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Teacher guide

BIOLOGY A
BIOLOGY B
(ADVANCING BIOLOGY)

H020, H420, H022, H422

For first teaching in 2015

Biological Drawing

Version 2.1

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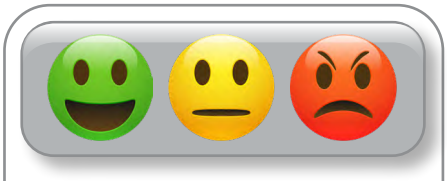

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INTRODUCTION TO BIOLOGICAL DRAWING

This biological drawing skills handbook has been developed to support GCE Biology A H020/H420 and GCE Biology B H022/H422.

Why bother?

The ability to draw, label and annotate biological specimens is an important and useful biological skill. These days students may well challenge the need for making biological drawings, particularly given the ease of using digital photography for record-keeping. So how can it be justified? The following points help to provide a rationale for developing biological drawing skills:

- **Accurate observation and attention to detail is encouraged.** Having to draw a biological specimen not only increases the amount of time spent examining the specimen, which in itself will aid learning, but requires a much greater level of accurate observation than a casual examination.
- **Active recording aids memory.** The educational philosophy behind this is neatly summarised in the well-known Chinese proverb:

  I hear and I forget

  I see and I remember

  I do and I understand

  Confucius
- **The drawing provides a permanent record of what has been observed.** There is a historic tradition within biology of providing accurate records of specimens so that the images could be used for future reference purposes. Today's taxonomists are often indebted to the illustrators of the 17th and 18th centuries, particularly where the 'type' (reference) specimen may only exist as an illustration. Even today, when digital photography can be used to store images, artists are still often commissioned to record biological specimens of interest by drawing or painting. This is particularly true for flowering plants. This is partly because all the features of interest can be combined in one or several scientifically accurate, but aesthetic, images with great clarity (see **Figure 1**).

Figure 1: Antique botanical illustration of *Limon vulgaris* (lemon tree), including detail of flowers and fruit.

GUIDANCE FOR BIOLOGICAL DRAWING

What equipment is needed?

- **Sharp pencil** - HB is generally preferred, but H, 2H or B (for emphasis) can all be used according to preference.
- **Pencil sharpener** - A nail file may also be useful to keep the point really sharp.
- **Eraser**
- **Ruler** - For label lines.
- **Plain paper**

General Principles

When assessing biological drawing, marks are awarded for both **quality** of drawing and **labelling**. The latter may include **annotation**. The general principles described below apply to all types of biological drawing:

- **Use a sharp pencil only.** Don't use pens or coloured pencils.
- **Use clear, continuous lines.** A line which encloses a shape, such as a circle, should join up neatly without obvious overlap. Overlapping lines is a common error in hastily drawn sketches and is easily spotted and penalised by examiners.
- **Don't use any form of shading.** This includes stippling, cross-hatching and shading. Students find this is a hard instruction to follow, and it is sometimes difficult to justify. Although shading may help to make the drawing look more realistic and/or to discriminate between areas of the specimen, it does not represent a permanent structural feature. Artistic impression is certainly not what is required.
- **Accuracy is paramount.** It shows good observation. Remember that observation is assisted by understanding, so a good knowledge of theory goes alongside good drawing. Pay particular attention to the outlines of structures and to the relative proportions of different parts of the specimen. Don't draw what you think you *should* see, for example text book style drawings. Draw what you observe.
- **Guidelines can help.** Faint sketching of the main areas of the specimen which can later be erased may help. Some students find a simple grid helps them.
- **Magnification and illumination.** To help in the drawing process it is often useful to use a hand lens or a magnifying glass for larger specimens and, for microscopy, both low and high power lenses when making preliminary observations. Field biologists usually carry a hand lens as standard equipment. Dissection, and drawing from a dissection, is greatly aided by good illumination of the specimen by a lamp and by a tripod lens placed over the material where possible.
- **Make the drawing large enough.** If the specimen is a relatively large structure such as a plant or a section of an organ, it should normally occupy more than half the available space on the page. In microscopy, individual cells drawn at high power should be about one to several centimetres in diameter.
- **Correct mistakes.** If you make a mistake, use a good quality eraser to rub out the lines completely.
- **Include a title.** Include a title stating what the specimen is.
- **Include a scale.** If you are drawing from a microscope, it is useful to state the combined magnification of the eyepiece plus objective lenses used when making the drawing, e.g. x100 (low power) or x400 (high power). Note, though, that this is not the same as recording the scale (see **Labelling** below).

Labelling

When labelling biological drawings, follow the guidance below:

- Use a sharp pencil.
- Label all relevant structures, including all tissues in the case of microscopy.
- Use a ruler for label lines and scale bars.
- Label lines should start exactly at the structure being labelled; don't use arrowheads.
- Arrange label lines neatly and make sure they don't cross over each other. It is visually attractive, though not essential, if the length of the label lines is adjusted so that the actual labels are right or left justified, i.e. line up vertically above each other on either side of the drawing.
- Labels should be written horizontally, as in a textbook, not written at the same angle as the label line.
- As previously mentioned, a title, stating what the specimen is, should be added at the top or bottom of the drawing.
- Add a scale bar immediately below the drawing (see below).

Annotating

Annotation adds concise notes about the structures labelled on a biological drawing. It is often used to draw attention to features of particular biological interest, either structural (such as shape, size, colour, hairiness) or functional.

See **Figure 3, 4e, 4h** and **5e** for examples of annotation in this booklet.

Scale and magnification

It is useful to give an indication of the scale/magnification of a drawing, particularly for large specimens drawn without the aid of a microscope. The actual size of a plant or leaf, for example, may be impossible to judge simply from a drawing. For drawings made using microscopes, if the actual scale or magnification is not given, it may be useful simply to indicate whether a low or high power lens was used, preferably the actual magnification achieved by the combined eyepiece and objective lens, usually just below the title.

Calculating scale/magnification of a drawing

Scale, or magnification, is simply how much bigger or smaller the drawing is compared with the actual specimen. Calculate as follows:

1. Measure between two appropriate points of the drawing (e.g. total length or width).
2. Measure between the same two points of the specimen.
3. Divide measurement 1 by measurement 2.

Unfamiliar specimens

As stated above, the same basic principles of drawing technique apply to all drawings and specimens. Nevertheless, it can be daunting for a student if they are asked to draw something they have not seen before or in a new situation, for example a plant growing in a field, a fungal colony growing on an agar plate or an unfamiliar slide. Assessment questions will always be phrased so that it is clear exactly what is required and any relevant information the student is not expected to know will be provided. The important thing to remember is to follow instructions carefully and to observe and draw the actual specimen and not try to guess what should be visible. For example, roots should not be drawn on a plant growing in the field if they are not visible.

Specimens should be studied carefully before any drawing is undertaken, noting particularly where the outlines of structures are going to be delimited in the final drawing. Depending on the subject, separate, more detailed drawings may be useful to highlight features of particular biological interest.

The following figures are good biological drawings. **Figure 2** shows a drawing made from a heart dissection and **Figure 3** shows two flowers during a fieldwork exercise.

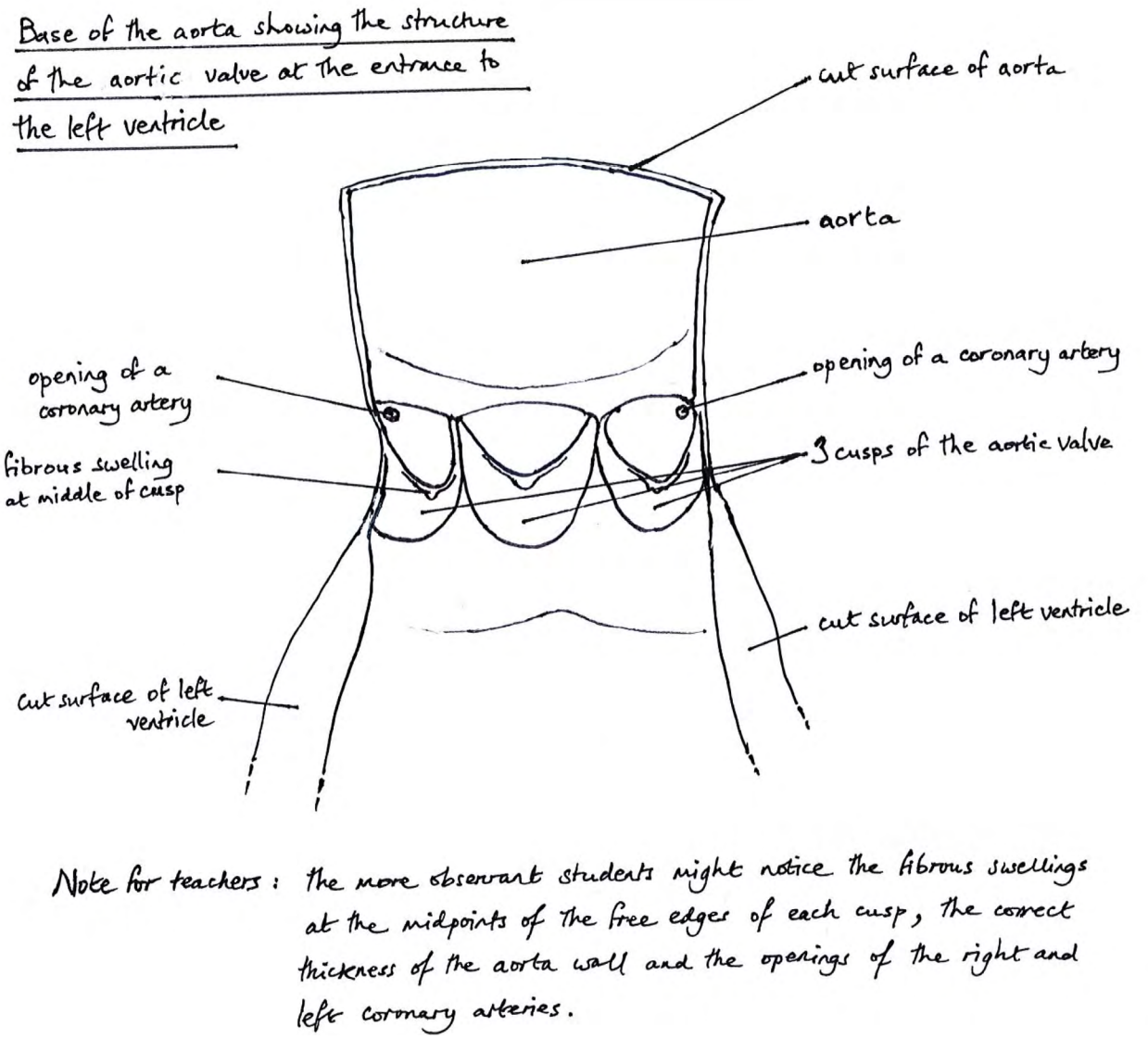

Figure 2: Drawing of the base of the aorta showing the aortic (semilunar) valve through which blood leaves the left ventricle of a mammalian heart. (Note the fibrous swelling at the middle of the cusps may not be present in some mammalian hearts.) This is a good biological drawing, fully labelled, and clearly showing detail from the dissection, although care should be taken to ensure lines do not overlap or are left incomplete. Also, a scale bar is not present.

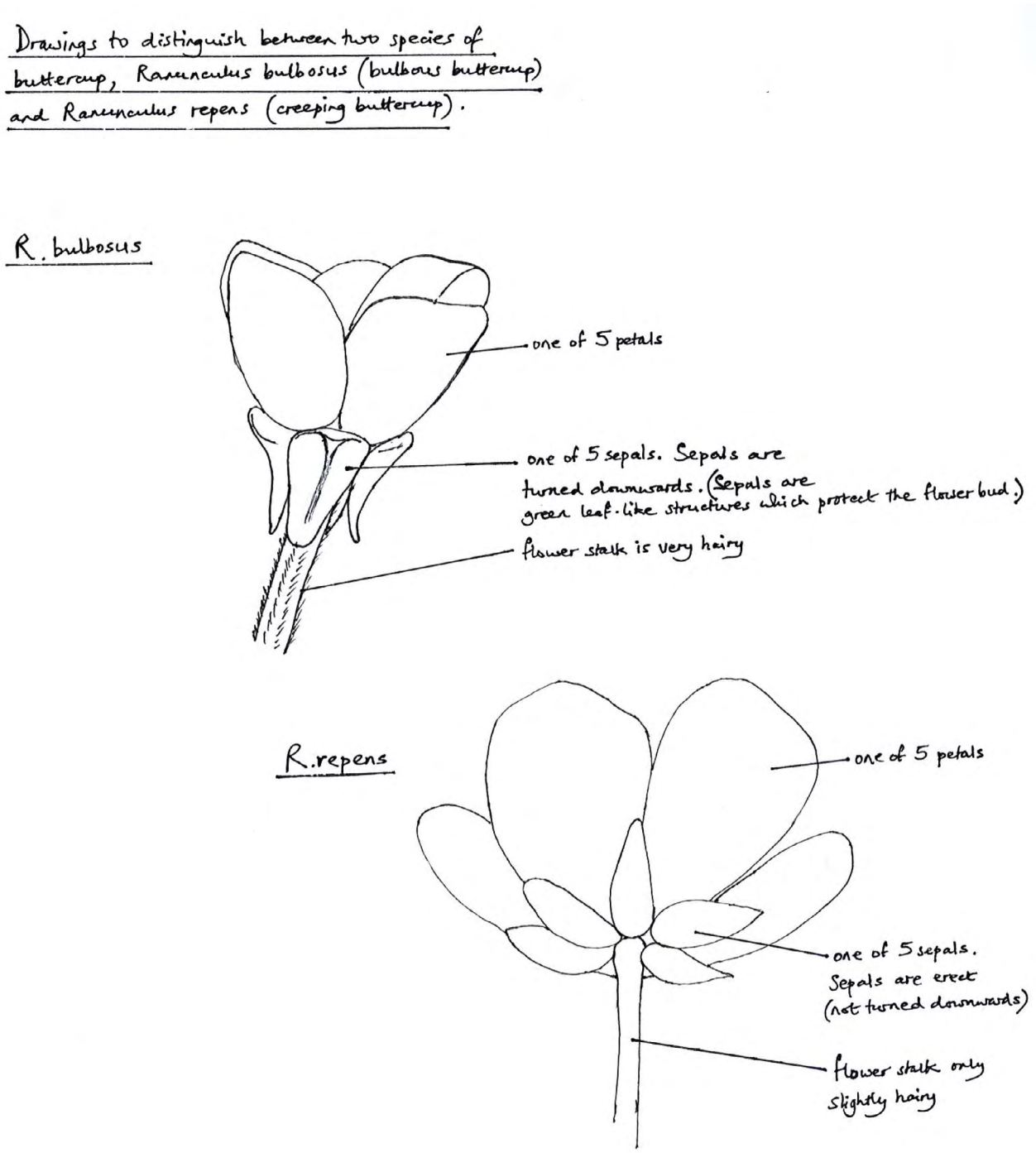

Figure 3: The difference in arrangement of the sepals in two species of buttercup, *Ranunculus bulbosus* and *R. repens*. Again, this is a good biological drawing, showing specific details of the flowers and labelling them accordingly. However, care should be taken to ensure lines do not overlap or are left incomplete. Also, a scale bar is not present.

DRAWING FROM A MICROSCOPE SLIDE

Low power drawings

The purpose of a low power drawing is usually to show the distribution of the main tissues within an organ, for example in a transverse section of a stem or a trachea. Students are required only to identify the tissues and to delimit the different tissues with boundary lines. **No individual cells should be drawn**. There should be no mysterious gaps between tissues. The temptation is to try to make the drawing look like the specimen, hence the tendency to fill spaces with cells. The final drawing is basically a map – accurate details of the cells can only be revealed at high power.

Follow these guidelines:

- Identify the different tissues, using high power to help if necessary
- Draw all tissues and completely enclose each tissue by lines
- Don't draw individual cells
- Accuracy is important – the specimen will not necessarily look like a textbook drawing. For example, vascular bundles in a stem may vary in size and shape.
- A representative portion may be drawn if the structure is symmetrical, e.g. a wedge or half of a transverse section of root or stem, or in the case of a leaf, half a midrib and a small portion of the adjacent lamina.

High power drawings

The purpose of high power drawings is to show as much accurate detail as microscopy will allow. It is important to realise that the high power and low power drawings are complementary – neither on its own looks like the whole specimen being viewed, but the combination would allow someone to reconstruct the structure being drawn. As with low power drawings, students often fall into the trap of wanting the drawing to 'look like what they see down the microscope' and draw a lot of cells, none accurately.

- Draw only a few representative adjacent cells (assessment questions will usually give specific instructions about what exactly is required.) If all the cells are similar, then three cells is often sufficient to show both cell structure and the way in which cells are arranged in relation to each other. In such a case, detail of only one cell may be needed, with outlines only of adjacent cells just to show their relative positions.
- Don't shade in nuclei – just draw the outline. Similarly with nucleoli.

Examples

Figures 4a-i show photomicrographs and low and high power drawings of a section of mouse pancreas. Two versions of each drawing are shown, one based on tracing the photomicrograph and one an example of an acceptable drawing of the same structure/cells completed by an able student. Students are not expected to produce facsimiles of what they observe, but drawings should show an understanding, realistic proportions and recognition of key features.

Figures 5a - e show photomicrographs and low and high power drawings of transverse sections of leaves of beech (*Fagus*) from sunny and shaded conditions. A student would not be expected to have seen sections of this leaf before and would be given sufficient information to make the drawings based on knowledge of the specification content.

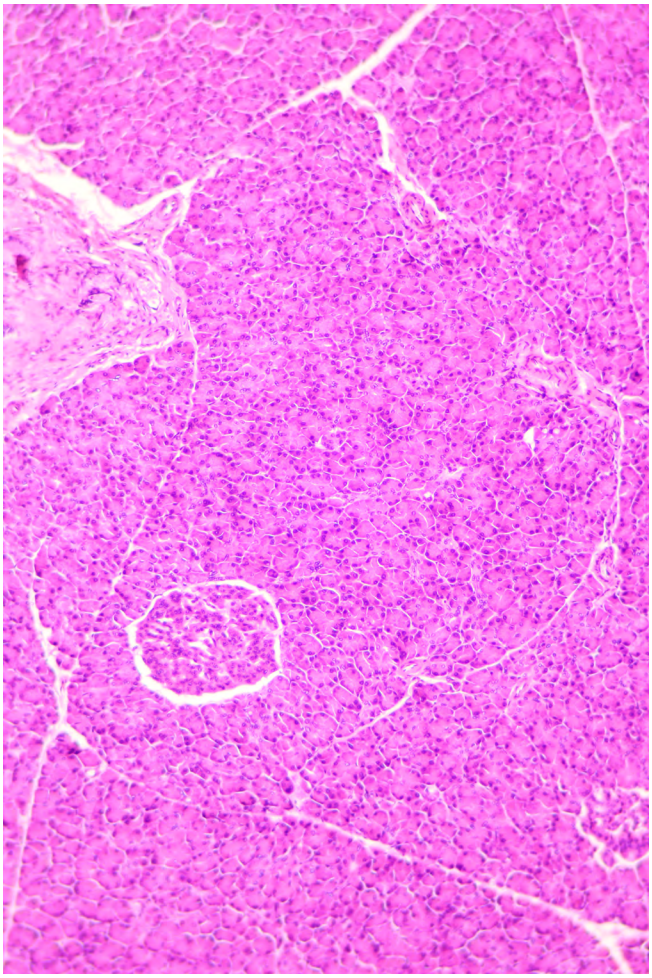

Figure 4a: Photomicrograph of part of a section of the pancreas of a mouse taken at low power.

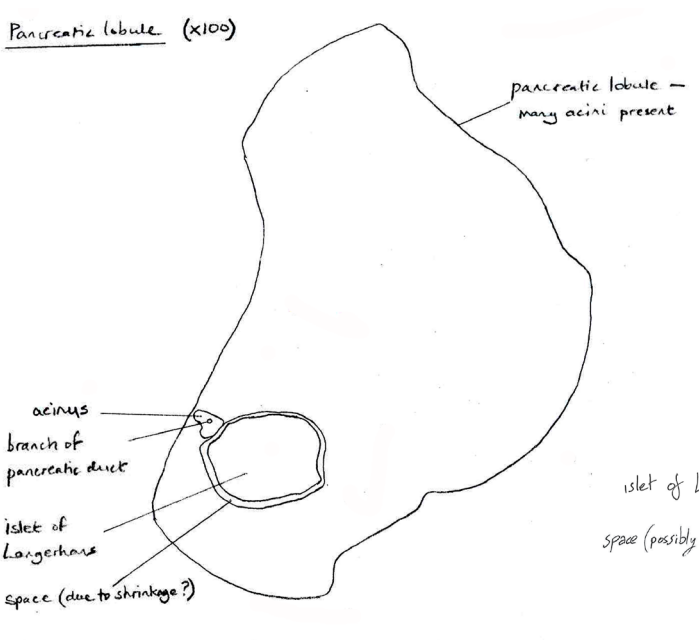

Figure 4b: Low power plan trace of one lobule from the pancreas shown in Figure 4a showing an islet of Langerhans and one acinus.

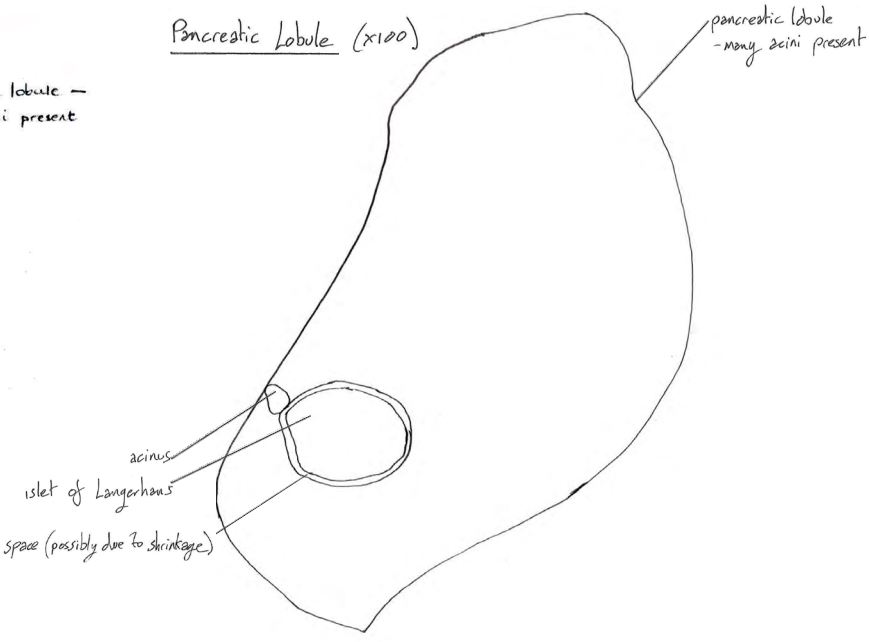

Figure 4c: Low power plan of the same lobule as in Figure 4b but drawn by a student. This is a good attempt at drawing the lobule shown in Fig 4a, although some lines are thicker than others.

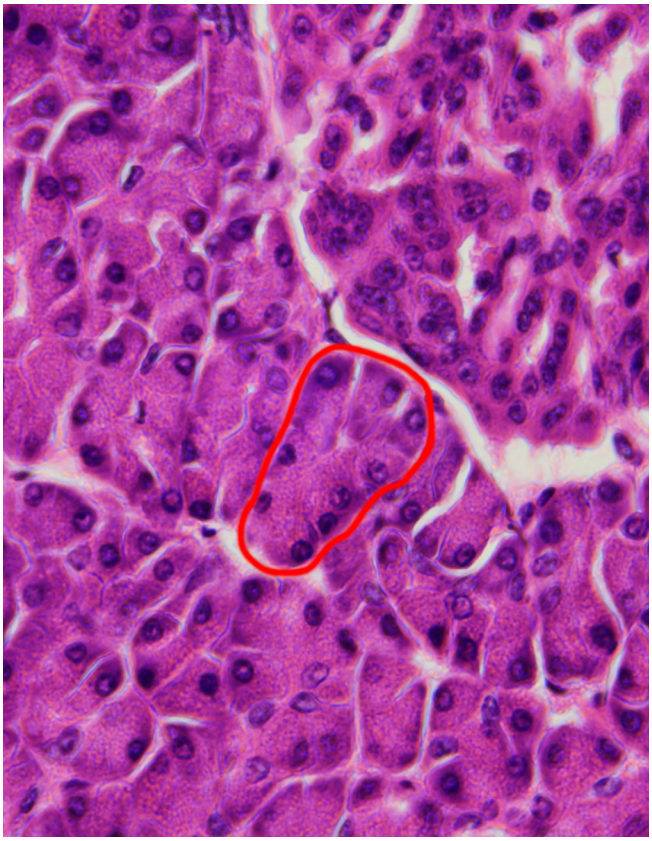

Figure 4d: High power photomicrograph of the pancreas shown in Figure 4a. The acinus drawn in Figures 4e and 4f is outlined.

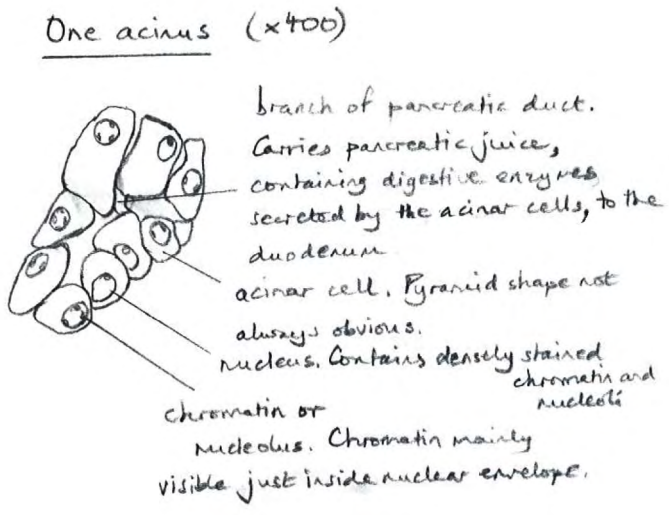

Figure 4e: High power drawing of the acinus outlined in Figure 4d, obtained by tracing and fully labelled.

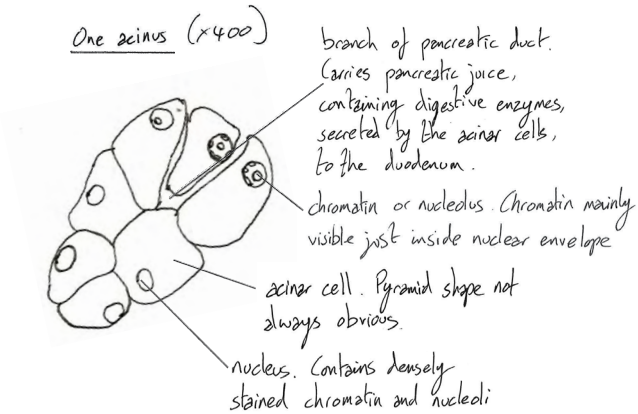

Figure 4f: High power drawing of the acinus outlined in Figure 4d, drawn from the slide by a student. This is a good attempt at drawing the acinus from Figure 4d, although there are some overlapping lines.

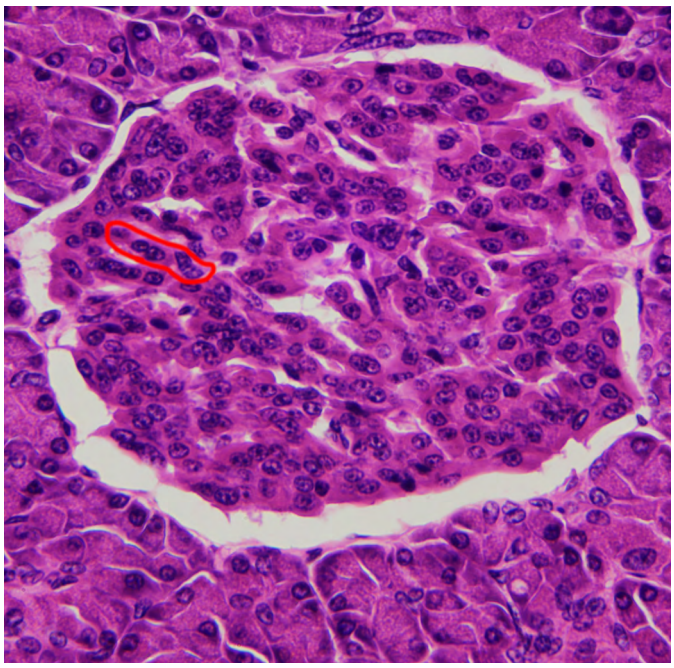

Figure 4g: High power photomicrograph of an islet of Langerhans from the pancreas shown in Figure 4a. The chain of four cells drawn in Figures 4h and 4i is outlined.

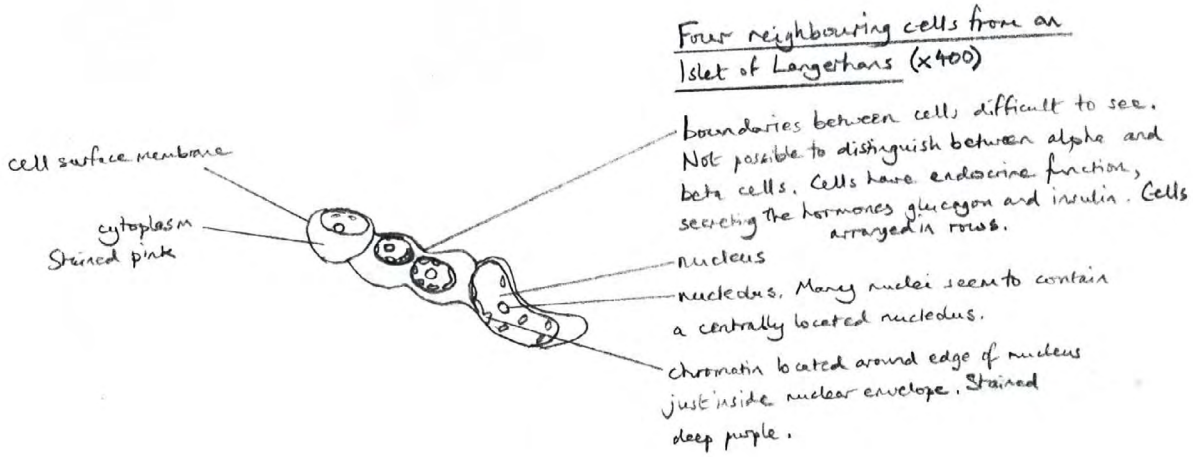

Figure 4h: High power drawing of the chain of four cells outlined in Figure 4g, obtained by tracing.

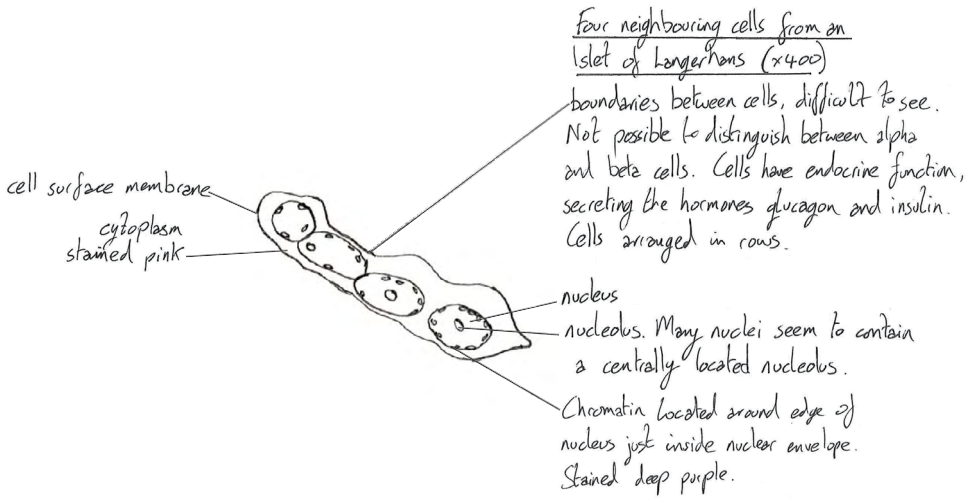

Figure 4i: High power drawing of the chain of four cells outlined in Figure 4g, drawn from the slide by a student. Again, this is a good attempt at the drawing but this student needs to be careful they do not overlap lines.

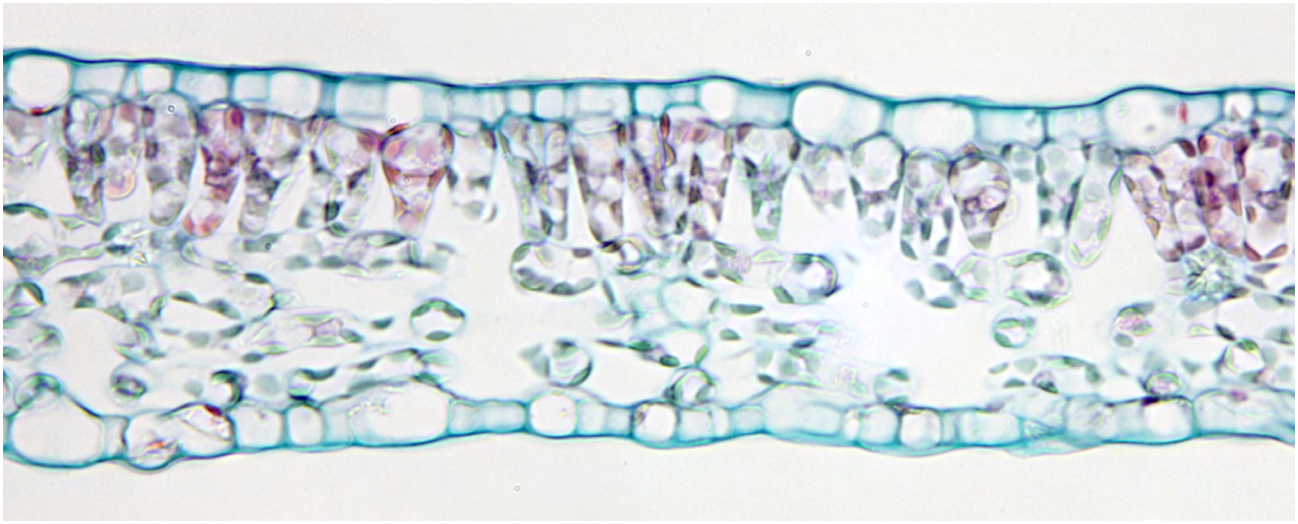

Figure 5a: Photomicrograph of a transverse section of the lamina of a shade leaf of beech (*Fagus*) taken at low power.

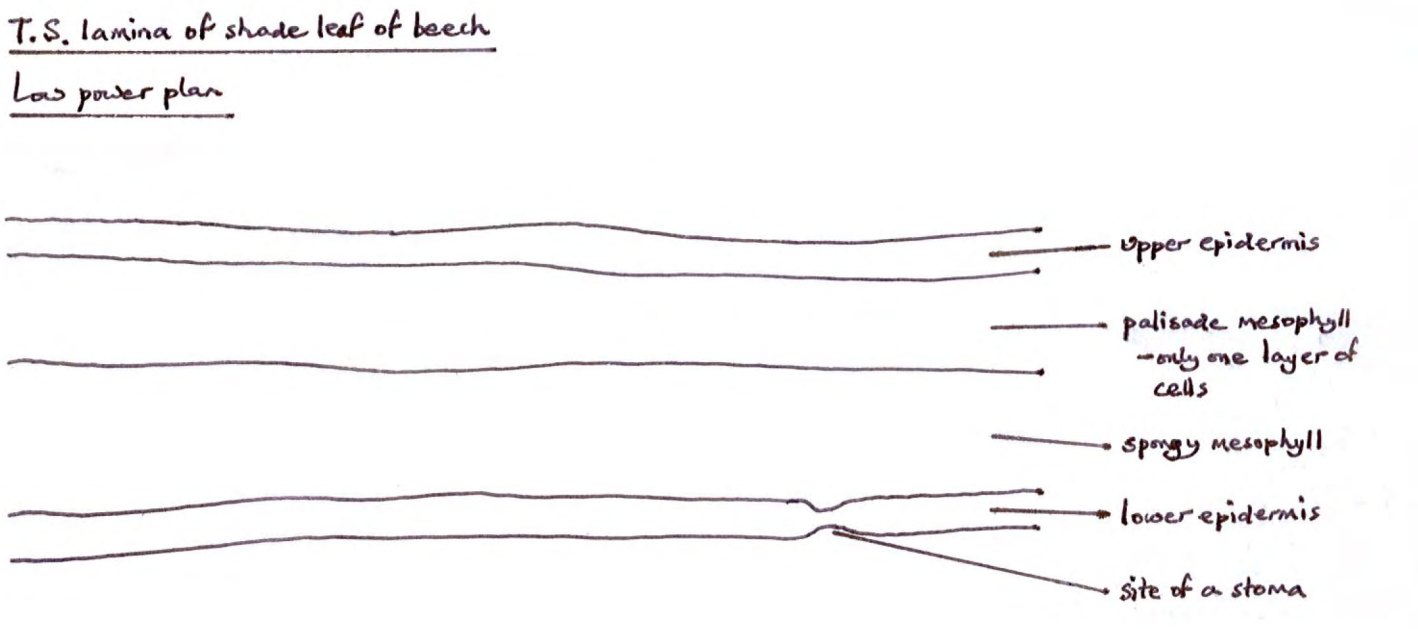

Figure 5b: This is a low power plan of the beech leaf section shown in Figure 5a drawn by a student. The student has correctly drawn and labelled the different tissues, rather than drawn individual cells.

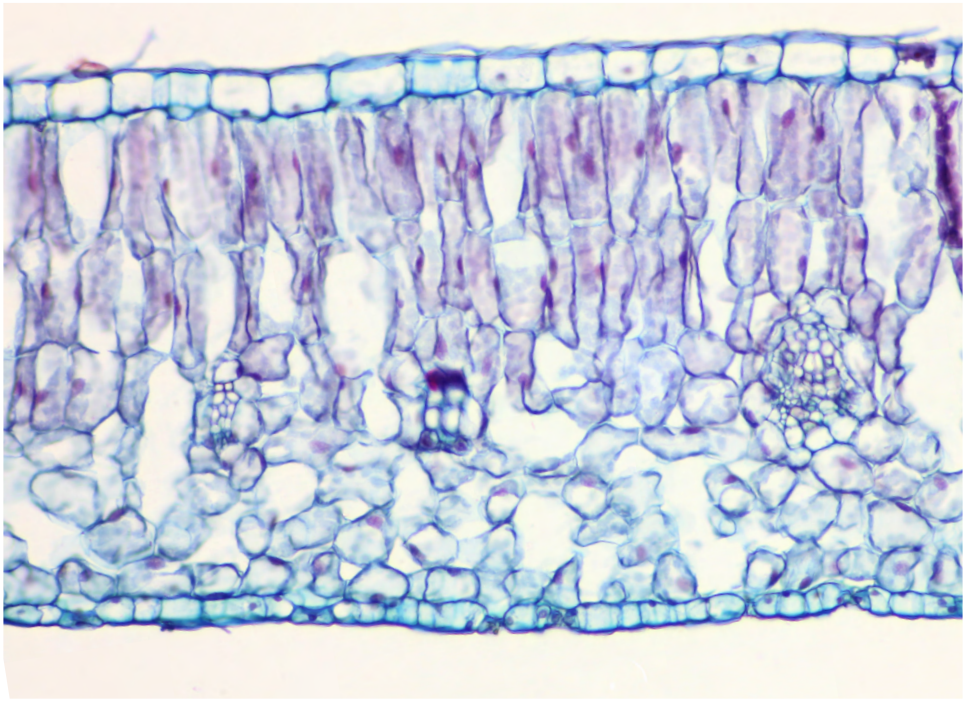

Figure 5c: Photomicrograph of a transverse section of the lamina of a sun leaf of beech taken at low power.

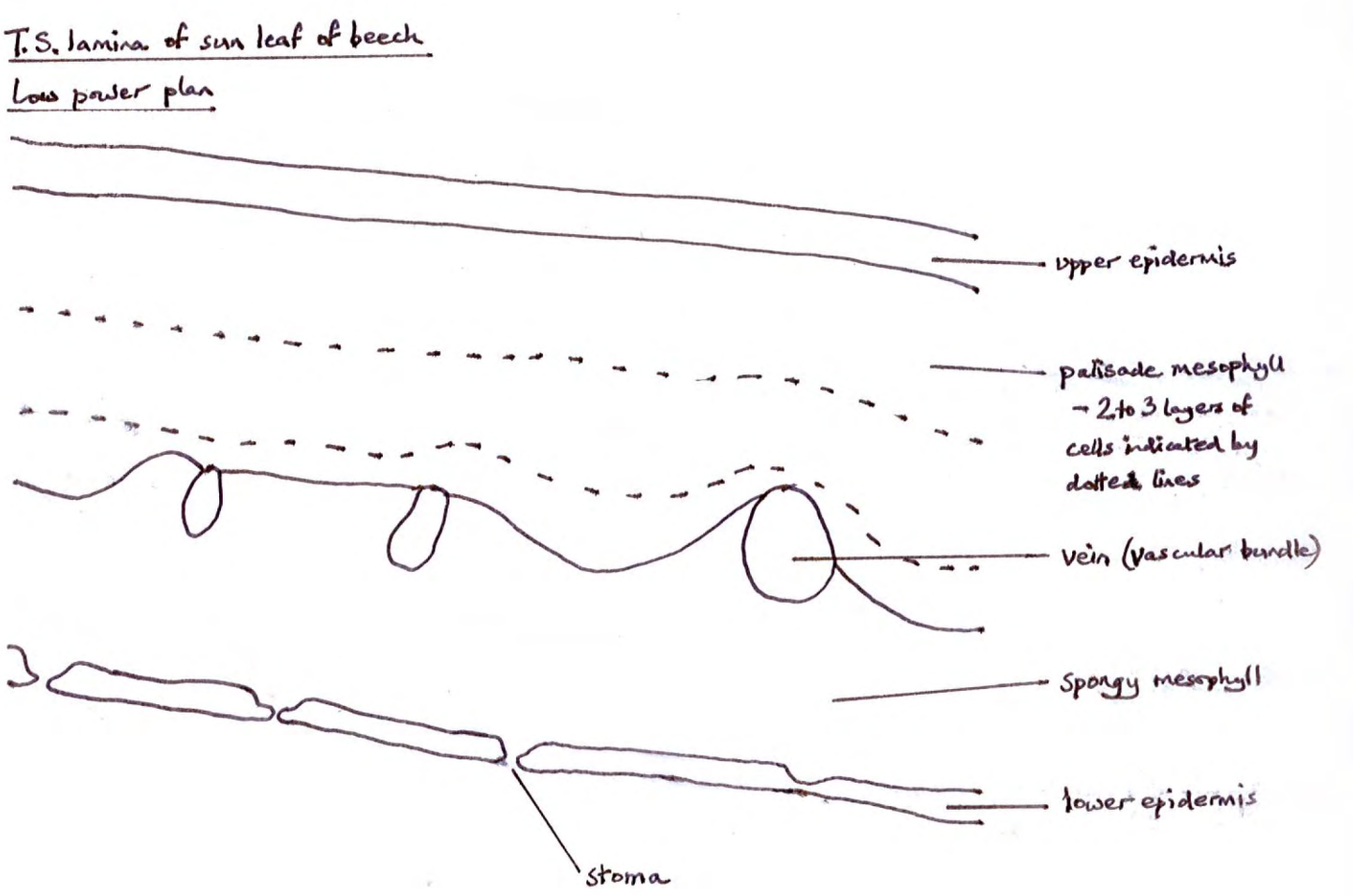

Figure 5d: This is a low power plan of the beech leaf section shown in Figure 5c drawn by a student. Again the student has correctly drawn and labelled the different tissues, rather than drawing individual cells.

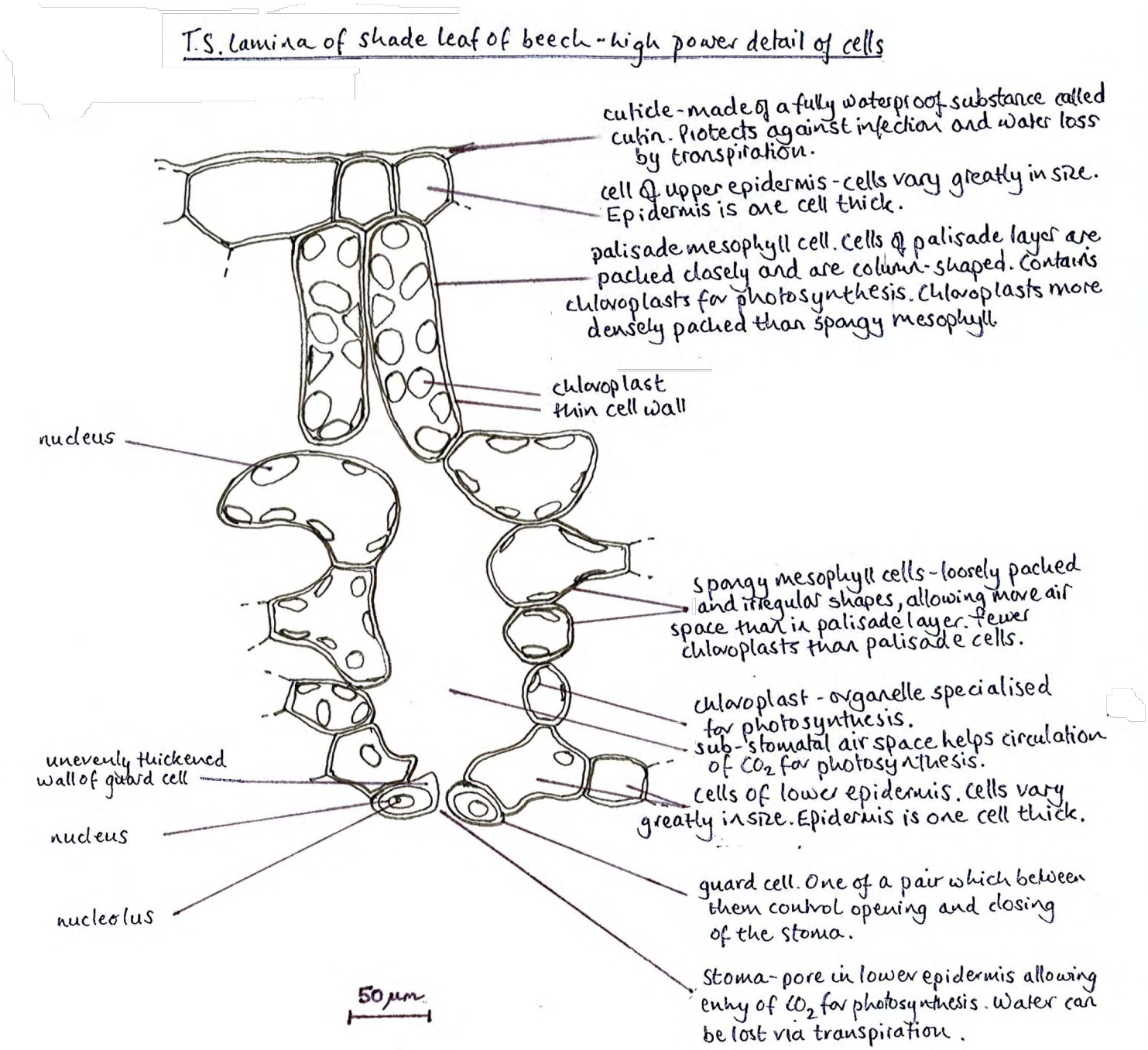

Figure 5e: This is a student drawing at high power detailing cells in a transverse section of the lamina of a shade leaf of beech (a different part of the same leaf shown in Figure 5a). The student has correctly included a title and scale bar. The student has labelled the drawing and there is good use of annotation. The drawing itself is detailed and clear. (Note: the cell walls of all the plant cells have been drawn; this is because they were visible with the microscope and slide used. It is not always possible to see this much detail using a classroom light microscope).

TEACHER RESOURCE 1 – COMMON ERRORS ACTIVITY

Figure 1 below shows a drawing of a transverse section of *Helianthus* stem at low power. The left hand half of the drawing shows some common errors that are avoided in the right hand half. Students could be asked to try to spot the errors.

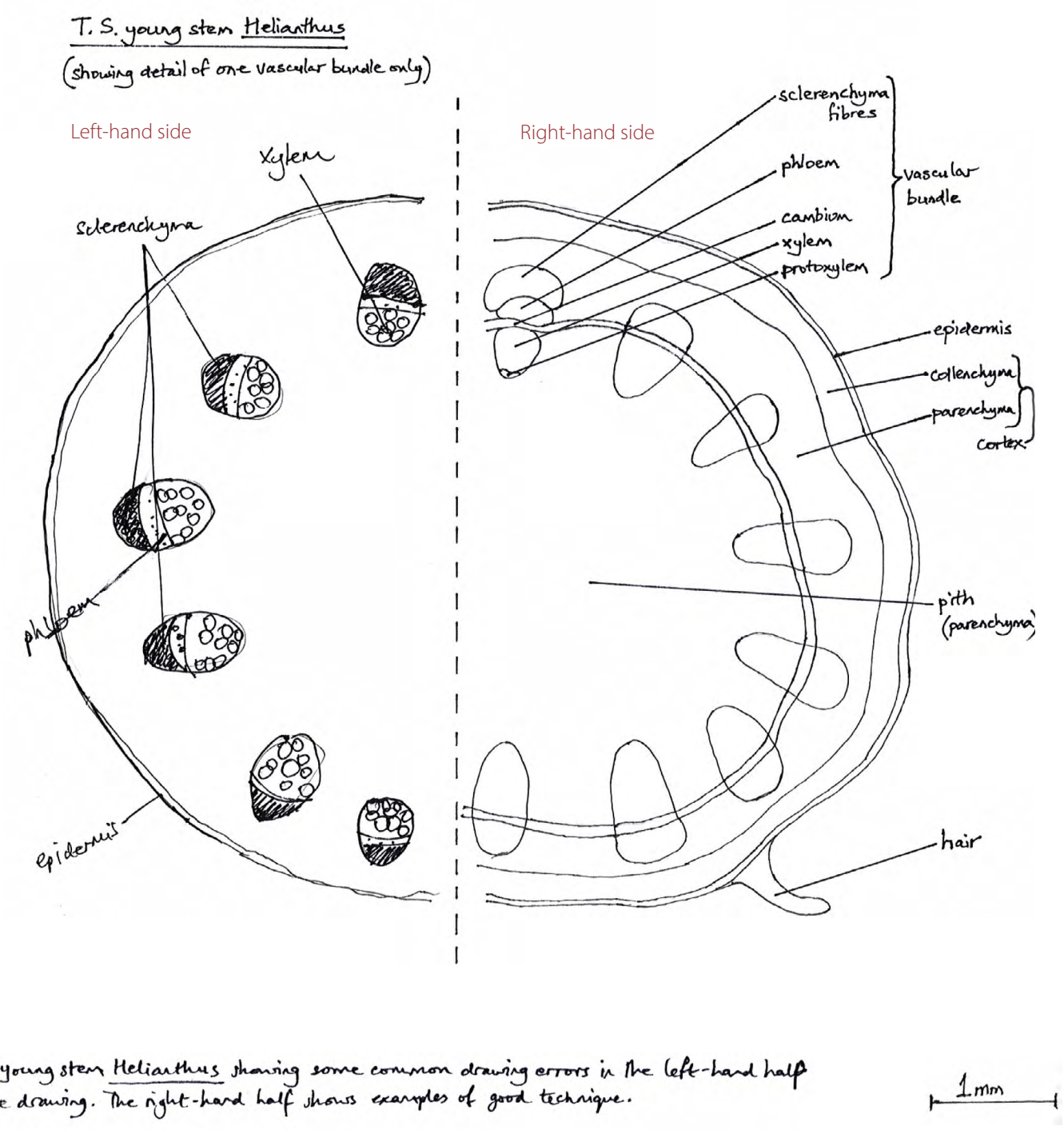

Figure 1: Transverse section of a young *Helianthus* stem showing some common drawing errors in the left-hand half of the drawing. The right-hand half shows examples of good technique.

LEARNER CHECKLISTS – GRAPHS, TABLES AND DRAWINGS

Instructions for teachers

Introduction

In line with the new DfE subject criteria for GCE Biology qualifications (available here: https://www.gov.uk/government/publications/gce-as-and-a-level-for-science), a number of practical skills will be assessed as part of the Practical Endorsement (directly-assessable practical skills) and within the examinations (indirectly-assessable practical skills). This includes presenting data and observations in graphs, tables and drawings.

All the practical skills that must be covered as part of the teaching and learning within the new Biology qualifications can be found in Module 1 of the new OCR Biology specifications:

Biology A – H020, H420,
http://www.ocr.org.uk/qualifications/as-a-level-gce-biology-a-h020-h420-from-2015/

Biology B (Advancing Biology) – H022, H422,
http://www.ocr.org.uk/qualifications/as-a-level-gce-biology-b-advancing-biology-h022-h422-from-2015/

The following pages contain three optional checklists that can be given to learners to help self-evaluate their graphs, tables and drawings.

Drawings

The following practical Learning Outcomes relate to biological drawing:

Module 1: Development of practical skills in biology (Biology A and Biology B),

1.1.2(c) presenting observations and data in an appropriate format

1.2.1(f) present information and data in a scientific way (Practical Endorsement)

1.2.2(e) production of scientific drawings from observations with annotations (Practical Endorsement).

Drawing skills are also part of many of the Learning Outcomes throughout the biological content e.g.:

2.1.1(d), 3.1.1(g), 3.1.2(e)(ii), 3.1.3(b)(ii), 4.1.1(e)(ii), 5.1.2(b)(ii), 5.1.2(c)(ii), 5.1.2(c)(iii), 5.1.4(c)(ii) (Biology A).

2.1.1(c)(ii), 2.2.1(b)(ii), 2.2.4(c)(i), 3.1.1(b)(ii) (Biology B).

Here is a checklist you can use for your drawings,

1	Your drawing and its label lines must be done with a really sharp pencil (not a pen).	
2	Your drawing should take up at least half the page / space available.	
3	Lines need to be clear and continuous – not ragged or broken – and no shading or colouring is allowed.	
4	Ensure the proportions are correct, i.e. different areas are the right size relative to each other, and that your drawing is a true likeness of the specimen that you are drawing.	
5	Label all the different areas of tissue that you have shown, writing the words in pencil or pen.	
6	Rule the label lines (in pencil). Don't let the label lines cross each other and do not write on the label lines.	
7	Make sure the label lines touch the part you are labelling.	
8	Annotations - add concise notes about the structures/features labelled on your drawing.	
9	Include a scale - add a scale bar immediately below the drawing.	
10	Include a title stating what the specimen is.	

LOW POWER TISSUE PLAN
Remember: A low power tissue plan defines the extent of areas of different tissues but does NOT show any individual cells.

Graphs

The following practical Learning Outcomes relate to graph drawing:

Module 1: Development of practical skills in biology (Biology A and Biology B),

1.1.2(c) presenting observations and data in an appropriate format

1.1.3(d) plotting and interpreting suitable graphs from experimental results, including:

(i) selection and labelling of axes with appropriate scales, quantities and units

(ii) measurement of gradients and intercepts.

1.2.1(f) present information and data in a scientific way (Practical Endorsement).

Graphs must also be covered under the biology mathematical skills requirements,
See maths skills M1.3, M1.7, M3.1, M3.2, M3.3, ***M3.4****, M3.5, M3.6.*

Here is a checklist you can use for your graphs,

S	**S**ize of the graph: does the bit with actual plotted points in take up at least half the paper?	
P	**P**lotting: is every data point within half a little square of where it should be?	
L	**L**ine of best fit: if there's a trend in your data, is it indicated with a smooth curve or straight line?	
A	**A**xes right way round: the thing you changed (independent variable) along the bottom; the thing you measured (dependent variable) up the side.	
T	**T**itle: have you included a title that tells you what this graph shows?	
A	**A**xis labels: name of each variable with the right unit symbol.	

Tables

The following practical Learning Outcomes relate to tables:

Module 1: Development of practical skills in biology (Biology A and Biology B),

1.1.2(c) presenting observations and data in an appropriate format

1.2.1(d) make and record observations/ measurements (Practical Endorsement)

1.2.1(f) present information and data in a scientific way (Practical Endorsement).

Tables must also be covered under the biology mathematical skills requirements,
See maths skills M1.3, M3.1.

Here is a checklist you can use for your tables,

1	All raw data in a single table with ruled lines and border.	
2	Independent variable (IV) in the first column; dependent variable (DV) in columns to the right (for quantitative observations) OR descriptive comments in columns to the right (for qualitative observations).	
3	Processed data (e.g. means, rates, standard deviations) in columns to the far right.	
4	No calculations in the table, only calculated values.	
5	Each column headed with informative description (for qualitative data) or physical quantity **and** correct units (for quantitative data); units separated from physical quantity using either brackets or a solidus (slash).	
6	No units in the body of the table, only in the column headings.	
7	Raw data recorded to a number of decimal places appropriate to the resolution of the measuring equipment.	
8	All raw data of the same type recorded to the same number of decimal places.	
9	Processed data recorded to up to one significant figure more than the raw data.	

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