Pocket Examiner in Physiology

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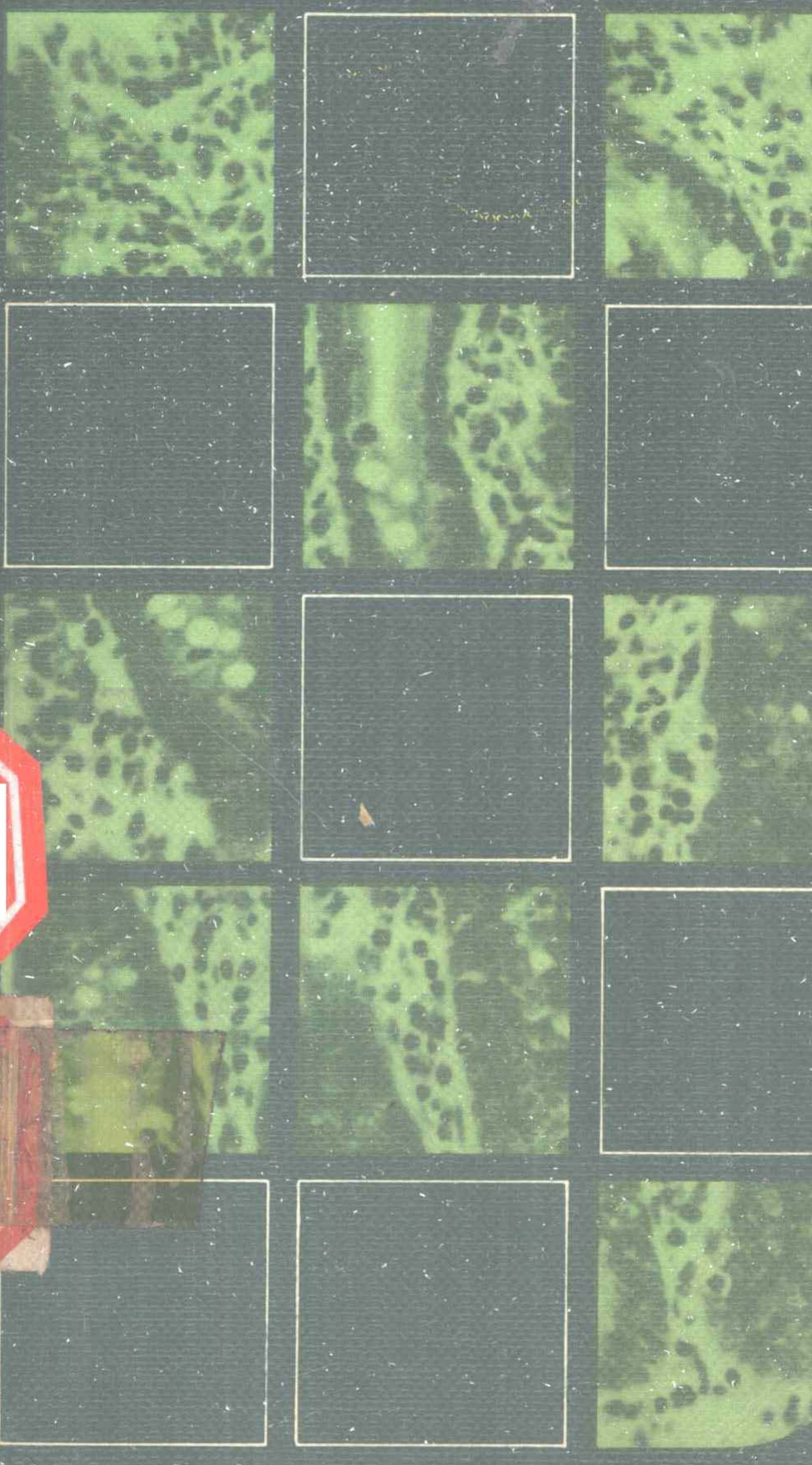

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Mary L Forsling BSc, PhD

Senior Lecturer, Department of Physiology, The Middlesex Hospital Medical School, University of London.

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Preface

An aim of any course in medical sciences is to give the students the basic tools for medical practice, not, as it may sometimes appear to them, to train them to pass examinations. These are, however, hurdles which must be overcome and it is an unwise student who does not prepare himself well. Students generally have very little practice in *viva voce* examinations and in many ways preparation for this form of examination is the most difficult. While purists may object to the aims of this book, nevertheless, it is hoped that it will aid in revising the subject of physiology and be especially useful for oral examinations.

The questions have been selected to represent topics frequently covered in physiology examinations and are in no way intended to represent a syllabus for a physiology course. Emphasis has therefore been placed on the integrated aspects of the subject. A large number of the questions inevitably require factual answers, but many are included to test comprehension. The amount of information required in the answer varies greatly from question to question, but in most instances relatively brief answers have been given. For more detail, the student should consult one or more of the ten standard texts cited or any book recommended for study. These particular textbooks have been selected because they are widely used in medical schools. Physiology is a rapidly developing subject and certain topics are the subject of some controversy, so different textbooks may present different arguments. Areas of dispute have been indicated in the text and the consensus opinion given.

Inevitably some of the answers given are oversimplified; it is not the remit of this book to review all the experimental evidence. For this the student should consult a fuller text and, indeed, is encouraged to do so. Physiology is an experimental subject with changing concepts and it is important that students learn to evaluate the evidence so that they not only comprehend current concepts, but will be able to evaluate those developed 20–30 years hence.

In the course of a *viva*, a student may be asked to clarify a point by drawing a diagram. Some questions therefore ask for this. Diagrams are not included in the text but may be studied in the references cited.

MLF

Some physiological variables and their approximate values in SI units

Parameter	*CGS system*	*SI units*
Alveolar air:		
PO_2	14%, 100 mmHg	13 kPa
PCO_2	6%, 40 mmHg	5 kPa
Arterial blood:		
PO_2	95–100 mmHg	13 kPa
PCO_2	40 mmHg	5 kPa
Haemoglobin	14.5 g·100 ml^{-1}	2.2 mmol·l^{-1}
Blood oxygen capacity	20 ml·100 ml^{-1}	8.8 mmol·l^{-1}
Arterial blood:		
O_2	19 ml·100 ml^{-1}	8.5 mmol·l^{-1}
CO_2	48 ml·100 ml^{-1}	22 mmol·l^{-1}
Venous blood:		
O_2	14 ml·100 ml^{-1}	6.0 mmol·l^{-1}
CO_2	52 ml·100 ml^{-1}	24 mmol·l^{-1}
Red cell count	5×10^6·mm^{-3}	5×10^{12}·l^{-1}
White cell count	4000–11 000·mm^{-3}	4–11 $\times 10^9$·l^{-1}
Packed cell volume	45	45
Blood:		
glucose	60–100 mg·100 ml^{-1}	3.5–5.5 mmol·l^{-1}
urea	30 mg·100 ml^{-1}	5.0 mmol·l^{-1}
pH	7.4	7.4
Plasma:		
Na^+	145 mEq·l^{-1}	145 mmol·l^{-1}
Cl^-	105 mEq·l^{-1}	105 mmol·l^{-1}
K^+	5 mEq·l^{-1}	5.0 mmol·l^{-1}
Ca total	10 mg·100 ml^{-1}	2.5 mmol·l^{-1}
Ca^{2+}	2.5 mEq·l^{-1}	1.25 mmol·l^{-1}
proteins	6–8 g·100 ml^{-1}	60–80 g·l^{-1}
Intracellular fluid:		
K^+	150 mEq·l^{-1}	150 mmol·l^{-1}
Mg^{2+}	30 mEq·l^{-1}	15 mmol·l^{-1}
Osmotic pressure of plasma proteins	25 mmHg	4.3–1.6 kPa
Arterial blood pressure	120/80 mmHg	16/11 kPa
Pulmonary artery pressure	25/8 mmHg	3.3/1 kPa
Capillary blood pressure	32 → 12 mmHg	4.3 → 1.6 kPa
Duration of systole	0.3 s	0.3 s
Duration of diastole	0.5 s	0.5 s
Cardiac output	5.0 l·min^{-1}	5.0 l·min^{-1}

Volume of:		
plasma	3.0 l	3.0 l
tissue fluid	12.0 l	12.0 l
intracellular fluid	30.0 l	30.0 l
Glomerular filtration rate	120 $ml \cdot min^{-1}$	0.12 $l \cdot min^{-1}$
Urine flow rate	1500 $ml \cdot day^{-1}$	1.5 $l \cdot day^{-1}$
Respiratory tidal volume	400 ml	0.4 l
Respiratory dead space	150 ml	0.15 l
Metabolism of:		
1 g carbohydrate	4.1 kcal	17.0 kJ
1 g fat	9.3 kcal	38.0 kJ
1 g protein	4.1 kcal	17.0 kJ
Basic metabolic rate:		
females	37 $kcal \cdot m^{-2} \cdot h^{-1}$	150 $kJ \cdot m^{-2} \cdot h^{-1}$
males	40 $kcal \cdot m^{-2} \cdot h^{-1}$	170 $kJ \cdot m^{-2} \cdot h^{-1}$

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Key to references and further reading

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2
Questions

GENERAL PHYSIOLOGY AND BODY FLUIDS

General principles

1 Cells of the human body have some functions in common and some different. Indicate these functions.

2 Explain why diseased cells swell whereas healthy ones do not.

3 State the approximate concentrations of ions inside and outside the cell.

4 Describe the Davson–Danielli model of a membrane.

5 Give the chemical and electrical forces which affect the movement of substances across cell membranes.

6 Give the criteria for facilitated diffusion.

7 Why is active transport an energy-consuming mechanism whereas passive and facilitated diffusion are not?

8 Say why the Donnan effect is important for the distribution of ions across a semi-permeable membrane.

9 Evaluate the importance of Claude Bernard's concept of 'la fixité du milieu intérieur'.

10 What is the difference between negative and positive feedback, and why is the latter uncommon in physiology?

11 Given the context of a system of controls

maintaining a steady internal environment, why do some physiological measures lie within a narrow and others within a wide range?

12 State the Fick principle and its significance.

13 Name two organs through which blood flow can be determined in man, and indicate the markers employed.

14 In what situation other than those listed in answers 12 and 13 may the Fick principle be used?

15 If the oxygen uptake is 225 $ml \cdot min^{-1}$, the oxygen content of arterial blood 190 $ml \cdot l^{-1}$ and the venous content 140 $ml \cdot l^{-1}$, what would be the cardiac output?

16 How would the values cited in answer 15 be obtained?

17 Question 16 is concerned with the direct Fick method. What is the principle underlying the indirect Fick method?

18 What other methods are available for determining cardiac output?

Blood

19 Give the approximate value for plasma volume and say how it may be determined.

20 State the concentrations of the main plasma proteins and how they may be separated from plasma.

21 List the chief functions of plasma proteins.

22 Give a reason why oedema may occur in starvation.

23 Describe the formation of lymph and give its functions.

24 Outline the circulation of lymph.

25 In what range does the white cell count normally fall, and how do the various cell types contribute to this number?

26 Bearing in mind the functions of the white cells, in what circumstances and in which direction would you expect to see a change in white cell count?

27 How do the red cell count and the life span of red cells compare with those of white cells?

28 Since red cells have a deep colour and are present in such greater numbers than white cells, how is it possible to carry out a white cell count?

29 What red cell indices may be used clinically?

30 How would red cell indices change with dietary deficiency of iron and chronic blood loss?

31 On examination of a blood sample from a patient, she was found to have a haemoglobin content of 115 $g \cdot l^{-1}$, a red cell count of 3.2×10^{-12} and a mean red cell diameter of 0.2 μm. Are these indices normal and, if not, what would produce such a picture?

32 Outline the life cycle of a red cell.

33 Give details as to the fate of the haem moiety of haemoglobin.

34 In what circumstances is the formation of red cells enhanced and what is the mediator?

35 On what evidence can we say that the red cell has a life of 120 days?

36 Cite the major deficiency in pernicious anaemia and the conditions in which it may occur.

37 For a blood transfusion service, what are the main physiological principles to bear in mind?

38 Name the principal blood group system and explain how the various blood groups are classified.

39 As with many other things in life, why is it that some people are universal donors and others universal recipients?

40 That Rhesus incompatibility leads to haemolytic disease of the newborn is well known. Can ABO incompatibility also occur?

41 In what way is the complement system similar to the blood clotting system?

42 It sometimes happens that a researcher acquires an allergy to the species of animal they study. Explain the underlying mechanisms.

43 Blood groups may be used to determine who is the father of a disputed child. If the mother was O Rh^- and the child A Rh^-, could the father be A Rh^+ or O Rh^+?

44 Bleeding from an artery is far more dangerous than from a vein. Why is this?

45 List the main ways in which bleeding from a small blood vessel may be controlled physiologically.

46 What are the two basic steps in the formation of a fibrin clot?

47 How is prothrombin converted to thrombin?

48 Clarify the use of the terms 'intrinsic' and 'extrinsic' with regard to blood clotting.

49 List the factors associated with blood clotting, indicating which contribute to the intrinsic and which to the extrinsic path.

50 Is it possible for a haemophiliac to suffer from coronary thrombosis?

51 From a knowledge of the clotting mechanisms, list some anticoagulants which could be used to obtain blood for determination of the constituents of plasma. Could these techniques be used *in vivo*?

52 Describe the process of clot dissolution and say why it is important *in vivo*.

Membrane properties of nerve and muscle

53 In what ways may an action potential be measured?

54 Draw a diagram of an action potential in nerve with suitably labelled voltage and time axes.

55 Explain the features of the action potential in terms of the changes in membrane permeability.

56 What happens to action potentials if the sodium–potassium pump is inhibited?

57 In what respect does nervous tissue obey the 'all-or-none' law?

58 Define the terms 'absolute refractory period' and 'relative refractory period'.

59 You wake up in the morning and find an arm has gone 'numb' in the night. What would account for the tingling sensation you subsequently experience?

60 What is the effect on membrane excitability of hypoxia, of introducing local anaesthetics and of reducing the external Ca^{2+}?

61 Is the velocity of the action potential the same in all types of nerve? If not, how does it vary?

62 A compound action potential has a different form if recorded near to the point of stimulation as opposed to a distance from it. Explain why.

63 List the typical conduction velocities for (*a*) group I muscle afferents, (*b*) group III or Aγ cutaneous afferents, (*c*) for group IV or C fibres.

Synaptic transmission

64 Draw a labelled diagram of a synapse.

65 Outline the sequence of events in synaptic transmission and indicate how this transmission may be blocked.

66 List at least six putative neurotransmitters acting centrally or peripherally.

67 List the three features characteristic of synaptic transmission and explain them in terms of the underlying mechanisms.

68 What is the difference between the electrical sign of an inhibitory and an excitatory postsynaptic potential (IPSP and EPSP), and how does it arise?

69 Using the concept of IPSPs and EPSPs explain how 'decisions' are made at synapses.

70 An IPSP produces *direct* inhibition; what other types of inhibition exist?

71 Define convergence, divergence and subliminal fringe.

72 Outline the structure of a muscle end-plate in striated muscle.

73 Describe the effect of acetylcholine on ion permeability at the end-plate region.

74 What is the role of acetylcholinesterase?

75 Explain why drugs such as suxamethonium (succinylcholine) are used during general anaesthesia.

76 Give the effects of curare at the neuromuscular junction.

77 Summarise the changes which section of the nerve produces at the neuromuscular junction.

78 Name a disorder of neuromuscular transmission and indicate the cause.

Muscle contractility

79 Contrast the action potential of skeletal muscle, ventricular muscle and cardiac pacemaker tissue.

80 How does the action potential in smooth muscle compare with that in other muscles?

81 Compare the propagation of impulses in skeletal muscle, heart muscle and smooth muscle.

82 Describe the levels of fibrillar organisation of skeletal muscle and indicate how smooth muscle and cardiac muscle differ.

83 Draw a diagram of part of a skeletal muscle fibril.

84 Explain in terms of the structure how changes in muscle length occur.

85 How can ATP be resynthesised in the muscle?

86 Indicate the significance of triads—i.e. the transverse tubules and neighbouring cisternae of the cytoplasmic reticulum—in terms of Ca^{2+} uptake and release.

87 In simple terms, what is the effect of Ca^{2+} upon actomyosin?

88 Define isometric and isotonic contraction.

89 Explain how a twitch and a tetanus are produced.

90 State the approximate 'time to peak' for the 'twitch contraction' in a fast twitch muscle and a slow twitch muscle.

91 Give the type of curve for a plot of current strength against duration required to depolarise a nerve or muscle membrane to threshold.

92 What is the underlying cause of muscle fatigue?

93 Describe the length tension relationships for resting and contracting muscle during isometric contractions.

94 In terms of the sliding filament, explain why tension is low with very long and very short muscle lengths.

95 How does the force exerted and the work done by a muscle during contraction vary with the speed of contraction?

96 What characteristics do series and parallel elastic components lend to muscle contraction?

97 How does the motor unit allow gradation of muscle contraction *in vivo*?

98 Name the main transmitters affecting smooth muscle and describe their effects.