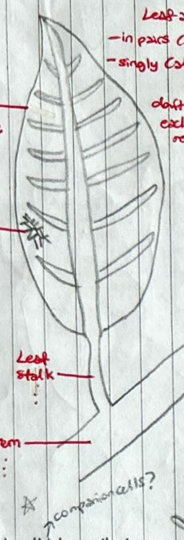
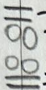
CH12 - PLANTS

(Know how to draw)
External Structure of a Leaf



Leaf arrangement
- in pairs (opp 80)
- singly (alt. arrangement)
↓
don't block ☼ each leaf receives sufficient light

see diagram.
Stomata present



tissue 1 : palisade m.
tissue 2 : spongy m.

Contains chloroplasts that contain chlorophyll in all m. cells

main site of PS between epidermal layers.

funct2: absorbs energy from light and transfers it to chemical stores of energy in glucose molecules

absorbs light energy and converts it to chemical energy for the formation of carbs & subs. uses ★

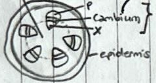
- check SEA (cloud)

> Leaf — How it looks like — Vascular bundle { Xylem / Phloem }

t.s. - see diagram
l.s.

V. bundles ring around
pith: center of stem

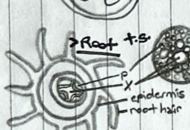
> Stem t.s.



group tgt: vascular bundle

layer of actively dividing cells [like bone marrow]
↳ ↑ thickness (stem cells)

> Root t.s.



- P & X not bundled tgt
- located at centre of root.

X & P alt w/ e.

↗ companion cells?

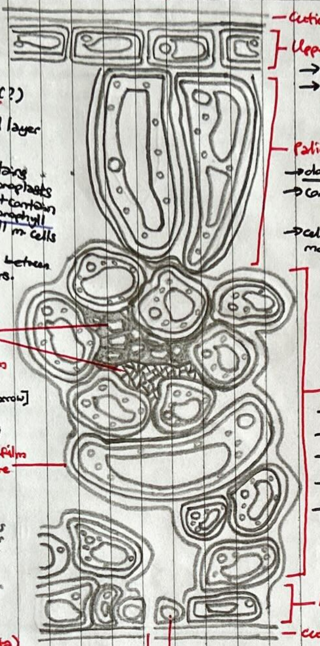
X · has thicker walls due to lignin.
· lumen is larger than surrounding cells
· above phloem

diff ← diff amt lignin
support ↑ diff designs

Cellular and Tissue structure

· Transverse section using a light microscope

see what ↗↗ × ?



· Features | · Significance to functions

- Cuticle → ① transparent & ② waxy
  - ① - allow ☼ to enter [for PS]
  - ② - reduces (excessive) water loss thru evaporation from epidermis [wilting]
- Upper Epidermis
  - → single layer of closely packed cells — outermost layer — protects internal structure of leaf (✗ mentioned)
  - → covered on outside by cuticle
- Palisade Mesophyll
  - → closely packed long, cylindrical cells
  - → contains more chloroplasts than lower (most in leaf) — more light can be absorbed near upper leaf surface (↑ cause upper → more exposed)
  - → cells covered by thin film of moisture
  - (↑ est rate of PS)

Palisade M.	Spongy M.
Both are covered by a thin film of moisture.	
Both contain chloroplasts.	
Contains more chloroplasts	Contains less chloroplasts
closely packed long cylindrical cells	Loosely packed irregularly-shaped cells

situated close to trans tissue.

- Spongy Mesophyll
  - → loosely packed irregularly-shaped cells
  - → contains fewer chlpt than palisade m.
  - → has numerous large intercellular air spaces (interconnecting system of) — allow rapid diffusion of CO_2 and O_2 into & out of mesophyll cells.
  - → cells covered by a thin film of moisture
  - → Situated close to veins containing transport tissue (xyl, phl)
    - xylem → transports ~~salt~~ H_2O & mineral salts to mesophyll cells
    - phloem → transports sucrose away from leaf
- Lower Epidermis — see upper epidermis
- cuticle — see above

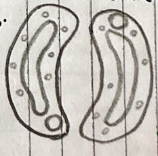
Stoma (exp)
→ openings found on both up & low epidermis
↳ usually more on lower → harder to get blocked
→ generally opens in light & closes in dark
↳ based on turgidity of guard cells
allow CO_2 to diffuse in / O_2 to diffuse out of leaf

Guard cell
→ one pair surrounds each stoma
→ contains chloroplasts — can PS (unlike lower epi cells)

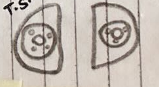
function:
→ controls rate of movement of gases like O_2, CO_2, H_2O(g) by opening and closing the stoma.

? fully close = ✗✗/✗ ★

L.S.



T.S.

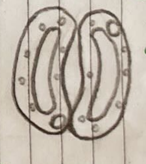


^ open in presence of light (turgid)

Guard cells PS in light
↓
produce glucose
↓
wp ↓ than surrounding epi cells
↓
water enters GC by osmosis down conc gradient. thru ppm (CM)
↓
GC swells, becomes turgid
↓
curve inwards → stoma opens #

↗ osmosis → H_2O

not caused by transpiration



^ closed in no light / (flaccid)

GC respire aerobically at ✗ light
↓
uses up glucose
↓
wp ↑ than surr. epi. cells
↓
water leaves GC by osmosis down conc grad. thru PPM
↓
GC becomes flaccid
↓
stoma closes #
↖ GC flaccid
↑

* Very hot day → leaf loses too much H_2O to atmosphere

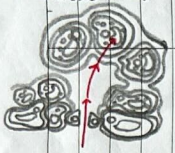
	Consists of:	function:	adaptation:
Xylem	~~Sieve tubes and companion cells~~ Xylem vessels	① transports water & dissolved mineral salts from roots → stems → leaves	X vessels ★ → long hollow tubes, X cross-walls, protoplasm ↳ continuous lumen ↳ reduce resistance to flow of water #
		② Provides mechanical support for the plant ↳ keep plant upright → max. ☼	inner walls → strengthened by deposits of lignin ↳ prevent collapse of vessels #
Phloem	~~Xylem vessels~~ Sieve tubes and Companion cells	Transports food (mainly sucrose & a.a.) from leaves (green parts of plant) to other parts of the plant by Translocation. (ch3 food test)	· sieve tube ↳ consists of a column of s.t. cells; have a thin layer of cytoplasm ↳ reduce resistance, allow rapid flow of substances # · sieve plate - sep. st. cells ↳ a lot of pores ↳ reduce R.

l.s.

· Companion cells - beside s.t. cells
→ provide nutrients to st. cell.
→ numerous mitochondria
↳ release energy (a lot of) to load sugars from mesophyll cells into s. tubes by AT. #
↳ translocat2

CO_2 (from air to mesophyll cells) — chloroplasts of mesophyll cells — During the day

Path
*know arrows (draw)



↑ PS
↓
CO_2 in leaf used, ↓ conc of CO_2 in leaf as compared to atm.
↓
CO_2 from atm diffuses into the intercellular air spaces via the stomata, down a conc grad.
↓
CO_2 dissolves into thin film of moisture/water coating the surfaces of mesophyll cells
↓
Dissolved CO_2 diffuses into the cells to reach the chloroplasts #

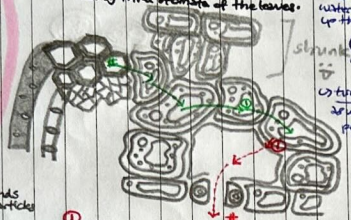
PS: carbon dioxide + water —(light, chlorophyll)→ glucose + oxygen

process: evap diffusion
• TRANSPIRATION

importance:
① evap of water ↳ cools plant

#2: inside plant to air.

def: Transpiration is (process) the loss of water vapour from aerial parts of the plant, mainly thru stomata of the leaves.



② causes ↑ pull ↳ major suction force for moving water & mineral salts up the xylem
③ Water is required at ⓟ for PS
↳ turgidity maintained ∴ water lost in aerial portions of plant is replaced
↳ keeps leaves spread apart to trap light for PS
↓
turgidity
leaves, guard cells

① Water moves out of mesophyll cells to form a thin film of moisture surrounding the cells.
↓
The film evaporates to form water v. in the intercellular air spaces
↓
accumulate → ↑ conc. of water v. (saturated w water)
↓ (cause)
water v. diffuses thru stomata to outer air outside the leaf. #

#3: inside plant
Transpiration Pull — osmosis
① As H_2O evaps from thin film of moisture, more water moves out of mesophyll cells to replenish it.
↓
↓ ψ of cell sap ⓟ as compared to neighboring cells
↓
mesophyll draw water from cells deeper inside the leaf by osmosis ↓ ψ grad
↓
Cells deeper inside leaf draw water from xylem by osmosis ↓ ψ grad. #
↓
Creates a suction force which pulls the whole column of water up the xylem vessels (transpiration pull)

rate of water absorpt?
how to measure: no words, no problem
potometer — parts
• water reservoir — rubber stopper
• tap (closed during use)
• graduated measuring capillary tube (cm³) — measure vol. of water lost
cork — no evap from water surface
How does it work? (can absorb H_2O, ions (?))
Duh, H_2O conc out?
spring balance.
oil
water
mass loss / time ?
alt ↳ petroleum jelly ↳ prevent water loss from stomata

Assume rate of water absorpt is proportional to rate of transpiration

Rate of transpiration = Vol. of water lost / time taken = cm^3/min

factors affecting rate of transpiration:

① air temp
↑ air temp
↓
↑ rate of evap of water from cell surfaces (?)
↓
↑ rate of transpiration #

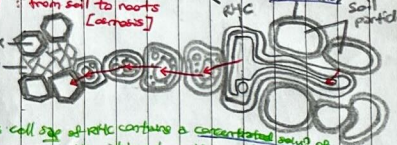
② air humidity
↑ humidity outside ⓟ
↓
gentler grad of conc of water between intercellular air spaces & outside
↓
↓ rate of transpirat? #

③ wind
↑/ presence of wind
↓
blows away water v. outside stomata
↓
steeper water v. gradient between inside & outside of leaf
↓
↑ rate of transpiration #

④ light intensity
↑ LI.
↓
stomata open wider — see ROI.
↓
more water v. evaporate out of leaf
↓
↑ rate of transpiration #.

WATER

#1 : from soil to roots [osmosis]



grows thin soil p.s, close contact with soil solu?
narrow extension of epidermal cell
sap ↑ up than RHC
film of liquid surrounds soil particles
(dilute solu of mineral salts)

As cell sap of RHC contains a concentrated solu of sugars and salts, it has ↓ up than soil solu?.
↓
∴ water enters RHC by osmosis thru ppm cell m. down conc grad. w.p.
↓
Entry of water-diluted cell sap of RHC ↳ has higher up than next inner cell
↓
∴ Water moves from outer RHS to inner cell by osmosis thru ppm, down grad...
↓
This process continues to next inner cell until water enters xylem vessels in root.

mineral salt & water absorption
RHC Adapt

Water	Mineral salts
osmosis	diffusion & AT → conc ↑ in cell sap

① root hair is long & narrow
↳ ↑ SA : V for faster rate of absorption of water & m.s.
② cell membrane ✓
↳ prevents leakage of cell sap
↳ allows water to enter cell by osmosis down ψ.c. grad.
③ many mitochondria
↳ carry out a. resp. → release energy — AT of ions into cells (moving against conc grad)

soil solu ↓ w.p. than RHC when air v. dry

Wilting 101
when rate of transpiration is ↑ than rate of water absorption by roots.
↓
guard cells, mesophyll cells in leaf lose turgor → flaccid
↓
leaves become flaccid and droop
+
soft stems become limp

+ve (Leaf droops)	↓ water loss	−ve (Leaf droops)	↓ rate of PS
① SA exposed to ↑ O. ↓	↓ water loss thru transpi. #	① ↓ in SA exposed to ☀	↓ rate of PS #
② Guard cells flaccid ↓ stomata close ↓	↓ water loss thru transpiration #	② Guard cell flaccid ↓ stomata close ↓	↓ amt of CO_2 entering ⓟ ↓ rate of PS #

No:

Photosynthesis

process 2:

definition

- An enzyme-catalysed process in which — LF③
- light energy is absorbed by chlorophyll
- and converted to chemical energy (glucose).
- Carbon dioxide and water are ☆ used for the synthesis of glucose.
- Oxygen is released as a by-product.

importance in ecosystem

— See Ch13 ecosystems

most forms of life are completely dependent on PS

① Plants are producers in foodchains that are able to convert Light energy into chemical energy (glucose) so that other forms of organic nutrients like fats and protein can be formed from these carbohydrate molecules ⇒ Become food for other organisms in food webs/chains. #

② PS removes CO_2 from the air + produces O_2 at the same time
⇓ O_2 used by living organisms in respiration # → release energy for cell activity.
⇒ maintains constant lvl of the 2 gases in the air # → greenhouse effect

All Energy from fossil fuels ③ comes from the sun # captured from PS → coal, oil, natural gas (chem: organic chem)

equations ☆

experiments

(in words & symbols) ☆

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{light — LF①}} C_6H_{12}O_6 + 6O_2$$

LF②

carbon dioxide + water → glucose + oxygen

- carbon dioxide ↙ see Pg 2 (diffuse into leaf)
- water ↓ See Pg 2 (transpiration pull)
- glucose ↓ translocation
- oxygen ↓ diffuse out of leaf?

Limiting Factors

↗ pH

→ experiments.

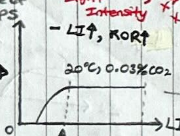
def: Any factor that directly affects the rate of a process/chemical rxn, if its value is changed.

LF① Light Intensity

× amt of light × brightness

— LI↑, ROR↑

Describe graph:
As LI↑, ROPS↑ until a constant rate is reached (at A).



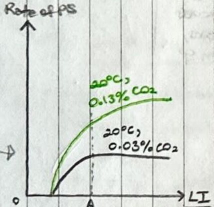
- At 0 to A, ↑ in LI = ↑ in RO PS
  ∴ LI is a LF
- Beyond A, ↑ LI but ROPS remains constant
  ∴ LI no longer a LF.
  ↳ some other factor becomes limiting — CO_2 — temp

LF② Carbon Dioxide Concentration

~0.04% CO_2 in atm

× amt!

— CO_2 conc↑, ROR↑



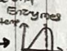
Beyond A, temp is constant ? ☆
LI is same across graphs
but ↑ in CO_2 conc results in RO PS ↑ (quote data)!
∴ CO_2 is LF.

↑ can't say for 0 to A - since LI might be LF (unconfirmed)

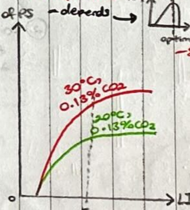
LF③ Temperature

— See Ch4 Enzymes

— depends →



— See behind →



Beyond E, CO_2 conc constant, — data!
LI is same across graphs
but ↑ in temp (from 20°C–30°C) results in ↑ in ROPS.
∴ Temp of surroundings is LF.

LF 101:
- only 1 variable changed
  ↓
  ↑/↓ in ROPS
  ↓
  ∴ changed variable = LF
- ONLY compare ≥2 graphs at one time
- quote data!!

Translocation

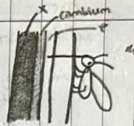
☆ see Ch3 Nutrient — how glucose is transported in phloem? — mainly sucrose, a.a. — see Pg1-phloem

def: The transport of manufactured food in the phloem, from leaves to other parts of the plant.

☆ ⇓ How? AT? → sugars (why?) diffusion? ... ?

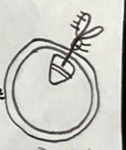
illustrated thru → **Translocation Studies**

① Aphids



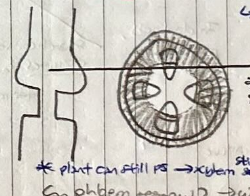
^ Aphids feed on plant juices by inserting their stylets into the leaf / stem

Fluid that exudes from cut end of stylet of a feeding aphid
↳ analysis shows sucrose & a.a. present
+
Section & examine stem/leaf under a microscope
↳ feeding stylet is inserted into phloem sieve tube
⇓
Translocation occurs in the phloem tissue.



② 'Ringing' Experiment

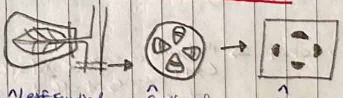
> remove a ring of bark from a woody branch — bark? > cork cambium, made of cork, phloem?
↳ removal of phloem tissue in that region.



swelling above ring caused by accumulation of food substances in region above ring
↳ ∴ cannot reach stem below cut region
↳ why doesn't drip out?
↓
∴ Translocation occurs

☆ plant can still PS → xylem still intact
Can phloem regrow? → will die in long-term?

③ Radioactive Carbon Isotope



^ Leaf supplied w CO_2 containing radioactive C-14 for PS
↓
Sugars formed will contain radioactive carbon -14

^ Section of stem cut + exposed to X-ray film
↓ cut below leaf ↘ sugars flow downwards(?) ☆
detected using (reacts)

^ Parts that darken (contains C-14)
↓
corresponds to position of phloem tissue
↓
shows that sugars containing radioactive carbon have translocated in the phloem.

Glucose 101

Produced in green leaves during PS

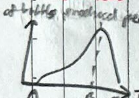
① as glucose
- 1A used immediately
  - ① Cellular respiration → provide energy for cellular activities
  - ② Form cellulose cell walls
- 1B Excess converted to starch.
  - In daylight, ROPS ↑ ~~[illegible]~~
    ↳ glucose formed faster than removed/used up
  - In darkness, PS stops
    - Starch converted back by enzymes to glucose for respiration.

③ converted to sucrose
- ① transported to other parts of the φ or storage organs
- ② converted to other storage compounds at storage organs, depending on φ
- ③ may be converted back to glucose for respiration
- ④ a component of nectar (sweet) in flowers that are insect-pollinated

④ converted to Amino acids in leaves
- 4A form proteins — synthesis of new protoplasm in leaves
- 4B excess transported to other parts of φ
  - ① synthesis of new protoplasm
  - ② storage as proteins.

⑤ forms ~~converted to~~ Fats.
- ① for storage
- ② used in cellular respiration
- ③ synthesis of new protoplasm

LF: Temperature - see Ch4



↗ data
Describe + Explain

(A to B) Temp ↑, ROPS ↑ → Molecules of enzyme and substrate in photosynthetic cells gain KE.
↳ ↑ frequency of effective collisions between photosynthetic enzymes & substrates to form more enzyme-substrate complexes.
↳ ∴ ↑ ROPS #

(B to C) Temp ↑, ROPS ↓ → As molecules gain more KE, bonds within enzymes break,
↳ causing them to lose their 3D shape (denature)
↳ substrates can no longer bind to active sites of the enzymes
↳ ↓ enzyme-substrate complexes formed → ↓ ROPS #

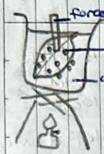
No:

EXPERIMENTS:

- familiarise w chemicals, know uses, plant

STRUCTURAL

• Presence of stomata in a Leaf



- drowning in hot water

↳ why heat to 75°C before taking readings?

observat^n: bubbles on both surfaces of leaf
↳ more on underside (more stomata)

expl: Air expands when heated
↓
air from intercellular air spaces expanded + escaped out of leaf thru stomata

① • Destarch ✓ before exp

• ensures starch is absent before exp. carried out
↳ ensure any starch present at end is due to the factor being investigated.
- place plant in dark for 2 days
↳ stop PS + change starch to sucrose
↳ used by plant

Glucose ↓ starch-stored ↓ sucrose ? — transport ↘ glucose?

ensure destarching is complete

② • Test for starch — Iodine test
- Remains brown (✗)
- turns blue-black (✓)

why have starch?
✗ starch pr. — Glucose formed from CO_2 during PS
- If more glucose formed more quickly than used up → excess glucose changed to starch for storage.
ROPS ↑ than RO resp
∴ starch pr = PS has taken place.
↳ won't work accurately for shoots?

boil leaf
• ① ↳ denature enzymes in leaf
stop rxn ↳ starch ✗ converted to glucose
↳ cos then ✗ starch to test for
ans B: ② Destroy cell m → release starch → can test.

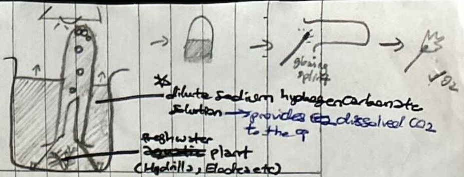
• Put boiled leaf in alcohol / ethanol (DO NOT boil ethanol!!!)
① → Remove chlorophyll (green pigment)
③ ↳ decolourise the leaf
↳ ensure color change due to iodine is clearly seen

④ • Put back brittle leaf into hot water
↳ Softens leaf, makes it more permeable to iodine solu^n
↳ iodine can enter easily and react w starch.

see pt | pg 7

Ⓟ **Precautions?**

• test to show PS has occurred.



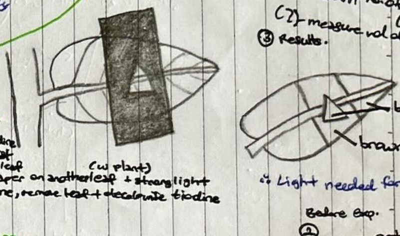
• What gas is given out during PS — O_2
- glowing splint

Using same set up
• measure ROPS
- invert measuring cylinder instead of test tube
↳ measure vol of gas in 1 min
- count no. of bubbles in 1 min
(error: size not same — SOE)
(2) - measure vol of gas produced using a gas syringe in 1 min
③ Results.

Photosynthesis

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O_6 + 6O_2$$

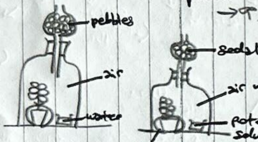
• Light needed for PS
Ⓟ Destarch + test iodine
① plant / 1 leaf: Paste black paper on another leaf + strong light (w plant)
② Aft some time, remove leaf + decolourise + iodine



∴ Light needed for PS

• CO_2 needed for PS

- KOH and soda lime.
prison
→ plant ✗ die cause still can resp
↓
but if food runs out



see transp.

Ⓟ Destarch
↳ see precautions
^ leaf in control → starch ✓
leaf from ✗ CO_2 → starch ✗
∴ CO_2 needed for PS.

Ⓟ Enclosed in a (elastic) polythene bag
→ So that CO_2 from aerobic resp by microorganisms in soil will not be released into bell jar.

Ⓟ Why add soda lime and KOH? — react and remove
→ rapidly absorb CO_2 → ensure ✗ CO_2.

*side note: $KOH + CO_2 \rightarrow H_2O + K_2CO_3$ — soda lime removes this?

Ⓟ why need control?
→ ensure results obtained and observations made are only due to presence of CO_2 (i.v.) and not other factors.

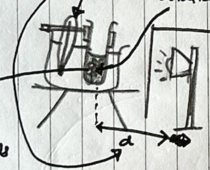
Effect of Varying Limiting Factors:

- assume RO O_2 produced is directly proportional to ROPS.

LI
- d from light source to plant

CO_2
% of sodium hydrogencarbonate solution

temp
temp of water bath



① temp may ↑ w time (?) → ROE ↑ ↓ ROPS ↑ RO bubbling ↑ #
SOE prevent^n: heat shield (transp. glass)
- ensure heat from light source does not affect exp.

*Bubbles given off from cut end of plant

Ⓟ Allow some time for plant to adapt to conditions provided before taking readings

- When bubbles produced at a regular rate, count no. of bubbles over a period of 5 minutes. Repeat 2 more times → avg.

Rate of bubbling per minute / min^{-1} — don't use shortform

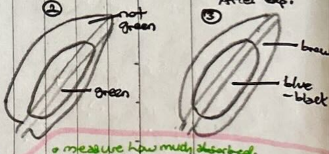
↑ ⌊→ d/cm — usually lolp

② SOE — prevent^n: use gas syringe to measure vol of gas produced
size of bubbles not the same
↓
actual vol. of gas inaccurate
↓
ROPS inaccurate # → cannot predict (?)

• Chl. needed for PS
Ⓟ Destarch plant w variegated leaves (eg. Duranta)
① Expose plant to strong light for a few hr.
② Remove 1 Leaf → draw distribut^n of green parts
③ Decolourise + iodine → draw
④ Compare drawings / distribution

what u see + expl (theory)

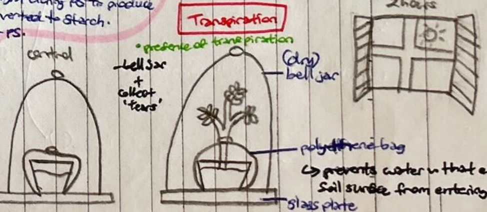
Expl. observations: Parts containing chlorophyll turn b-b, indicating it contains starch. White parts not containing chlorophyll remain brown → ✗ starch.
↳ Chlorophyll absorbs light during PS to produce glucose → excess converted to starch.
∴ Chlorophyll needed for PS.



• measure how much absorbed.
→ Potometer (see Pg 2)

Transpiration

• presence of transpiration



> Liquid (water) droplets seen inside bell jar
↳ water u lost from stomata of leaves (transpirat^n)

Test for water:
Test liquid inside bell jar w anhydrous copper (II) sulfate
↳ anhydrous $CuSO_4$ turns blue
→ when in contact w water / moisture (?).

How to increase accuracy? → Use instruments w higher precision

e.g. syringe vs test tube

1cm3 vs 10cm3

↑ to measure 1cm3 of water.

(close to actual)

↳ as little SOEs as possible

How to ↑ reliability? → repeat experiment 2 more times ∴ 3 times total

2nd find mean/avg.

readings (close to ↑)

easier for odd no.

Cause even ↳ hard to decide, no tiebreaker.