

The Living Book of **Biology**



INTRODUCTION TO BIOLOGY

LESSON 4: DESIGNING BIOLOGICAL EXPERIMENTS

HOW CAN WE DESIGN A FAIR BIOLOGICAL EXPERIMENT?

A GOOD EXPERIMENT IS:

- ✓ AIM / QUESTION
- ✓ HYPOTHESIS —→ Educated prediction
- ✓ VARIABLES —→ Independent, Dependent, Controlled
- ✓ CONTROL —→ Baseline for comparison
- ✓ REPLICATION —→ Repeat for reliability
- ✓ DATA COLLECTION —→ Accurate & consistent
- ✓ ANALYSIS —→ Find patterns
- ✓ CONCLUSION —→ Answer the question



EXPERIMENT PLAN

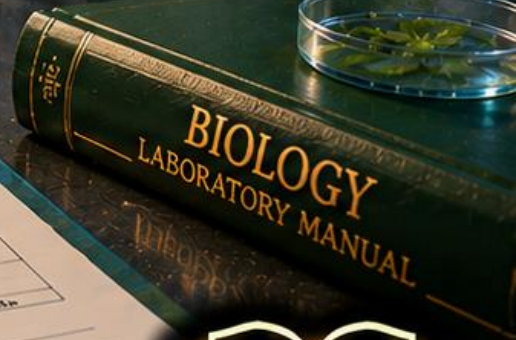
QUESTION:
Does sunlight affect plant growth?

HYPOTHESIS:
Plants that receive more sunlight
will grow taller.

VARIABLES:
Independent: Amount of sunlight
Dependent: Plant height
Controlled: Water, soil, temperature

CONCLUSION:

DATA TABLE		
Day	Control (cm)	Experiment (cm)
1	2.1	2.3
2	4.3	5.7
3	6.5	8.9
4	8.1	11.2
5	9.4	13.8



1

Defining the Experimental System



Define organisms and materials



Specify conditions and environment



Set the time period



Make the system precise and clear



Allow others to repeat it

EXPERIMENTAL SYSTEM

- Organism
- Materials
- Conditions
- Time period
- Replicable procedure

Clear
Precise
Repeatable

22.5°C
45% RH

Arabidopsis thaliana

EXPERIMENTAL SYSTEM

- ☒ Organism: Arabidopsis thaliana.
- ☒ Material: Seeds, soil, solutions
- ☒ Conditions: Light, temperature, humidity
- ☒ Time period: 7 days
- ☒ Replicable procedure



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2

Identifying Variables



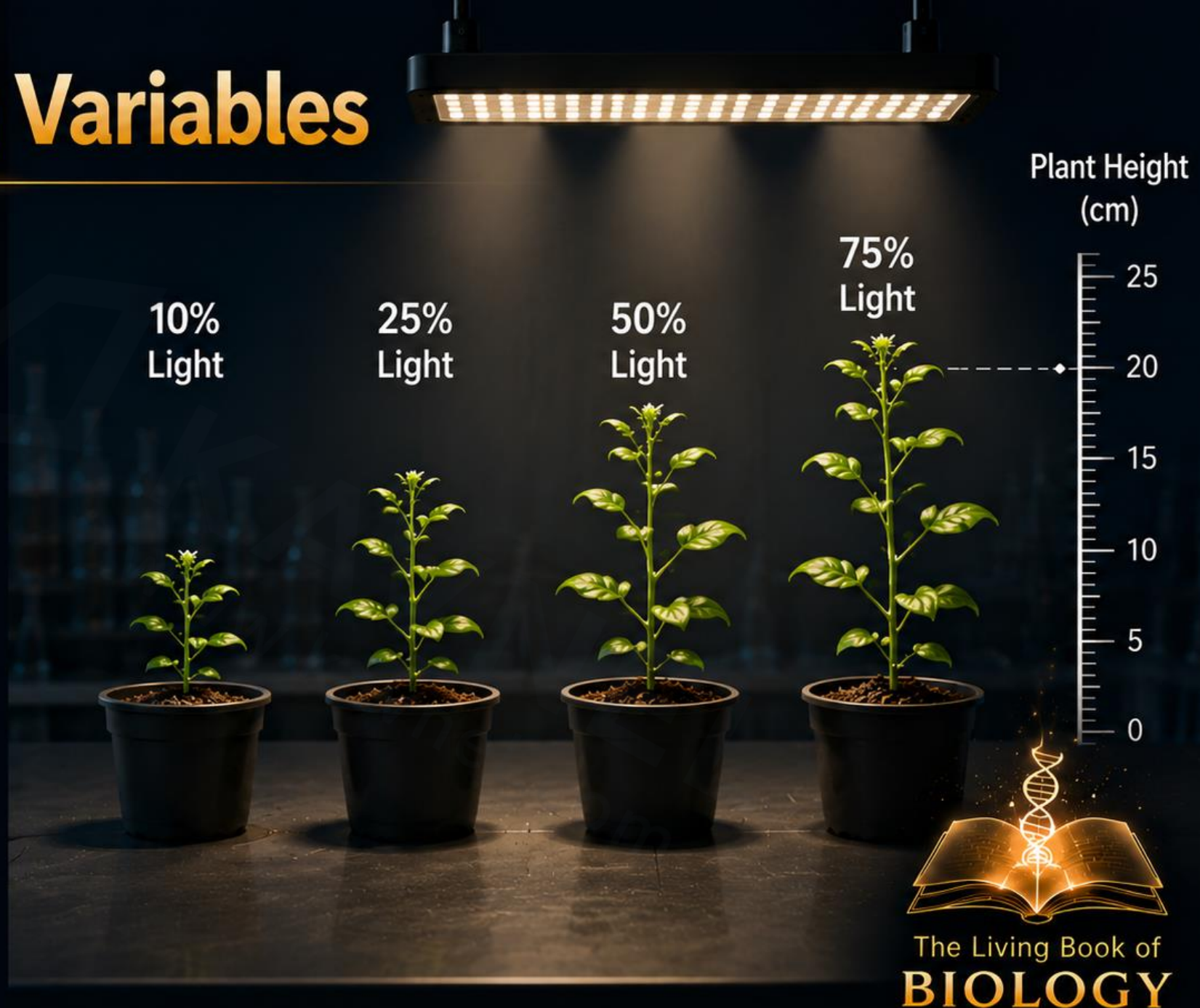
What we change
(Independent Variable)



What we measure
(Dependent Variable)



What we keep the same
(Controlled Variables)



3

Establishing Comparison Groups



Control Group

Baseline for comparison



Experimental Group(s)

Receive the condition being tested



Purpose

Compare to determine if the treatment caused an effect

CONTROL

No Treatment

GROUP 1

Low Treatment

GROUP 2

Medium Treatment

GROUP 3

High Treatment



CONTROL
BASELINE

VS.



EXPERIMENTAL GROUP(S)



Compare
Results



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4

Replication and Sample Size



Repeat

Do the test many times



Larger Sample

Use more individuals



More Reliable

Results are more accurate and representative

Example: Effect of Fertilizer on Plant Height

Control
No Fertilizer



Replicates
(n = 4)

Treatment
Low Fertilizer



Replicates
(n = 4)

Treatment
High Fertilizer



Replicates
(n = 4)



Few Observations
Less Reliable



Many Observations
More Reliable



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5

Reducing Bias and Confounding Factors



Random Assignment
Randomize groups.



Consistent Procedures
Keep methods same.



Blinded Measurement
Keep results unbiased.



Matched Groups
Make groups similar.



Control Other Factors
Keep other factors constant.

HIGH BIAS

Unreliable results



Control
Different

Treatment
Unfair

- ✗ Different light
- ✗ Different pots
- ✗ Blinded no
- ✗ Other factors change

LOW BIAS

More reliable results



Control
Same

Treatment
Fair

- ✓ Same light
- ✓ Same pots
- ✓ Blinded yes
- ✓ Other factors controlled



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6

Ethics and Reproducibility



People
Respect



Animals
Humane care



Environment
Do no harm



Record
Be clear



Reproduce
Repeat and verify



Ethical research is trustworthy research.



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S

SUMMARY

Good experiments
find cause and effect.



1. Define



2. Change and
Measure



3. Compare



4. Replicate



5. Reduce Bias



6. Ethics &
Reproducibility

CONTROL

No treatment



TREATMENT 1

Low



TREATMENT 2

Medium



TREATMENT 3

High



Plan



Test



Analyze



Conclude



Share



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