1.8 Gas exchange surfaces and membrane structure

Name: _____ Class: _____ Date: _____ **Total: 22 marks**

KEY WORDS surface area • diffusion distance • concentration gradient • bilayer • intrinsic protein • fluid mosaic

Objective

Practise Topic 2 statements 2.1–2.3 with Core Practical 3: gas-exchange surface properties, the fluid mosaic membrane, and the model history the examiners love to test.

1 Key knowledge and worked examples

■ Three properties every exchange surface shares

Large **surface area** relative to volume, a short **diffusion distance** (walls one or two cells thick), and a maintained **concentration gradient** (blood flow, ventilation, or water flow sweeping one side).

■ The fluid mosaic model

A phospholipid **bilayer** (hydrophobic tails inside, fluid), **intrinsic proteins** spanning the bilayer (channels, carriers), **extrinsic proteins** on surfaces, **cholesterol** between tails controlling fluidity, glycolipids and glycoproteins for recognition and adhesion. "Fluid": molecules can move within the layer. "Mosaic": scattered protein shapes.

■ Model history – each step added evidence

Overton (lipid-soluble solutes cross) → Gorter and Grendel (enough lipid for two layers) → Davson–Danielli (proteins as coats) → Robertson (unit membrane) → Singer–Nicolson 1972 (proteins within the bilayer; freeze–fracture electron microscopy showed bumps inside, and membrane proteins varied in size and shape, which uniform coats could not be).

■ Worked example: beetroot Core Practical 3

Cut identical beetroot cylinders, rinse, place in water at each of five temperatures for the same time, read absorbance of the released betalain. Higher temperature disrupts the bilayer (phospholipids gain kinetic energy, proteins denature), so pigment leaks faster: absorbance rises. Controls: cylinder size, volume, time; rinse surface pigment first.

2 Practice

2.1 State three properties of an efficient gas-exchange surface and give the alveolus's version of each. [3]

2.2 Explain why the phospholipid bilayer is described as fluid. [2]

2.3 Name the evidence that finally overturned the Davson–Danielli protein-coat model. [2]

3 Exam-style questions

3.1 The table shows the absorbance of betalain leaked from identical beetroot discs after 10 minutes at five temperatures.

Temperature / °C	Absorbance / a.u.
20	0.04
40	0.09
60	0.31
80	0.62
100	0.88

Describe the trend, explain the rise in molecular terms, and predict with a reason what would happen to the results if the discs were not rinsed before testing. [6]

3.2 Frog tadpoles exchange gases across their skin; adult frogs add lungs. Explain why the adult needs the extra surface with reference to surface-area-to-volume ratio, and name one property of skin that still makes it useful for exchange in both stages. [5]

3.3 Explain why the membrane's intrinsic transport proteins cannot diffuse out of the bilayer, referring to their hydrophobic and hydrophilic regions. [4]

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 Large surface area – 300 million alveoli per lung; thin barrier – alveolar and capillary walls are each one cell thick; maintained gradient – blood flow and ventilation constantly renew both sides.

2.2 The phospholipids are not bonded to one another, so individual molecules can move laterally within their layer, changing the membrane's shape and allowing proteins to drift within it.

2.3 Freeze–fracture electron microscopy split membranes through the bilayer showing protein bumps inside it; the known proteins varied in size and shape, incompatible with continuous uniform coats.

3.1 Absorbance rises with temperature, slowly at first then steeply. At higher temperature phospholipids gain kinetic energy and the bilayer becomes more fluid, while membrane proteins begin to denature; both increase permeability so betalain leaks out faster. Unrinsed discs would carry surface pigment cut from the cells, giving high readings at every temperature and masking the temperature difference.

3.2 As the tadpole grows into an adult, its volume grows faster than its surface area, so per-unit-body demand exceeds what skin alone can supply; lungs add a large internal exchange surface with a rich capillary network. Skin in both stages is thin and well supplied with capillaries, keeping the diffusion distance short.

3.3 Intrinsic proteins have hydrophobic regions sitting among the hydrophobic tails and hydrophilic regions lining the pore or facing the solutions either side; moving out of the bilayer would expose hydrophobic regions to water, which is energetically unfavourable, so the protein stays embedded.