil in opposite direction to each other.
- b). Transpulmonary pressure is negative.
- c). Intrapulmonary pressure is negative.
- d). Pulmonary collapse is prevented by surfactant.

**Comment.** Rule # 11 violated. The stem does not grammatically gel with option (d).

15. A 32-year old high-altitude mountaineer is observed to have a hematocrit value of 70%. Which of the following represents the most likely cause/explanation?

- a). Polycythemia with increased red cell count.
- b). Relative polycythemia due to dehydration.
- c). Polycythemia due to hemoconcentration.
- d). Polycythemia with high altitude pulmonary edema.

**Comment:** Rule # 6 violated. Alternatives (b) and (c) have similar meaning.

16. Stimulation by touching or pulling on which of the following structures is likely to cause a painful sensation?

- a). Postcentral gyrus.
- b). The dura over postcentral gyrus.
- c). Branches of the middle meningeal artery that lie superficial to the dura over the postcentral gyrus.
- d). Branches of middle cerebral artery that supply the postcentral gyrus.
- e). Temporal cortex.

**Comment:** Rule # 1 violated. Stem and options are illogical and far-fetched. Pulling or touching a tissue cannot produce same response. How can one pull postcentral gyrus or temporal cortex?

17. Receptor of joint capsule and ligaments is:

- a). Slow adapting.
- b). Fast adapting
- c). Different to slow and fast adapting.
- d). Non-adapting

**Comment:** Rule # 4 violated. Option c is illogical

18. Regarding the Golgi tendon, true is:

- a). Senses dynamic length of muscle.
- b). Involved in reciprocal innervation.

- c). Alpha-motor neuron stimulation.
- d). Senses muscle tension.

**Comment:** Rules # 1, # 7 and # 11 violated. The stem is written in grammatically defective language. The stem could be: Which of the following statements about Golgi tendon organ is true? The stem and the alternative (c) do not gel together. Alternatives do not have homogeneous content.

19. True about nuclear bag fiber:

- a). Sense dynamic length of muscle.
- b). Involved in reciprocal innervation.
- c). Alpha motor neuron stimulation.
- d). Senses muscle tension

**Comment:** Rule #1 and 7 violated. The stem is written in grammatically defective language. The stem could be written as: Which of the following statements about nuclear bag fiber is true? Alternatives do not have homogeneous content.

20. True about visceral pain:

- a). It is poorly localized.
- b). Resembles 'fast pain' produced by noxious stimulation of the skin.
- c). Mediated by B fibers in the dorsal root of the spinal nerve.
- d). Causes relaxation of nearby skeletal muscles.
- e). Shows relatively rapid adaptation.

**Comment:** Rules #1 and 5 violated. The stem is written in grammatically defective language. The stem could be written as: Which of the following statements about visceral pain is true? Moreover, *receptors may* show rapid or slow adaptation, not pain.

21. Which is not a medial pathway for maintenance of posture:

- a). Reticulospinal tract.
- b). Rubrospinal tract.
- c). Tectospinal tract.
- d). Vestibulospinal tract.

**Comment:** Rule # 1, 2 and 3 violated. There is no need of 'is not' in the stem. Stem could have been written as : Which of the following tracts is located in lateral white column of spinal cord? Mention of posture in the stem is superfluous.

22. Function of vestibulospinal tract:

- a). Facilitates flexors.
- b). Facilitates extensors.
- c). Inhibits flexors.

d). Inhibits extensors.

**Comment:** Rule # 1 violated. Stem could have been written as: Vestibulospinal tract---. a,b,c,d. Options are not proper. Due to reciprocal innervation, any tract which facilitates extension also inhibits flexors of a joint.<sup>4</sup>

23. Without external cue, the sleep –wakeful cycle in humans:

- a). Unchanged.
- b). Continues with cycle length of > 24 hours
- c). Continues with cycle length of < 24 hours.
- d). Continues with cycle length of > 12 hours

**Comment:** Rule # 1 and 11 violated. The stem does not grammatically gel with option (a). The phrase "Continues with cycle length" is repeated in three options.

24. Left lobe of the brain is mainly responsible for:

- a). Spatial recognition.
- b). Written and spoken language.
- c). Agnosia.
- d). Muscle proprioception.

**Comment:** Rule # 7 violated. The alternatives are not homogeneous. Agnosia is a speech defect. It cannot be function of any lobe of the brain. Sensory area of the left lobe is responsible for *conscious proprioception* of right side of the body.

25. Which of the following statements about renal function is not true?

- a). Oncotic pressure of filtrate is equal to glomerular capillaries.
- b). If afferent arteriole is vasoconstricted, then pressure in the glomerular capillaries will fall.
- c). The hydrostatic pressure of peritubular capillaries determine the glomerulotubular balance.

d). Ureteric obstruction increases the hydrostatic pressure of Bowman's space and reduces GFR

**Comment:** Rules # 3 and 5 violated. Use of 'not' in the stem could be avoided. The stem could be written as : All of the following statements about renal function are true, *except. The options are very long and grammatically defective. There is no single*

best answer. Option (a) as well as (c) are false. An increase in GFR causes an increase in the reabsorption of solutes, and consequently of water, primarily in the proximal tubule. This process is called glomerulotubular balance.<sup>6</sup>

26. Which of the following is not a function of gut flora?

- a). Fermentation of mucus.
- b). Production of vitamin K.
- c). Decreased proliferation of epithelial cells.
- d). Synthesis of short chain fatty acids.

**Comment:** Rules # 1 and 3 violated. The stem could have been written as: All of the following are functions of gut flora, *except*. Moreover, there is no agent which can decrease proliferation of epithelial cells in the gut. Give away MCQ.

27. What should be the value of BMI to be considered as "Lethal" in men?

- a) 12
- b) 18
- c) 13
- d) 14

**Comment:** In discussion on BMI, standard textbooks of physiology<sup>4,5</sup> do not mention "lethal BMI." BMI is discussed in reference to obesity only.

28. Steroid receptors present at:

- a). Cell membrane.
- b). Cytoplasm.
- c). Nucleus.
- d). All of above.

**Comment:** Rule # 9 violated. Once the examinee knows option (b) and (c) are correct, he/she would select option (d) as an answer.

29. True about second messenger:

- a). Bind first messenger,
- b). Integral protein.
- c). Hormone secreted by other hormone.
- d). Substances that increase or decrease function.
- e). Intracellular receptor

**Comment.** Rules # 1 and 4 violated. Option (c) is meaningless

30. Mineralocorticoid receptors are present in all of the following sites, except:

- a). Hippocampus

- b). Kidney
- c). Colon
- d). Liver

**Comment:** This MCQ is totally unfair to the examinees. Which medical graduate or a physiologist is expected to know that mineralocorticoid receptors are present in hippocampus?

31. In surgical stress all hormones are increased except:

- a). Adrenalin
- b). ACTH
- c). Epinephrine
- d). Cortisol
- e). Insulin

**Comment:** Rule # 6 violated. Options (a) and (c) are same hormone.

32. Baroreceptor reflex is which type of feedback system?

- a). Positive feedback
- b). Negative feedback
- c). Feedforward
- d). Both positive feedback and negative feedback.

**Comment:** Rules # 1 and 4 violated. The stem could be written as: Which type of system is baroreceptor reflex? Option (d) is illogical.

33. During exercise in physiological limits, what is the effect on end-systolic volume?

- a). ESV decreases
- b). ESV increases
- c). ESV remains unchanged
- d). ESV first decreases and then increases.

**Comment:** Rules # 2 and 6 violated. Exercise is classified as mild, severe and strenuous, not within or outside physiological limits. Option (d) overlaps options (a) and (b). Word ESV is repeated in every option. It could have been brought in the stem.

34. Hormones which is/ are under inhibitory control of hypothalamus:

- a). Prolactin
- b). Prolactin only
- c). Both GH and prolactin
- d). GH

**Comment:** Violates rule # 6. Options (a) and (b) as well as (c) and (d) are overlapping. Normally, only prolactin is under constant inhibitory control of hypothalamus. During pregnancy and lactation inhibitory control is abolished.

35. How electrical synapse is different from chemical synapse?

- a). No cytoplasmic continuity between presynaptic and post synaptic neuron
- b). Direction of impulse is unidirectional.
- c). Connexions are involved in electrical synapses.
- d). Electrical synapses have more latent period than chemical synapses.

**Comment:** Violates rule # 1. From the language of the stem, it is not clear whether options (a), (b) and (c) refer to electrical or chemical synapse.

36. Which of the following clotting factor in a patient on Warfarin therapy, would have decreased gamma carboxyglutamate residue?

- a) Factor 2
- b) Factor 11
- c) Tissue factor
- d) Factor 5

**Comment:** Rule # 2 violated. Clotting factors are described in Roman numerals, (I, II, III etc.); not Arabic numerals (1, 2, 3 etc.). Gamma carboxyglutamate residue is a component of clotting factor II, but this fact is mentioned in research papers,<sup>6</sup> not in textbooks of physiology. An unfair question for the examinees.

37. Hepcidin inhibits?

- a) Absorption of cobalamin
- b) Transfer of iron into enterocytes
- c) Folic acid synthesis
- d) Respiratory oxidase

**Comment:** Rule 4 violated. None of the option is true. In the small intestine, luminal iron is transferred into the enterocytes by DMT-1 (non-heme iron) or HCP-1 (heme iron). On the basolateral side of the enterocyte, iron is exported to the blood using an iron export channel called ferroportin. Hepcidin inhibits iron export by binding to ferroportin, leading to its degradation.<sup>7</sup>

38. C-peptide seen in?

- a) In Pre-proinsulin
- b) In Proinsulin
- c) As a combined entity with insulin after secretion
- d) A gastrointestinal proactive molecule

**Comment:** Rules # 1 and 7 violated. The stem is not properly worded. The alternatives are not homogeneous.

39. After ovulation, corpus luteum releases which of the following hormones?

- a). Progesterone
- b). Estrogen
- c). LH
- d). Inhibin

**Comment:** Rule # 2 violated. "After ovulation" in the stem is redundant. Corpus luteum is formed in the ovary only after ovulation. Moreover, both options (a) and (b) are correct. Corpus luteum secretes both estrogens and progesterone.<sup>4</sup>

40. In forceful expiration, which of the following neurons gets fired?

- a) VRG
- b) DRG
- c) Pneumotaxic centre
- d) Chemoreceptors

**Comment:** Rules #1 and 12 violated. Neurons fire impulses, not "gets fired." In the alternatives, two are as abbreviations and the other two are full names.

41. Golgi tendon organ is stimulated:

- a) Tension in the muscle
- b) Length of the muscle
- c) Velocity of the muscle
- d) Muscle position

**Comment:** Rules # 1 and 11 violated. The options do not grammatically gel with the stem. For example, the stem read in continuation with option (a): "Golgi tendon organ is stimulated tension in the muscle" is meaningless.

42. C wave in JVP means

- a) Iso-volumetric contraction
- b) Slow filling at end of diastole
- c) End of systole
- d) Start of diastole

**Comment.** Rules # 1 violated. C wave does not mean any of the options. The stem could be written as: The c-wave in JVP represents (or coincides with).

43. Polyuria is -

- a) 70ml/kg
- b) 60ml/kg
- c) 50ml/kg
- d) 40ml/kg

**Comment.** Rules # 1 and 5 violated. Stem could have been written as: Polyuria is defined as---. The alternatives are meaningless. The duration for which urine is



collected has to be mentioned. Urinary excretion per kg body weight has not been describe in any standard textbook of physiology. The urinary volume is not dependent on body weight in adults. It varies with the amount of water ingested and the amount lost in sweat. Urinary volume greater than 2500-3000 ml/day is considered as polyuria .

44. Components responsible for countercurrent mechanism in kidney are allecept:

- a) Sodium outflow in thick ascending limb
- b) Water outflow in thin descending limb
- c) Sodium outflow in thin ascending limb
- d) Flow of tubular fluid from PCT to DCT

**Comment:** Rule # 1 violated. Stem is vague. There are two types of counter current mechanisms in the kidney: (i) Counter current multiplier system operating at thick ascending limb of loop of Henle, (ii) counter current exchanger system operating in vasa recta. Option (d) is problematic. The outflow of water or sodium (options a, b, and c) occurs as the tubular fluid flows from PCT to DCT.

45. Oxygen hemoglobin dissociation curve is shifted to the left by:

- a). Increased PCO<sub>2</sub>
- b). Increased 2,3 DPG
- c). Increased temperature
- d). Fetal hemoglobin.

**Comment:** Rule # 7 violated. Options are not homogenous.

46. How much % of glucose absorption occurs in the late PCT (PST 3)''

- a). 2
- b).5
- c) 7
- d). 10

**Comment:** MCQs cannot be framed on the basis of some information obtained from the internet. In the standard textbooks of physiology, PCT is given as a site of reabsorption of glucose; not percentages absorbed in different segments of PCT. MCQs should be framed to test an important learning outcome. Moreover, knowledge of percentage of glucose absorption in proximal straight tubule ( PST) has no application in medical practice.

47.False about funny channel in heart

- a). It is an Na-K channel
- b), It is responsible for spontaneous rhythm producing tissue of the heart.
- c),They are voltage dependent channels only.
- d).They are responsible for diastolic depolarization.

**Comment:** Rules # 7 and 8 violated. MCQs should be framed about the information available in standard textbook, not based on information picked up from the internet. The term "funny channel" is found neither in Guyton and Halls Physiology<sup>7</sup> nor in Ganong's Review of physiology<sup>4</sup>. The stem could have been written as: One of the following statements about the funny channel is false. Moreover, there is a problem with the options. Two options start with "It" and the other two start with "They." The options are not homogeneous..

48. Which of the following is false in decerebrate rigidity?

- a). Upper limb flexed, lower limb extended.
- b).Both upper and lower limbs are extended.
- c). Lesion between superior and inferior colliculi produces this rigidity.
- d). Cutting dorsal roots abolishes the rigidity,

**Comment:** Rule # 7 violated. First two options are position of limbs, the other two refer to experimental procedures.

49. Feedforward control system is employed during regulation of:

- a). Blood volume
- b), pH
- c). Temperature
- d). Blood pressure.

**Comment:** The question is invalid. Blood volume, pH, body temperature and blood pressure are all regulated by negative feedback control systems<sup>8,9</sup>

50. Blood urine filtration barrier permits:

- a). 4,000 KD
- b).400 KD
- c), 40,000 KD
- d). 40 KD

**Comment:** Rules # 1 and 10 violated. Unlike blood-brain barrier and blood-CSF barrier, there is no term "Blood urine filtration barrier. More over, in the options, the molecular weights should be written an chronological order : lowest to highest or highest to lowest. Stem could have been

written as: Glomerular filtration barrier permits passage of substances with molecular weight (in kDa): (a). 40(b). 400(c). 4000(d). 40,000

### Conclusion

Out of 500 physiology MCQs taken from the internet, 50 were found to be structurally defective. Defective stem was the commonest problem. The construction of options was also often defective. Such high percentage of defective MCQs, if used in examinations, would cast doubt on the reliability of an examination. The Medical Education unit, in each medical college, should hold workshops at regular intervals to train the faculty in construction of valid MCQs for greater reliability of examinations based on such questions.

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