ZNOTES.ORG

UPDATED TO 2019-21 SYLLABUS

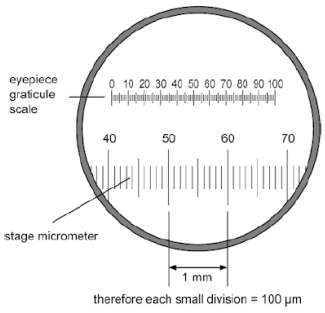
CAIE AS LEVEL BIOLOGY (9700)

SUMMARIZED NOTES ON THE PRACTICAL SYLLABUS

1. Manipulation of Apparatus, Measurements & Mathematics

1.1. Eyepiece Graticule & Stage Micrometer

- Eyepiece graticule is a transparent scale with 100 divisions, which is placed in the microscope eyepiece.
- Stage micrometer is a transparent ruler which is used to calibrate the eyepiece graticule.
- Each division on the stage micrometer is 0.01mm.
- The eyepiece graticule can be calibrated using the following steps:
  - Place a micrometer slide on the stage of the microscope
  - Focus on the micrometer scale using the low-power objective lens.
  - Move the slide and rotate the eyepiece to align the scales of the eyepiece graticule and the micrometer scale in the field of view
  - Count the number of divisions on the eyepiece graticule and compare them to a known length on the micrometer scale to figure out the length of one eyepiece unit
  - Repeat steps 1-3 with the medium-power and high-power objective lens.



1.2. Magnification & Mathematics

- Magnification, M = Image size, I / Actual size, A
- Calculating the magnification of a photomicrograph or an image
  - Measure the width of the cell in mm on the photomicrograph using a ruler
  - Convert the measurement from millimeter to micrometer.
  - Apply magnification equation, using given value of the actual size.
- Calculating magnification from a scale bar
  - Measure the given scale bar using ruler
  - Convert the measurement from millimeter to micrometer
  - Apply the magnification equation
- Calculating the real size of an object from its magnification
  - Measure the observed length of the image in mm using a ruler
  - Convert the measurement from millimeter to micrometer
  - Apply the equation to calculate the actual length, using given value of the magnification.
- When counting in grids, count half squares and full square as one square. The final answer should be a whole number or 0.5.
- Smaller grid size increases accuracy of measurements.
- The calibrated eyepiece graticule can be used to measure the diameter of a certain area of field view. It can then be used to find area of field view.
- It can be used to measure lengths of cells in certain areas.
- Take at least 5 measurements to increase accuracy of results.
- $\%\ \text{error} = \frac{\text{No. of readings} \times \text{Half of smallest scale division}}{\text{Total reading}} \times 100\%$
- $\text{Mean} = \frac{\text{Sum of data}}{\text{No. of data}}$
  - Useful for replicated readings.
- $\text{Gradient} = \frac{\Delta y}{\Delta x}$, where Δy & Δx are height and width of triangle.
- Draw right-angled triangle from 2 points on straight line graph or tangent of curve; Ensure that triangle exceeds half of graph.
- $\%\ \text{change} = \frac{\text{Final} - \text{Initial}}{\text{Initial}} \times 100\%$
- It makes comparing easier by negating effects of differences in initial readings between samples.
- Error in a measurement is half of the value of the smallest division on the scale you are reading from.
- If you read from two positions in the scale, i.e., initial, and final reading, the error is multiplied by 2 because error in measurements can occur twice
- To calculate percentage uncertainty, use the equation:

$$\text{percentage of uncertainty} = \frac{\text{uncertainty}}{\text{actual measurement}} \times 100$$

1.3. Variables

- Independent Variable is the factor whose values are decided (and can be changed) by the experimenter. It is plotted on the x-axis of the graph. (**Bold** in examples)
- Dependent Variable is the factor whose results need to be collected during/after the experiment. These results are out of control. It is plotted on the y-axis of the graph. (*Italics* in examples)

- **Enzyme concentration** on the *rate of activity of rennin*
- **Temperature** effects on the *rate of activity of catalase*
- **Surface area** effects on the *rate of diffusion*

- Concentration of a solution effects on the *percentage of onion cells that become plasmolysed.*

- Standardized Variable is the factor that can affect the rate of reaction, reducing the reliability of the experiment. It is also known as control.
- Quantitative tests require numerical measurements to be taken.
- Qualitative tests require the quantification of observation, i.e. the presence or absence of starch in a sample after performing the starch iodide test.
- Semi-quantitative tests are used to confirm the presence of certain chemicals in a sample, and their approximate concentration. In Benedict's test, red colour shows presence of sugar in high concentrations, whereas yellow colour shows presence of sugar in low concentrations

1.4. Common Errors in Experiments

- Difficult to judge/compare colour/colour change using colour charts.
- In experiments that use water-baths, temperature of the test tube falls when it is removed from the water bath.
- Fast changes in colour/formation of bubbles can cause errors in timing, i.e., stopwatch started/stopped late/early.
- Difficult to start/stop stopwatch and add/remove samples at the same time.
- Difficult to judge and count the number of cells that are plasmolysed.
- In experiments where length/width/diameter of specimen is measured, error occurs due to difficulty in focusing both ruler and specimen at the same time; parallax error; thickness of ruler lines.
- In immobilizing enzyme reactions, error can occur due to sodium alginate beads:
  - sticking to the sides of the tube
  - sticking together with those already dropped
  - floating up under each other
- In experiments that require shaking of test tubes, errors can occur due to uneven shaking/varying forces used to shake the tubes.
- Errors can occur due to different sizes of bubbles, difficulty in counting number of bubbles (fast formation).
- In experiments that require formation of drops using syringe, error due to different sizes of drops as pressure applied on the syringe.
- In experiments that require measurements to be made using eyepiece graticule and stage micrometer, errors can occur due to
  - Difficulty in judging the edge of the specimen
  - irregular shape of specimen.
- Errors can occur due to decrease in Hydrogen peroxide concentration if left open, as H_2O_2 degenerates.
- Errors can occur if test tubes used are not dry, as droplets on water on sides of test tube can reduce experiment's reliability.
- Systematic errors occur throughout the experiments, as they result from uncertainties in measurements.
- Random errors differ across experiments as they arise due difficulties in controlling standardized variables and measurements of dependent variable.
- Anomalous readings are too low/too high/does not fit the trend and are usually discarded, and the experiment repeated.

1.5. Modifications & Improvements of experiments

- To standardize temperature, use thermostatically controlled water bath
- Use colorimeter instead of colour chart to compare colours.
- Use buffer solutions to standardize pH, datalogger and pH sensor to measure pH.
- Use same size/shape/volume/mass/surface area of the prime sample of investigation (e.g. potato strips/leaves) from the same plant/potato when experimenting for effects of other independent variables on the strips/leaves.
- Use larger numbers of the prime sample of investigation (e.g. potato strips/leaves)
- Use digital balance to measure mass accurately.
- To keep surface area constant, use Vernier calipers to measure lengths and sharp scalpel to cut (e.g. potato strips).
- Use graduated pipettes to measure small volumes of solution accurately.
- In Benedict's tests, heat samples for the same amount of time.
- Carry out experiments for the same amount of time if time is not the independent variable. To do this, stagger start or carry out experiments separately.
- Carry out experiments at wider ranges of temperature/concentrations (at least 5)
- Make wider ranges of concentration using serial or simple dilutions.
- Repeat experiments at each temperature/concentration 3-5 times AND take the mean of results.
- Keep volumes of solution same throughout all the repeats (using graduated pipette/burette).
- During Benedict's tests, keep temperature at around 80-100 degrees Celsius.
- Use same volume of Benedict's solution in all tests.
- Cover H_2O_2 with lid/aluminum foil to prevent degeneration.
- Dry test tube with white towel or use new test tubes before starting each experiment
- To prevent evaporation, use rubber bungs in test tubes or cover the containers (air-tight).
- To standardize the position of delivery of solution into a test tube, make a mark on the test tube.
- Use magnetic stirrer to prevent errors caused by uneven shaking of test tubes.

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  - increase evaporation rates in experiments
  - Increase temperatures using thermostatically controlled water bath.
  - Increase wind speed using fan (keep fan speed constant).
  - Decrease humidity using fan or
    - (calcium/sodium/potassium) hydroxide/chloride/oxide
    - Silica gel/drying agent
    - dehumidifier
- In experiments where oxygen is released, gas syringe can be used to collect oxygen; oxygen sensor can be used to detect oxygen produced.
- Burettes can be used to make drop sizes similar since pressure is not applied as in syringes.
- To control the effects of light intensity, the lamp can be set at a constant distant/power.
- Place a container of water in front of the lamp to act as a heat shield.
- Alter light intensity by increasing power or adding more identical lamps.
- Other standardized variables include mass, concentration, volume, source, age, storage, conditions, and genotype of sample depending on the requirements of the experiment.

1.6. Quality of Measurements

Term	Explanation	Improvement
Accuracy	Closeness to true value	Better instruments
Precision	Closeness to repeated readings	Control all variables
Reliability	Confidence in results	Repeat readings and take mean
Validity	Agreement between hypothesis and investigation	Check relation between key and derived variables

1.7. Methods of dilution & Slide Preparation

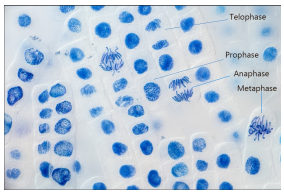
- Two common types of dilution are:
  - Simple, where a stock solution is diluted by different ratios:

STOCK solution		Volume of H_2O added / cm^{-3}	Final solution	
Conc. / mol dm^{-3}	Volume / cm^{-3}		Conc. / mol dm^{-3}	Volume / cm^{-3}
1.0	80	2.0	0.8	10.0
1.0	6.0	4.0	0.6	10.0
1.0	4.0	6.0	0.4	10.0
1.0	2.0	8.0	0.2	10.0

2. Photomicrographs of Specimen & Biological Drawings

2.1. Common Photomicrographs

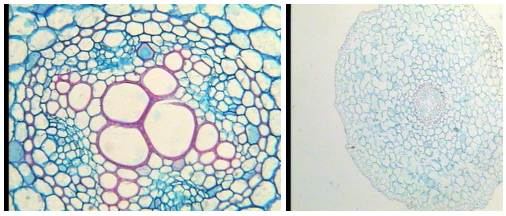
Mitosis



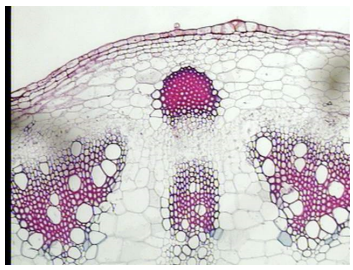
Early Anaphase

Late Anaphase

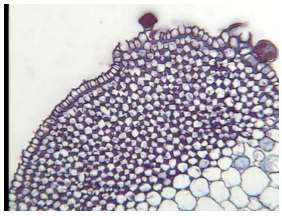
Transverse Section of Root



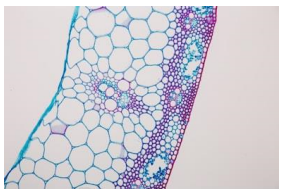
Transverse section of Stem



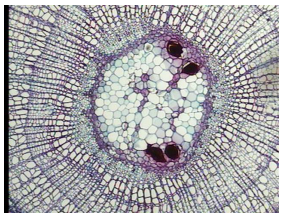
Stem Collenchyma



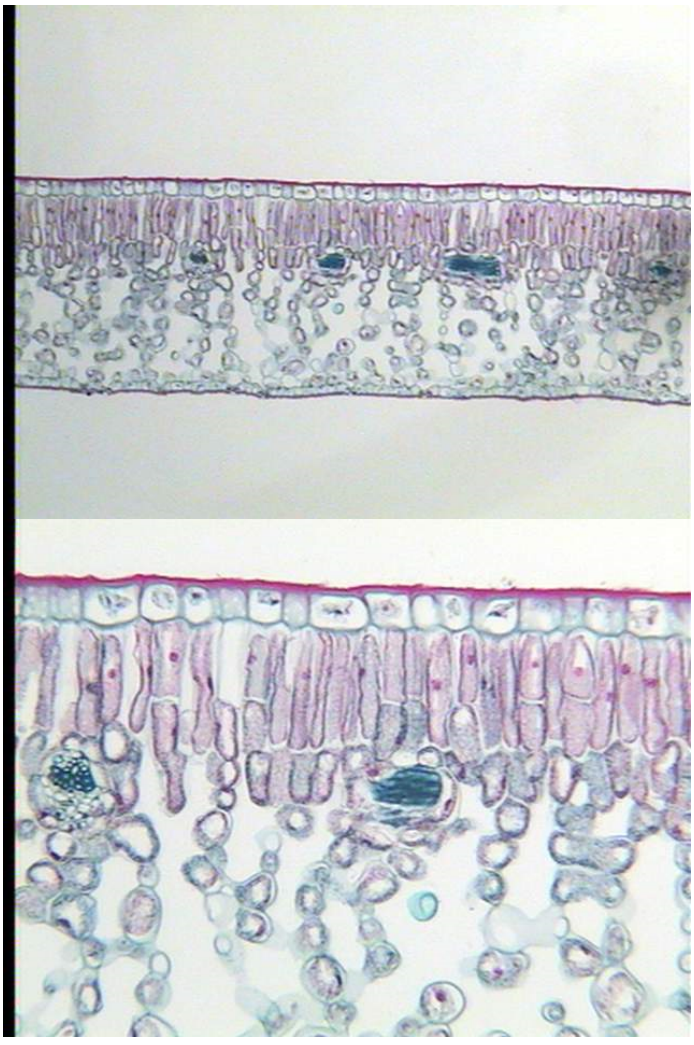
Sclerenchyma



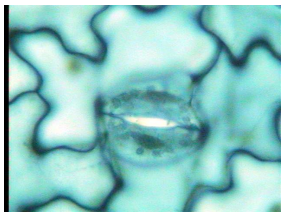
Pith of Stem



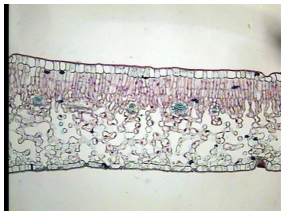
Transverse section of Dicot Leaves

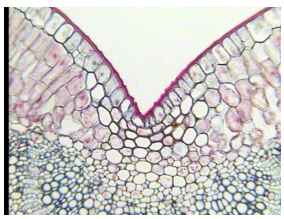


Transverse section of Guard Cells

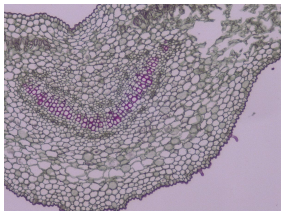


Transverse section of Mesophytic Dicot Leaves

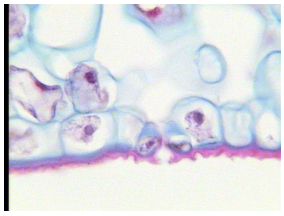




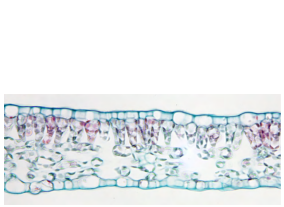
Transverse section of Xerophytic Leaves



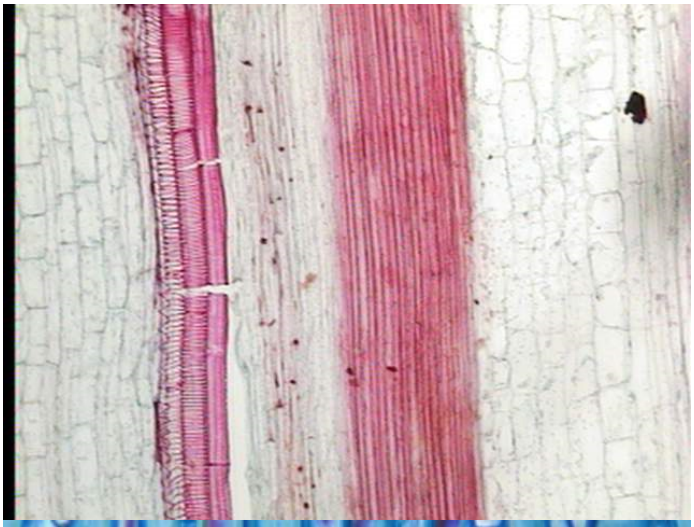
Transverse section of Stomata

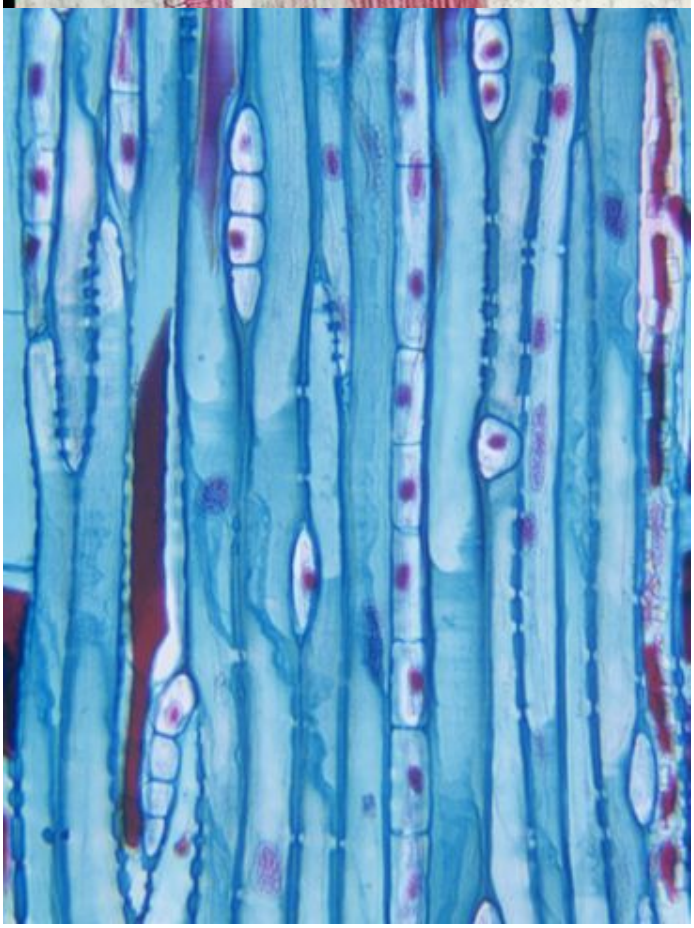


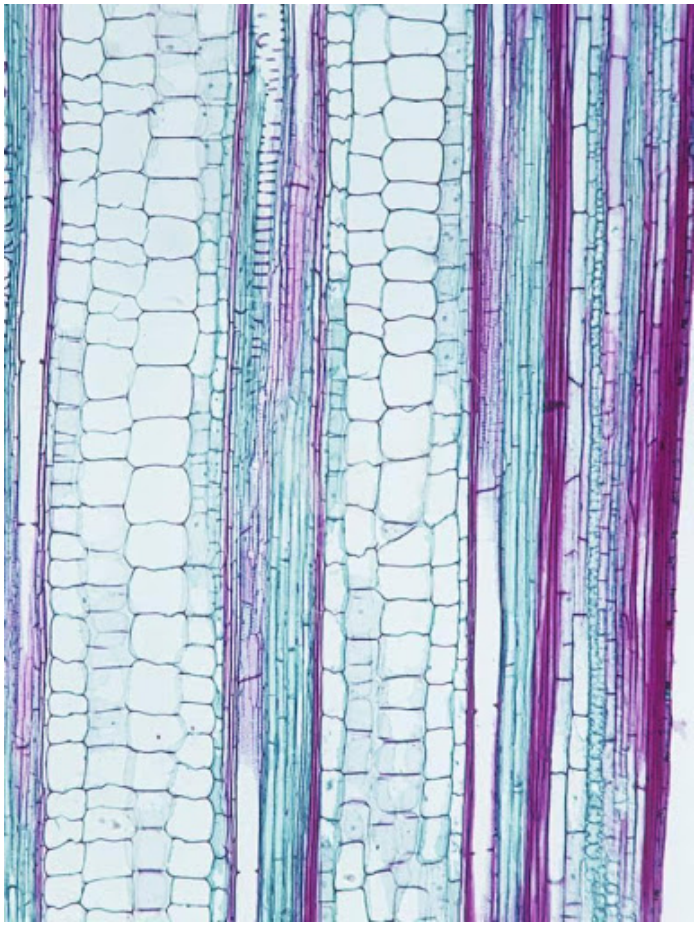
Transverse section of Lamina



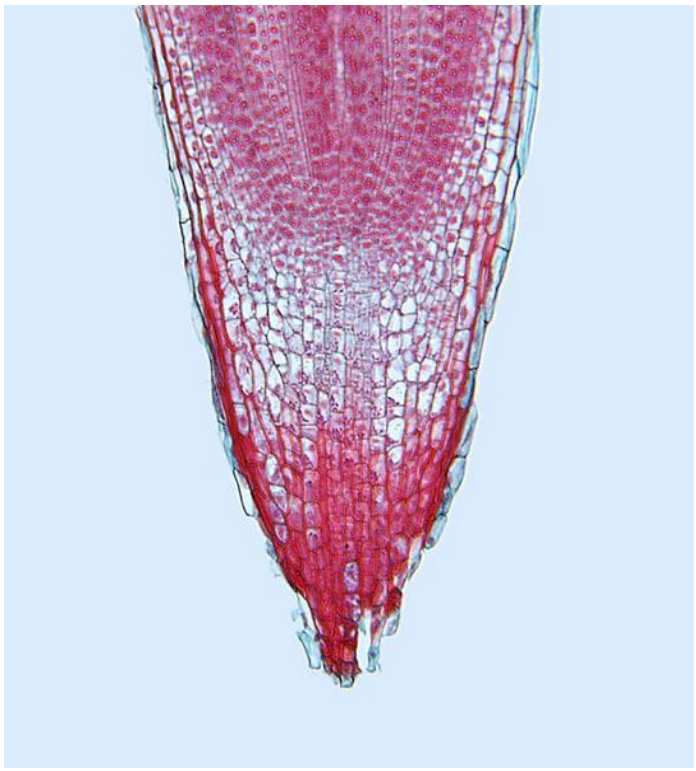
Longitudinal section of Stem

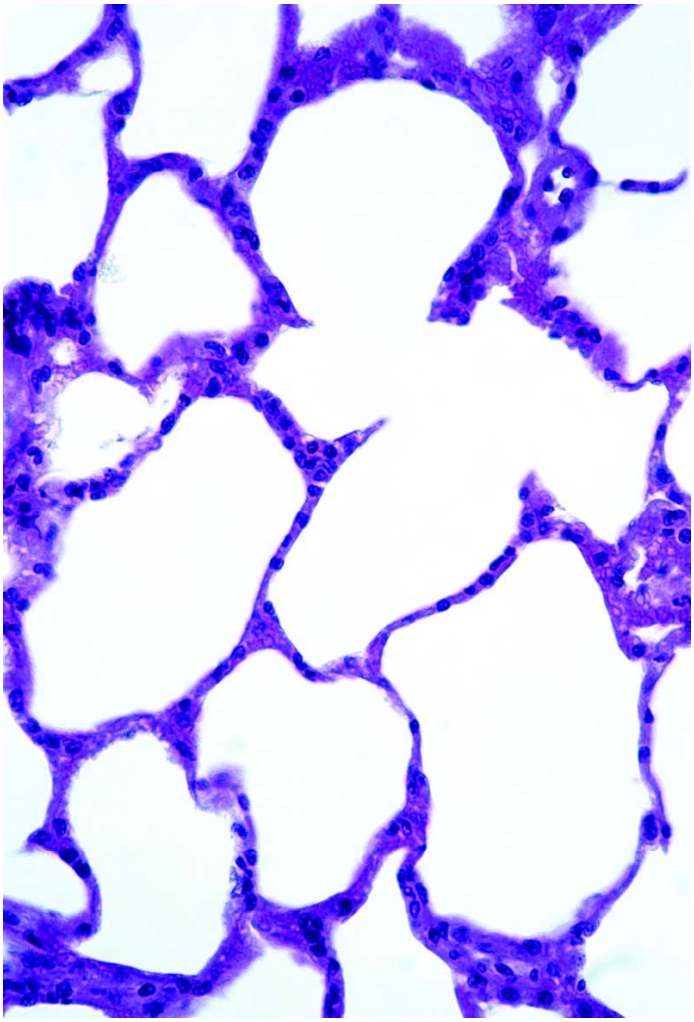




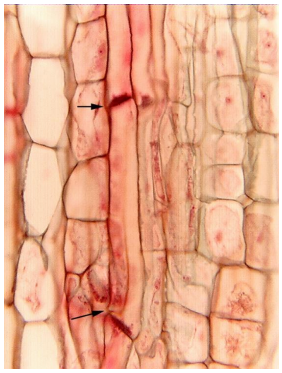


Longitudinal section of Root'

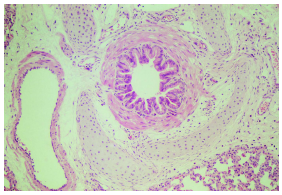


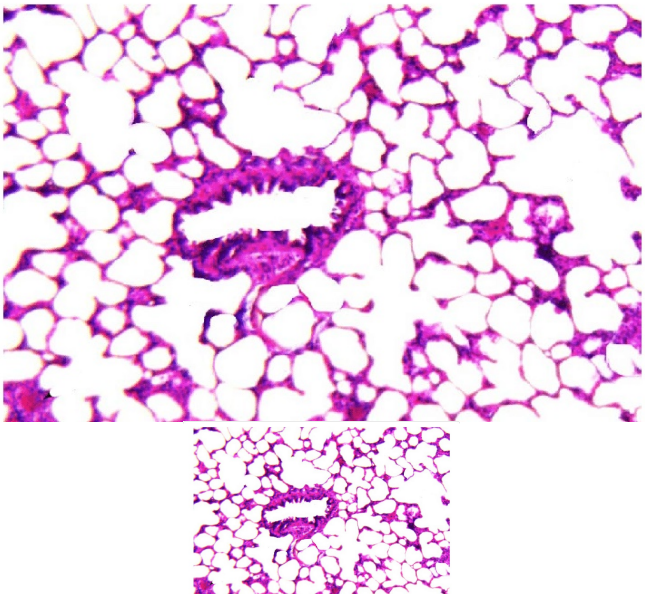


Sieve Tubes

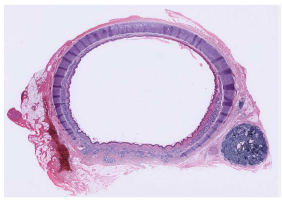


Transverse section of Lung, Lung tissue and Alveoli

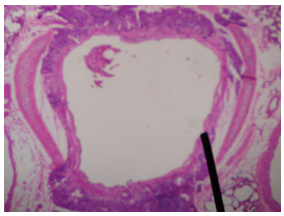




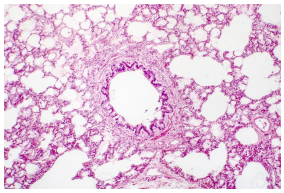
Transverse section of Trachea

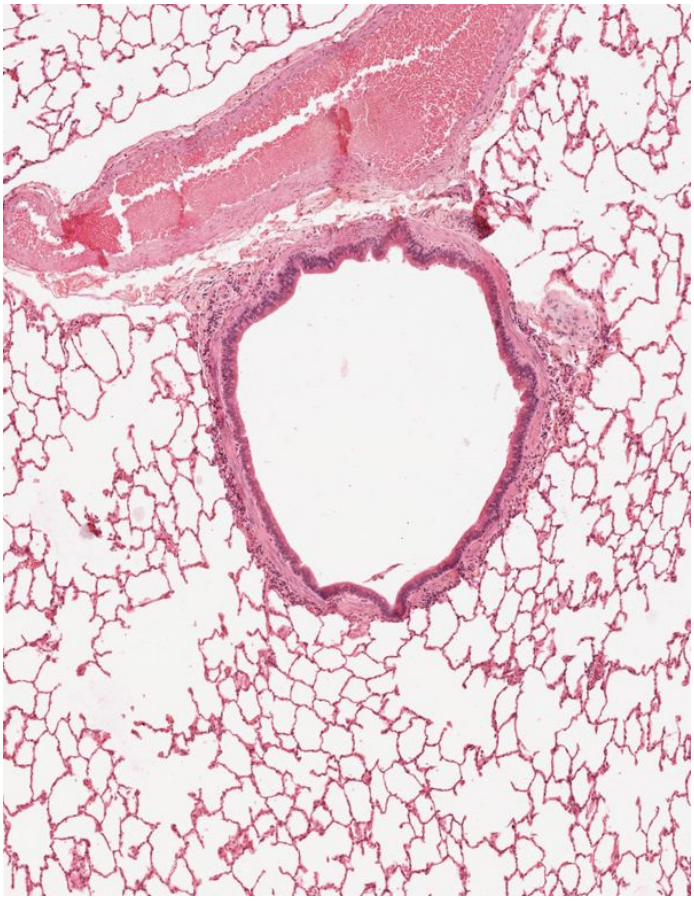


Transverse section of Bronchus

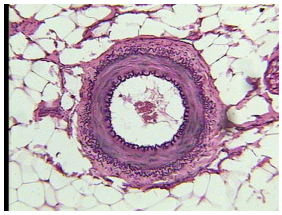


Transverse section of Bronchiole

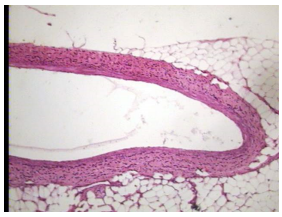




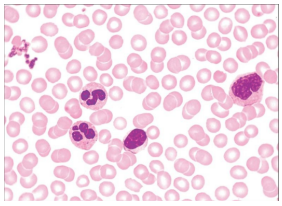
Transverse section of Artery



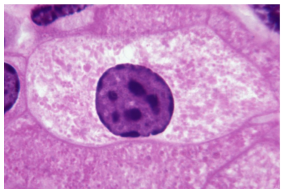
Transverse section of Vein



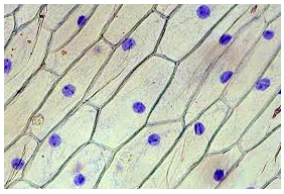
Blood Smear



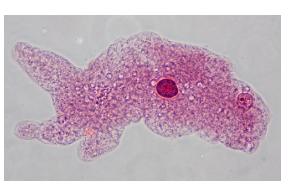
Animal Cell

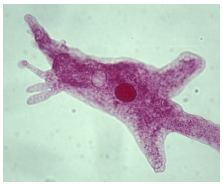


Plant Cell



Protoctists (Amoeba)





2.2. Biological Drawings

- Draw in clear, unbroken lines. Do not sketch.
- Label using straight and horizontal lines.
- Low power diagrams
  - Identify the different tissues, using high power to help if necessary.
  - Draw all tissues and completely enclose each tissue by lines.
  - Do not draw individual cells.
  - Accuracy is important. Do not draw from imagination. Draw only what you see.
- High power diagrams
  - Make large drawings of cells.
  - Draw the nuclei but do not shade it

3. Presentation of Data & Observations

3.1. Tabulating Results

- Draw table with neat, ruled pencil lines.
- Give each column suitable heading (Quantity/SI unit)
- Arrange columns in order: independent, dependent & derived variable.
- Round data to same number of decimal places to maintain consistency.

3.2. Plotting Graphs

- Decide type of graph:
  - Line graph (Both variables are continuous)

  - Histogram (Independent variable is continuous)
  - Bar chart (Dependent variable is continuous)
  - Bars touch in histograms only, not in bar charts.
- Independent variable at x-axis and dependent at y-axis.

- Use linear scale with sensible (1s, 2s, 5s, 10s, ...) intervals.
- Axes do not have to stand out. If they do, a break should be indicated.
- Use more than half of the graph paper provided.
- Label each axis fully, according to variable's column heading.

- For line graphs:
  - Plot points with ⨯ or ⊙ marks.
  - Join successive points with straight lines.
  - If there is a clear relation, draw smooth wave, or line of best fit.
  - Do not extrapolate the line.

3.3. Describing & Interpreting Data

- Describe overall trend.
- Comment on changes in gradient.
- Quote figures with units to support claim.
- Avoid phrases that suggest something is happening over time unless it is the independent variable.
- Draw a conclusion by connecting it to description using theoretical reasoning.
- Conclusion should be simple, clean, focused and scientifically explainable statement describing deduction regarding the hypothesis from results.

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Biology (9700)