Mark scheme – Cell Structure: Microscopes

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td></td><td>i</td><td>
<table>
<tr><th></th><th>laser scanning confocal microscope</th><th>scanning electron microscope</th><th>transmission electron microscope</th></tr>
<tr><td>maximum resolution</td><td></td><td></td><td></td></tr>
<tr><td>image appearance</td><td></td><td>3D</td><td>2D ✓</td></tr>
<tr><td>image colour</td><td>named colour / coloured</td><td>black and white</td><td>✓</td></tr>
</table>
</td><td></td><td>Mark each row</td></tr>
<tr><td></td><td></td><td>ii</td><td>larger number of (named) organelles ✓

more DNA / larger nucleus ✓

no visible chromosomes ✓

nuclear membrane present ✓</td><td>2 max</td><td>ALLOW twice as much DNA</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>4</td><td></td></tr>
<tr><td>2</td><td></td><td></td><td>B</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
<tr><td>3</td><td>a</td><td></td><td>(pond community is) final / stable / not subject to further succession</td><td>1</td><td>IGNORE ‘permanent’, it is in the rubric.</td></tr>
<tr><td></td><td>b</td><td></td><td>light microscope (1)
graticule (1)</td><td>2</td><td></td></tr>
<tr><td></td><td>c</td><td>i</td><td>urea / uric acid</td><td>1</td><td>ALLOW ammonia, ammonium (ions).</td></tr>
<tr><td></td><td></td><td>ii</td><td>Nitrosomonas (1)
nitrite (1)
Nitrobacter (1)
nitrate (1)</td><td>4</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>8</td><td></td></tr>
<tr><td>4</td><td></td><td>i</td><td>3157 $\underline{\mu m}^3$ / 3.157×10^3 $\underline{\mu m}^3$

OR</td><td>3</td><td>ALLOW for two marks
correctly calculated value not given to 4SF
e.g. 3156.55 μm^3

3157.82 μm^3 (22/7used)
3154.95 μm^3 (3.14 used)</td></tr>
</table>

			3155 μm^3 / 3.155×10^3 μm^3 *(3.14 used for value of π)* **OR** 3158 μm^3 / 3.158×10^3 μm^3 *(22/7 used for value of π)* **OR** 3.157 / 3.155 / 3.158, $\times 10^{-15}$ m^3 *(answer using SI units)* ✓✓✓		**OR** *correctly calculated value without units* e.g. 3157 / 3.157 **OR** *correctly calculated value with inappropriate units* e.g. 3.157×10^{-6} mm^3 3.157×10^{-9} cm^3 ***If two or three marks were not awarded for the correct answer or calculated value:*** *for **one mark** look for evidence of use of the formula:* $(4/3) \times \pi \times r^3$ **Examiner's Comments** The necessity to use π in the equation for **Q17(b)(i)** generated three different versions of the correct answer in order to encompass all the various values of π e.g. 3.14 or 22/7. Candidates could gain credit for a variety of responses and many variations that included errors could still gain one or two marks if Examiners could clearly see how candidates had arrived at their response e.g. one mark was awarded for candidates that had used the correct equation for calculating the volume of a sphere. The most common error was using the wrong value for the radius, having confused it with the diameter or simply not knowing the formula for a sphere. The equation for calculating area of a circle rather than volume of a sphere was another common error. Some candidates mistakenly squared the value of the radius or mis-keyed the correct values into the formula and it is recommended that centres encourage candidates to repeat calculations to check for such errors, provided time allows.
		ii	(transmission) electron (microscope) ✓ **AND ONE** of the following: 2D image ✓	**2 max**	**ALLOW** TEM **DO NOT ALLOW** scanning electron microscope / SEM **IGNORE** black and white / colour

			internal details visible ✓ (named) organelles / ultrastructures , visible ✓ high <u>magnification</u> ✓ high <u>resolution</u> ✓		e.g. mitochondria **IGNORE** nucleus (as visible under a light microscope) **Examiner's Comments** For candidates who recognised that an electron microscope was necessary to produce the image of the Kupffer cell, **Q17(b)(ii)** posed few problems and both marks were often achieved. Some candidates suggested a scanning electron microscope rather than transmission which was not credited but error carried forward was used for the second mark of this question to avoid candidates losing both marks. Error carried forward was also used where candidates had incorrectly stated a light microscope but marks were only gained for the mark points in the mark scheme and not for incorrect statements such as '*no organelles can be seen*' or '*has low resolution*'.
			Total	**5**	
5		i	A = (permanent / temporary) vacuole ✓ B = <u>nucleolus</u> ✓	2 (AO1.1)	**ALLOW** vacule **DO NOT ALLOW** nucleus **<u>Examiner's Comments</u>** Most candidates correctly identified A as the vacuole, but only a minority of candidates identified B as the nucleolus, with many identifying it as the nucleus. Other answers seen included xylem and phloem, and air space for vacuole.
		ii	(x)14000 / 1.4 x 10^4 ✓✓	2 (AO2.8)	If the answer is incorrect, award one mark for a correct calculation not rounded to 2 s.f. (e.g. 0.02 / 0.0000014 = 14285.71429 20000 / 1.4 = 14285.71429) **ALLOW** 0.019/0.0000014 = 13571.428 **or** 0.021/0.0000014 = 15000 for 1 mark **<u>Examiner's Comments</u>** On the whole this question was well answered, with the majority of candidates correctly calculating the magnification. However, some candidates lost a mark for failing to round the answer to 2 significant figures. **OCR support**

					There are available resources on the 'Maths for Biology' website which can be used to support candidates with the correct use of significant figures: https:/www.ocr.org.uk/subjects/biology/maths-for-biology/handling-data/
		iii	no, shading / cross hatches / AW ✓ add, a scale / magnification ✓ add a title ✓	2 max (AO3.4)	**Mark first two improvements described** e.g. only use outlines **IGNORE** references to labels or annotations and the use of a pencil (because this is mentioned in the question stem) **IGNORE** drawing should take up half a page / no overlapping lines / use continuous lines **Examiner's Comments** Many candidates correctly recognised that the drawing could be improved by removing shading or by adding a scale bar. However, many referred to adding labels or annotations or the use of a sharp pencil which gained no credit, as this was mentioned in the question stem. **OCR support** The Biological Drawing handbook can be used as a guidance in this case: https:/www.ocr.org.uk/Images/251799-biology-drawing-skills-handbook.pdf
		iv	place stain at edge of sample (not the centre) ✓ lower cover slip at an angle / use mounted needle ✓ use blotting paper to, remove excess stain / pull stain through ✓ use more than one stain (to improve contrast) ✓	2 max (AO3.3)	**Mark as prose** **IGNORE** use forceps / lay sample flat **ALLOW** place stain at side of sample **ALLOW** stated angles given e.g. 45° **ALLOW** 'tissue/paper towel' instead of 'blotting paper' **ALLOW** ensure stain covers whole sample **Examiner's Comments** Candidates who had a practical knowledge of slide preparation scored well, mentioning lowering the cover slip at an angle or using blotting paper to remove excess stain, as ways

					to improve the method. However, many candidates wrote about aseptic technique, adding water, wearing gloves, or pressing down on the cover slip to remove air bubbles, which gained no credit. **OCR support** Practical work should be an integral part of the study of Biology. The practicals provided by OCR to support the practical endorsement include Practical Activity Group (PAG) 1 in which there is practical activity on preparing microscope slides which can be applied into different contexts. PAG activities are available on OCR interchange: https:/interchange.ocr.org.uk/Downloads/PAG1.zip
			Total	**8**	
6		i	transmission electron (microscope) ✓	1 (AO2.1)	**ALLOW** TEM, 'microscopy' for 'microscope'
		ii	**M** = matrix ✓ **N** = crista(e) ✓	2 (AO1.1)	**ALLOW** inner membrane for **N**
			Total	**3**	
7			B ✓	1 (AO1.1)	
			Total	**1**	
8		i	*you can now see* Golgi body / mitochondria / (smooth / rough) endoplasmic reticulum / ER / RER / SER / ribosomes **OR** organelles seen in more detail / grana (in chloroplast) / thylakoids (in chloroplast) / nuclear pore / cristae (in mitochondria) / membranes within organelles / double nuclear membrane / (double) nuclear envelope **OR** resolution is, higher / better ✓	**1**	**IGNORE** clarity **IGNORE** ref to size of organelles **DO NOT ACCEPT** chloroplast **IGNORE** ref to ultrastructure unqualified **Examiner's Comments** This was answered well with most candidates correctly identifying an organelle which could not be seen with a light microscope, but could then be seen in the second image. Many correctly referred to rough endoplasmic reticulum or mitochondria although the presence of organelles simply being visible was insufficient. Many were able to comment on the higher resolution of cell B but a good proportion failed

					to gain credit due to the use of 'high' rather than 'higher'. Weaker answers often were too vague, simply stating that the 'ultrastructure' or 'detail' of the cell could be seen.
		ii	*LSCM image* has lower <u>resolution</u> (than EM) **OR** can have <u>fluorescent</u> tag **OR** can see movement (as can be used on living cells) **OR** can see, different layers / at different depths (of the sample) ✓	**1 max**	**ORA** for electron microscope needs to be comparative **IGNORE** colour **IGNORE** ref to 2D / 3D / depth of field **Examiner's Comments** The majority of candidates were not confident in answering this question and as a result gave an incomplete or irrelevant answer. Some candidates were awarded the resolution mark but some were clearly confused as to which microscope has the higher resolution or were unsure about the difference between resolution and magnification. Many students responded in terms of the image being either 2D or 3D, some answers stated 'in colour', and several did not state which type of microscope they were referring to. Of the few correct answers seen, the majority referred to different depths of sample or the usefulness of being able to use a fluorescent tag. None referred to the advantage of being able to see movement (in living cells).
			Total	**2**	
9	a		Z;	1	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **Examiner's Comments** Most students recognised that microscope Z was the transmission electron microscope.
	b		Fig. 3.1(a) (no mark)	max 2	Please place a green blob on paper

			shows surface view; 3D / three dimensional; better resolution (than b);		Do not allow mp 2 if fig 3.1 b selected Do not allow mp 3 if fig 3.1 b selected Must be comparative comment **Examiner's Comments** Most students recognised that Fig. 3.1(a) was the image from a scanning electron microscope and were able to justify their choice successfully. The most common response was that the image was three dimensional, but many candidates also stated that it was a surface view. Fewer candidates stated that the resolution was higher than in Fig. 3.1(b).
			Total	**3**	
10		i	1.7 mm (1)	1	
		ii	× 50 (1)(1)		**ALLOW** 1 mark for correct working e.g. 80 / 1.6 **ALLOW** answer in the range of 48–51
		iii	air spaces give buoyancy (1) supported by (surrounding) water (1)	2	
			Total	**5**	
11			D	1	
			Total	**1**	
12			11.91 μm ✓✓	**2**	***Correct answer = 2 marks (indicated by 2 ticks) even if no working shown*** **ACCEPT** 11.06 to 12.77 μm **ACCEPT 1.106 x 10^{-5} m to 1.277 x 10^{-5}** m [sig figs retained for standard form] ***Otherwise,* Award ONE mark for:** correct final answer without (correct) unit **OR** correct final answer to wrong number of dp or incorrectly rounded **OR** seeing (one graticule division =) 20 ÷ 2.35 =

					8.51 **OR** seeing (measurement of nucleus =) 1.3 to 1.5 (graticule / eye piece) units / divisions **or** 1.3 to 1.5 cm **or** 13 to 15 (graticule / eye piece) units / division **or** 13 to 15 mm **OR** diameter = 110.63 to 127.65 μm **Examiner's Comments** A common error was misusing the formula linking magnification with image size and actual size, so wrongly dividing 2.35 by 20. The correct units were usually used. Students should be encouraged to think about what their answers actually mean - answers of hundreds of mm or cm for a cell nucleus are clearly wrong.
			Total	**2**	
13			use eyepiece graticule ✓ calibrate graticule, using stage micrometer / detail of calibration / calculate the length of one epu ✓ measure the diameter of the nucleus in, epu / graticule units ✓ take repeat measurements **and** calculate a mean diameter (in epu) ✓ use calibrated epu to calculate diameter (of nucleus) (in μm) / described ✓	4 max	e.g. of detail: align two scales and record number of divisions per graticule unit
			Total	**4**	
14		i	sharp blade (should be selected) (1) so slide is thin enough, individual cells are visible / resolution is high (1) method for slicing pieces of tissue (thinly) (1) so slide is thin enough, individual cells are visible / resolution is high (1) select thin(nest) slides (1) to ensure maximum light can penetrate sample (1)	6	**ALLOW** any reasonable method (e.g. microtome) **ALLOW** quantified thickness (e.g. measured with a micrometer)

			wet mount (1) prevents dehydration / distortion of tissue (1) squash slide (1) easier to see individual cells / allows light to penetrate tissue more easily (1)		**ALLOW** description **ALLOW** description
		ii	contrast is high(er) (1) more (internal) structures visible (1) some (named) organelles / cell components more visible, because they bind to stain (1) clearer image can be obtained (1)	3	
			Total	**9**	
15			D ✓	1 (AO1.2)	
			Total	**1**	
16			C ✓	1	
			Total	**1**	
17		i	**1** to, see / identify, (differences between) cells ✓ **2** to, see / identify, (differences between) organelles ✓ **3** red blood cells visible, anyway / without stain (due to haemoglobin) ✓ **4** ref. <u>contrast</u> ✓ **5** allows, white cells / leucocytes, to be counted ✓	max 3 (AO1.1 x5)	**ALLOW** so white blood cells / **A** / **C** / **D** can be seen or told apart from RBCs **ALLOW** named organelles e.g nucleus / cytoplasm **ALLOW** without stain white cells are, transparent / colourless **<u>Examiner's Comments</u>** A few candidates gained 2 marks out of the 3 for stating that the staining technique improves visibility of both cells and organelles. Limited vocabulary let candidates down, with frequent references to components or structures rather than 'organelles' or a named organelle. Higher ability candidates sometimes featured the word 'contrast' or made the point that white blood cells needed to be stained to be visible (or to be counted) while red blood cells contained their own pigment.
		ii	**1 C** (is, blue / purple, so) has (more) nucleic acid ✓ **2** (**C** has) (m / t / r) RNA ✓ **3 D** (is red so) has (more) protein ✓ **4** (**D** has) enzyme / antibody / immunoglobulin ✓ **5** *idea that* different cells have different, roles / (concentrations of) biochemicals / levels of activity ✓	max 4 (AO3.2 x5)	**IGNORE** suggested names for cells **IGNORE** some / no, protein present **2 DO NOT ALLOW** DNA **3 IGNORE** some / no, nucleic acid present **4 ALLOW** (named) hydrolases / (named) cytokines / perforins / granzymes

					Examiner's Comments This question required candidates to use the information about the chemical staining characteristics of haematoxylin and eosin to make deductions about the contents of the cytoplasm of two cell types they observed on Fig. 2. Most creditworthy answers made the link between the colour of the stained cytoplasm and the main biomolecule contained within it. Some candidates went on to suggest that the proteins in cell D were enzymes or antibodies and gained credit. Fewer candidates linked more nucleic acid in the cytoplasm of cell C to more RNA. A pitfall for lower ability students was missing the instruction in the question to consider the cytoplasm of the cells only, not the nuclei (both of which stained purple due to DNA).
			Total	**7**	
18			create / provide / increase contrast; make, cells / (named) component(s), visible OR cells / (named) components, can be, identified / distinguished / differentiated;	2	**IGNORE** clearer **ACCEPT** (named) organelle(s) stand out from surroundings **ACCEPT** regions / parts / AW, of cell **Examiner's Comments** Most candidates knew that staining made cell components visible and many also understood that the stain increases the contrast.
			Total	**2**	
19			TEM has, better / higher, resolution ✓ *TEM* (resolution figure in range) 0.05 - 2 nm ✓ (shows) image of cell interior ✓ (shows) ultrastructure / (two named) cell organelles ✓ *SEM* (resolution figure in range) 5 - 50 nm ✓ (shows) 3D / three-dimensional, image ✓ (shows cell) surface / topography ✓	4 max (AO1.1)	**ALLOW ora** SEM has, worse / lower resolution **IGNORE** magnification **ALLOW** 0.00005 - 0.002 μm / 50 – 2000 pm 'TEM has resolution of 0.5nm whereas SEM **only** has resolution of 3-10nm' gets mps 1, 2, 5 (as comparative implied by 'only') **ALLOW** 0.005 – 0.05 μm **ALLOW** see depth **DO NOT ALLOW** organelles in cell unless fracture explained
			Total	**4**	
20			A ✓	1	
			Total	**1**	

21			A ✓	1 (AO1.1)	**Examiner's Comments** The vast majority of candidates answered this straightforward definition question correctly.
			Total	**1**	
22			C	1	**Examiner's Comments** This was answered reasonably well. It should be emphasised that questions such as this, where data are presented that do not have definitive values (in this case, varying according to the particular make and model of microscope), that candidates are expected to have an appreciation of the magnitude of the values rather than learning precise figures and expecting to quote those.
			Total	**1**	
23		i	*B* comment about detail of organelles (1) comment about shapes of cells (1)	2	**No Mark for identification of B** e.g. light microscope would not allow nuclear pores / ribosomes / endoplasmic reticulum / plasmodesmata to be seen. e.g. sieve tube elements are angular / hexagonal.
		ii	the ability to see more detail / separate two objects (1)	1	
		iii	Nile blue (1) to increase contrast / to make nuclei visible / to show no nuclei in sieve tubes (1)	2	
			Total	**5**	
24			14 000 / 120 = 117 µm;	2	length of line A-B = 14mm / 14000 µm Correct answer = 2 marks. Allow one mark if correct working shown including units for cm & mm e.g. 1.4 cm / 120 14 mm / 120 14000 / 120 If answer = 125 µm allow one mark for correct working but incorrect measurement (15mm instead of 14) Allow one mark if not rounded to nearest micrometre **Examiner's Comments**

					As ever, many candidates proved incapable of performing a relatively simple calculation. Better candidates did well and gave the correct response or at least showed they knew how to carry out the calculation. However, too many candidates appeared to have little idea of what to do. Commonly the magnification was left out of the calculation and candidates simply converted mm to μm. Another common error was to convert mm to μm by dividing by 1000 rather than multiplying. This is an area in which centres need to improve in light of the increased maths requirements of the new specifications.
			Total	**2**	
25		i	*A because* nuclei (of white blood cells) are lobed ✓	1	Mark is for the explanation
		ii	(x) 1300 ✓✓	2	If answer is incorrect **ALLOW** 1 mark for evidence of 0.02 (m) / 0.000015 (m) or equivalent numbers in alternate units
			Total	**3**	
26			C ✓	1 (AO2.4)	**Examiner's Comments** Most candidates were able to correctly calculate the real length of the tardigrade and there was often evidence of working shown.
			Total	**1**	
27			12 ✓ ✓	2(AO2.2)	**Correct answer = 2 marks** even if no working shown. **ALLOW** 11 / 13 for 2 marks **If answer is incorrect** then **award 1 mark:** *if answer to >2 s.f.:* **ALLOW** range from 11.2 to 12.8 *if answer in mm:* 0.011 / 0.012 / 0.013 *if answer in cm:* 0.0011 / 0.0012 / 0.0013 *if answer in m:* 1.1×10^{-5} / 1.2×10^{-5} / 1.3×10^{-5} *for working:* 14 or 15 or 16 ÷ 1250 x 1000 *for converting scale bar to μm:* 15 000 or in range from 14 000 to 16 000

					ECF from mis-measured figure: answer to (x ÷ 1250 x 1000) e.g. 1cm gives an answer of 8 (µm) e.g. 1.5 mm gives an answer of 1.2 (µm) **Examiner's Comments** Many candidates correctly calculated that the 15mm scale bar represented a length on the magnified image equal to 12µm. Some candidates were given one mark for converting the scale bar length to µm. The use of a scale bar to represent a length on a magnified image confused some candidates A microscopic object such as a cell has a real-life size and a magnified image size. A scale bar's length is as measured on the page but this represents a length on the image that is smaller by a factor of the magnification shown. **OCR support** The 'Maths for Biology' website can be used in order to support students with conversion of units. https:/www.ocr.org.uk/subjects/biology/maths-for-biology/arithmetic-and-numerical-computation/
			Total	**2**	
28			350, (x / times) ✓✓	2	**ALLOW** range 333(.33) - 350 x scale bar = 21mm max.1 working mark for: 21mm / 0.06mm or 21 000µm / 60µm Note: candidate may measure size of photo (image size) and calculate size of object using the scale bar. If calculated correctly this gives an answer very close to 350. Allow 2 marks.
			Total	**2**	