BIOL10010 Foundational Biology: Life's Complexity

THE UNIVERSITY OF MELBOURNE · UNDERGRADUATE LEVEL 1 · SEMESTER 2, 2026

Full guide + ask Sia about BIOL10010

SIDE 1/2 PRIORITIES · DEFINITIONS · FORMULAS · MECHANISMS · COMPARISONS

EXAM REVISION SHEET

Written Examination 40% · two hours · minimum 30% of exam marks

01 · Exam map [COURSE · BRIEF]

Three Tests 40% | Report 20% | Examination 40%

Permitted materials: not confirmed for this offering in the course materials we hold — check the exam instructions on the LMS. [BRIEF]

TASK	WHAT EARNS CONTROL
Define	Name the biological object, scale and condition.
Explain	Give the mechanism linking start → outcome.
Apply	Use the changed scenario, not a memorised label.
Qualify	State the model, sampling or evidence boundary.

UNIVERSAL RESPONSE SPINE

```
Identify scale + comparison → define terms → trace mechanism → predict discriminating observation → test against model/control/alternative → qualify.
```

Evidence ledger: record system/specimen, condition, observed feature, comparison and inference in separate slots. This stops a diagram label, group difference or mean from silently becoming a mechanism.



association ≠ tested mechanism

Course-wide route: allocate each observation a job before drawing the conclusion.

02 · Biodiversity evidence [C1]

★ ***Biodiversity*** = variation across genetic, species and ecosystem dimensions in a defined comparison. ***Species richness*** counts distinct species; richness ignores relative abundance.

SHANNON DIVERSITY

```
H′ = -Σ pᵢ ln(pᵢ), i = 1…S
pᵢ = proportion of species i from the same sample total.
```

MEASURE	USE	BOUNDARY
Richness	Number of species	No evenness
H′	Richness + relative abundance	Sampling and resolution dependent
Taxonomy	Identify/name from shared and distinguishing traits	Needs observable evidence

CHECK *A diversity index is not an intrinsic constant of a place: name sampling effort, spatial scale and identification quality.*

MICROBES: SIZE IS NOT EFFECT

```
B_group = Σmᵢ · same mass unit · stated sample.
```

Biomass estimates living material; it does **not** identify whether the mechanism or ecosystem service is beneficial or harmful. Abundance alone is likewise non-diagnostic.

03 · Nutrition: form → function [C3]

STRATEGY	RESOURCE ROUTE	EVIDENCE FOCUS
Autotrophic	Inorganic resources + energy → organic molecules	Acquisition and synthesis
Heterotrophic	Consume/absorb organic material made by others	Processing and absorption
Digestive adaptation	Structure/physiology improves acquisition, processing or absorption	Comparative or experimental support

ASSIMILATION EFFICIENCY

```
AE = E_assimilated / E_ingested × 100%
Same energy unit; ingested ≠ assimilated.
```



Similar structure can serve different diets.

Do not jump from a plausible structure to function without comparative or experimental evidence.

04 · Water + nitrogen waste [C4]

★ *Osmoregulation* controls water and dissolved solutes. *Excretory adaptation* removes waste while balancing toxicity, water and energy.

WATER BALANCE

```
ΔW = W_input − W_output
Same interval + all named pathways.
Sign = net change over that interval.
```

OBSERVATION	VALID INFERENCE	TRAP
ΔW > 0	Inputs exceed outputs in stated interval	Not a timeless hydration state
Waste form	Trade-off among toxicity, water demand and energy cost	No universally superior product
Habitat fit	Relate environment → constraint → excretory feature	Label without mechanism

ANSWER *Name habitat water availability, identify the waste constraint, then explain the structural or physiological solution and its cost.*

DECISION CHECK	QUESTION TO ASK
Resource	What enters, and by which route?
Processing	What must be broken down, absorbed or removed?
Trade-off	Which water, energy, toxicity or evidence cost remains?

STRUCTURE–FUNCTION PROOF TEST

1. Describe the observed form without inference.
2. State the processing challenge.
3. Predict the performance consequence.

05 · Metabolism + temperature [C5]

★ *Metabolic rate* is the rate of energy/material transformation. Keep **whole-organism** and **mass-specific** rates distinct.

ALLOMETRIC METABOLISM

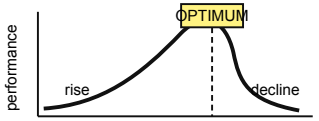
```
B = B₀M^b
B = metabolic rate; M = body mass; b = fitted scaling exponent.
```

IF PROMPT CHANGES...	TRACK...	QUALIFY...
Body mass	Whole-organism B via M^b	Taxa + mass range
Temperature	Position on thermal performance curve	Acclimation + measured range
Measurement	Rate definition and units	Method and conditions

A fitted relationship is conditional on taxa, acclimation, measurement and observed range; do not turn b into a universal biological constant.

SCALING INTERPRETATION

```
First identify what B measures and its unit. Then interpret the fitted exponent b only for the organisms, acclimation conditions and mass range used. A prediction outside that range is extrapolation, not a directly supported observation.
```



Thermal performance is a curve, not a rule that higher temperature always means higher performance.

06 · Homeostasis + gas exchange [C6]

Homeostasis keeps an internal condition within a functional range. A stable outcome alone does not reveal the feedback mechanism.

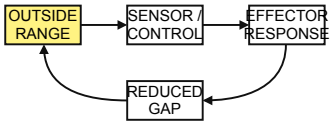
DIFFUSIVE FLUX

```
J ∝ AΔC / L
More area A or gradient ΔC → higher flux; longer path L → lower flux.
```

DESIGN	FLUX GAIN	REQUIRED CAUTION
Large area	More interface	Environmental exposure/trade-off
Thin surface	Shorter L	Protection and water balance
Maintained gradient	Larger ΔC	Needs flow/ventilation context

THERMOREGULATION ANSWER CHECK

A ***thermoregulatory strategy*** is a behavioural or physiological action affecting heat production, gain, retention or loss. State the environmental condition, direction of heat exchange and consequence for the regulated internal range. Do not equate a body-temperature pattern with its control mechanism.



Homeostasis answer: deviation → detection/control → effector → reduced deviation.

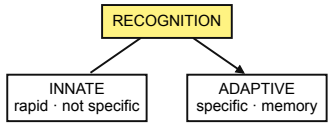
07 · Immune recognition [C7]

FEATURE	INNATE IMMUNITY	ADAPTIVE IMMUNITY
Targeting	Not antigen specific	Antigen specific
Components	Barriers, recognition systems, cellular responses	Lymphocyte activation, effectors, memory
Interpretation	Rapid defence	Recognition changes specific response

★ ***Immune recognition*** detects molecular features indicating damage, invaders or a specific antigenic target.

BLANK-CORRECTED SIGNAL

```
S = OD_sample − OD_blank
Then apply calibration or decision rule; background subtraction alone is not interpretation.
```



Marker or antibody response ≠ protection, disease cause or clinical outcome.

ASSAY JUDGEMENT

1. Correct the sample signal for the measured blank.
2. Check positive/negative controls and calibration or decision rule.
3. State what the signal measures.
4. Keep the biological claim inside that measurement.

TRAP *"Antibody detected" is an observation; it is not, by itself, a conclusion about protection or causation.*

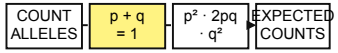
LAYER	QUESTION
Recognition	Which molecular feature is detected?
Route	Innate, adaptive, or coordinated contribution?
Effector	Which barrier, cell or response changes the threat?
Evidence	Signal, control, calibration and comparison?
Boundary	Does the result show a marker, response, protection or outcome?

08 · Evolutionary diagnosis [C8]

PROCESS/MODEL	DIAGNOSTIC FEATURE	DO NOT CLAIM
Natural selection	Heritable variation + differential survival/reproduction	Any change is selection
Genetic drift	Random sampling across generations; stronger influence in small populations	Adaptive direction
Hardy–Weinberg	Null-model genotype expectations under specified assumptions	Departure names the mechanism

HARDY–WEINBERG PROPORTIONS

```
p + q = 1
p² + 2pq + q² = 1
Expected counts = expected proportion × N.
```



OBSERVED vs EXPECTED
departure flags assumption/data issue

A departure diagnoses a failed assumption or data problem, not the evolutionary process.

ALLELE-COUNT DISCIPLINE

For N diploid organisms there are 2N alleles. Count homozygote alleles twice and heterozygote alleles once. Keep allele frequency, genotype frequency and biological assumptions on separate lines.

```
p(A) = [2n(AA) + n(Aa)] / 2N
q(a) = [2n(aa) + n(Aa)] / 2N
```

Process discriminator: selection requires heritable variation tied to differential survival/reproduction; drift is random sampling across generations and is especially influential in small populations. Neither label follows from a frequency change alone without evidence about how the change arose.

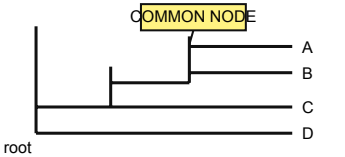
09 · Speciation + trees [C9]

Reproductive isolation reduces gene exchange before or after fertilisation. ***Coevolution*** requires reciprocal evolutionary change caused by interacting species imposing selection on one another.

```
d = differing sites / sites compared
```

Pairwise distance summarises one comparison; it does not choose a complete phylogenetic history.

CLAIM	EVIDENCE NEEDED
Closer relationship	More recent common ancestor on the tree
Similar trait	Character observation; similarity alone need not mean closest relationship
Coevolution	Reciprocal selection and evolutionary change, not mere present interaction
Isolation	Barrier reducing gene exchange before or after fertilisation



Tree proximity on the page, trait similarity and present interaction are different claims.

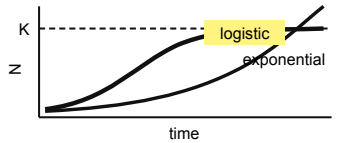
TREE READING RULES

- Start with the named root or branching structure; follow nodes, not left–right tip order.
- Closest relatives share the most recent common ancestor shown.
- Rotating branches around a node does not change relationships.
- A tree is a branching hypothesis; connect claims to the evidence and model used.

10 · Population models [C10]

MODEL	RULE	INTERPRETATION
Exponential	Constant per-capita rate; limiting feedback absent from model	Growth scales with N
Logistic	dN/dt = rN(1 − N/K)	Density feedback slows growth as N → K
Source–sink	Dispersal links habitats above/below local replacement	Movement can support persistence

K is modelled carrying capacity, not a permanent ceiling independent of environment, density, sampling or stochasticity.



Choose the model from the assumed feedback; do not infer a fixed K from a single plateau.

11 · Interactions + One Health [C11]

```
Prevalence P = n_positive / n_examined
```

CLAIM	EVIDENCE DISCIPLINE
Ecological niche	Conditions, resources and interactions defining persistence/function
Predator–prey	One captures/consumes another; reciprocal ecological pressures
One Health	Link human, animal and environmental health through shared systems/risks

Prevalence is a sampled proportion for the named population and period: not incidence and not causal effect. Host–parasite–environment association does not establish transmission direction or intervention effect.

BIOL10010

Self-test drills · answer paths · judgement cards

FOUNDATIONAL BIOLOGY: LIFE'S COMPLEXITY · UNIVERSITY OF MELBOURNE

Full guide + ask Sia about BIOL10010

SIDE 2/2 WORKED MINI-EXAMPLES · WHICH-IS-TRUE · IF X → Y · CLASSIC TRAPS · EXAM-MORNING PLAN

ACTIVE RECALL

Say the path aloud · then check formula, units, inference and boundary

12 · Worked: Hardy–Weinberg [COURSE WEX]

Q [5 marks]. N = 100 diploid organisms; AA = 36, Aa = 48, aa = 16. Find allele frequencies and expected genotype counts.

1 · COUNT ALLELES

```
2N = 200
A alleles = 2(36) + 48 = 120
a alleles = 2(16) + 48 = 80
```

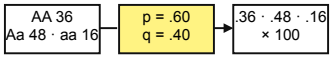
2 · FREQUENCIES

```
p(A) = 120/200 = 0.60
q(a) = 80/200 = 0.40
check: p + q = 1.00
```

3 · EXPECTED PROPORTIONS → COUNTS

```
p² = 0.36 → AA = 36
2pq = 0.48 → Aa = 48
q² = 0.16 → aa = 16
```

Observed = expected in this sample. This agreement does not prove that every equilibrium assumption is biologically true.



EXPECTED: 36 · 48 · 16

Keep allele counts, genotype expectations and biological assumptions separate.

SELF-CHECK VARIANTS

- If p + q ≠ 1, repair the allele-frequency line before squaring.
- If expected proportions do not sum to 1, repair $p^2 + 2pq + q^2$.
- If observed differs from expected, state "assumption/data issue"; do not name selection or drift without further evidence.

FALSE MOVE	REPAIR
36/100 used as p(A)	Count alleles: AA contributes two A alleles; Aa contributes one.
2pq treated as an allele frequency	2pq is the expected heterozygote genotype proportion.
Agreement treated as proof of assumptions	Call it agreement with the null-model expectation in this sample.
Departure labelled "selection"	State that an assumption or data issue exists; seek evidence for process.

FIVE-MARK DISCIPLINE *One line each for allele count, p, q, expected proportions and biological interpretation.*

INTERPRETATION FINISH

State what the calculation shows, then what it cannot show. Here the observed and expected counts coincide; the defensible conclusion is agreement with the model expectation in this sample, followed by the need for further evidence about mating, selection, migration, mutation and population size.

13 · Worked: diversity route [C1]

Prompt. Compare biodiversity with Shannon diversity while keeping the sampling question visible.

ANSWER PATH

```
1 Define sample total N and species
count S.
2 For every species i, compute pᵢ =
nᵢ/N using the same N.
3 Compute each pᵢ ln(pᵢ).
4 Sum and apply the leading minus sign.
5 Interpret H′ as richness + relative
abundance.
```

WHICH IS TRUE?	VERDICT
More species always means a valid cross-site H′ comparison.	False: sampling effort, scale and identification quality matter.
Richness and H′ answer identical questions.	False: H′ also uses relative abundance.
Every p_i uses one sample denominator.	True.

counts n_i → $p_i = n_i/N$ → $p_i \ln p_i$ → sum + minus → H′ qualify

SAME SAMPLE TOTAL · SAME SCALE

Arithmetic is only comparable when the sampling frame and taxonomic resolution are comparable.

14 · Worked: structure → function [C3–C4]

Prompt. A structure is proposed as a digestive or excretory adaptation.

1. **Observe:** describe the form or physiological feature without naming its function.
2. **Challenge:** state the resource, processing, water or waste constraint.
3. **Mechanism:** explain how the feature changes acquisition, absorption, water loss, toxicity or energy cost.
4. **Test:** predict a comparative/experimental result and name an alternative.

BOUNDARY *Similar forms can serve different diets; no nitrogenous-waste product is universally superior.*

CHANGED CASE	REQUIRED TRANSFER
Energy values use different units	Convert before AE; numerator and denominator must match.
Water pathways cover different intervals	Align the interval before ΔW.
Same structure appears with another diet	Revise the functional claim or propose a discriminating test.
Drier habitat	Re-evaluate water demand, toxicity and energy cost together.

TWO SYMBOLIC CHECKS

$AE \times E_{ingested}/100\% = E_{assimilated}$ (inverse check).

$\Delta W + W_{output} = W_{input}$ (balance check).

15 · Worked: flux + feedback [C6]

Prompt. Explain how a changed gas-exchange surface affects flux, then connect it to regulated internal state.

FORMULA FIRST

$J \propto A\Delta C/L$

CHANGE, OTHERS HELD CONSTANT	PREDICTED J	REASON
A increases	Increases	More exchange area
ΔC decreases	Decreases	Weaker gradient
L increases	Decreases	Longer diffusion path

Complete answer: name the changed term → state the directional effect → connect the resulting gas exchange to the internal variable → identify sensor/control and effector if feedback is claimed → state environmental trade-off.

ASSAY TRANSFER

$S = OD_{sample} - OD_{blank}$

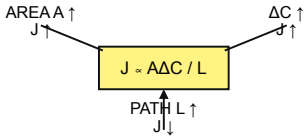
Carry the corrected symbol S into the calibration or decision rule. Then check positive and negative controls. Finish with exactly what the marker supports; do not turn a corrected signal into protection, disease cause or clinical outcome.

FEEDBACK FALSE POSITIVE

A value can remain stable for reasons other than the proposed feedback loop. To claim homeostatic control, name the regulated condition and show evidence for detection/control and an effector response that reduces deviation.

THREE-LINE FINISH

```
Change: ___ altered A, ΔC or L.
Mechanism: therefore J rose/fell
because ___.
Boundary: under this diffusion model
and stated environmental conditions,
___.
```

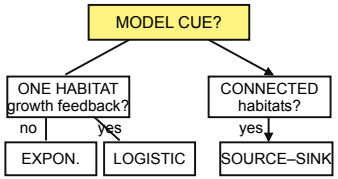


Directional reasoning is valid only while the other terms and model conditions are held.

16 · Worked: model choice [C10]

Prompt. Choose between exponential, logistic and source–sink reasoning.

IF THE SCENARIO STATES...	USE...	THEN CHECK...
No limiting feedback in model	Exponential growth	Constant per-capita rate
Density feedback; N approaches K	Logistic growth	(1 − N/K) → 0
Connected habitats differ in local replacement	Source–sink	Direction/effect of dispersal



Read the assumptions first; the curve label follows from the mechanism represented.

17 · If you see X → do Y [C1–C11]

SEE X	DO Y
Species counts	Define sample; richness or p_i → H′; qualify sampling.
Body size + metabolism	Use $B = B_0M^b$; state whole vs mass-specific and fitted range.
Stable internal value	Do not infer feedback; identify detection/control/effector evidence.
Assay OD	Subtract blank; then controls + calibration/decision rule.
Genotype counts	Count 2N alleles → p,q → expected counts → compare.
Tree diagram	Trace nodes/common ancestry; ignore tip order and page spacing.
Positive organisms	P = npositive/nexamined; name population + period.
Interaction + health outcome	Separate association, transmission direction and intervention effect.

18 · Short-answer frame [FAQ]

SIX-SENTENCE MAXIMUM-CONTROL FRAME

```
1 The relevant scale/comparison is __.
2 __ means __.
3 Starting condition __ changes __ by
__.
4 Therefore I predict observation __.
5 Compare against
control/model/alternative __.
6 This conclusion is limited by __.
```

MECHANISM TEST *Delete the topic label. If the remaining sentence does not show a process from cause/condition to outcome, it is not yet an explanation.*

COMPARISON SENTENCE STEM

"Both ___ and ___ address ___. They differ because ___ uses/assumes ___, whereas ___ uses/assumes ___. In this scenario, ___ is the better explanation/measure because ___. The remaining uncertainty is ___."

JUDGEMENT	MINIMUM EVIDENCE
Closest relatives	Most recent common ancestor shown
Coevolution	Reciprocal selection and change
Source habitat	Local demographic production above replacement
Sink habitat	Local production below replacement; assess dispersal

19 · Which-is-true traps [C1–C11]

STATEMENT A	STATEMENT B	TRUE CONTRAST
High abundance proves high ecological impact.	Impact requires a mechanism linking the group to function.	B
Ingested energy equals assimilated energy.	AE separates assimilated from ingested energy.	B
One waste form is always best.	Toxicity, water and energy change with context.	B
A larger organism necessarily has the same mass-specific rate.	Whole and mass-specific metabolism must be distinguished.	B
Stable output proves negative feedback.	Feedback needs mechanism evidence.	B
Antibody signal proves protection.	Signal needs controls, rule and bounded interpretation.	B
Hardy–Weinberg departure identifies selection.	Departure flags assumption/data issue only.	B
Nearby tips on a page are closest relatives.	Relationships follow common branching nodes.	B
K is a permanent ceiling.	K is a modelled, condition-dependent capacity.	B
Prevalence is incidence.	Prevalence is a proportion in a named sample/period.	B

OBSERVE what? → EXPLAIN how? → TEST against? → STOP where?

BOUNDARY PROTECTS THE CLAIM

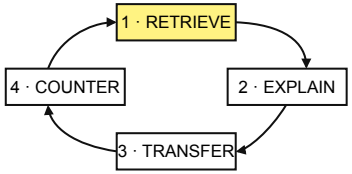
Classic error: a correct observation is stretched into an unsupported mechanism or causal claim.

20 · Fast formula check [C1–C11]

FORMULA	CHECK BEFORE INTERPRETING
$H' = -\Sigma p_i \ln p_i$	Same N; minus sign; sampling boundary
AE = Eass/Eing × 100%	Same energy unit
ΔW = Win − Wout	Same interval/pathways
$B = B_0M^b$	Taxa/conditions/range
$J \propto A\Delta C/L$	Direction; other terms held
S = ODsample − ODblank	Controls + decision rule
$p^2 + 2pq + q^2 = 1$	p + q = 1 first
d = differing/sites compared	One pair ≠ whole history
$dN/dt = rN(1 - N/K)$	K is modelled
P = npositive/nexamined	Population + period

21 · Retrieval circuit [PRACTICE]

Run each topic through four passes. A pass is complete only when the answer survives a changed scenario and a counter-case.



Source-derived practice loop: retrieval becomes useful only after transfer and boundary testing.

ONE-PASS PROMPTS

TOPIC	SAY WITHOUT NOTES
Biodiversity	Richness vs H′; sampling boundary
Nutrition/excretion	Constraint → structure → function → trade-off
Metabolism	Whole vs mass-specific; curve/range condition
Homeostasis	Variable → deviation → control → effector
Immunity	Innate vs adaptive; recognition; marker limit
Evolution	Selection vs drift vs null-model comparison
Ecology	Model assumptions; niche/interaction; prevalence limit

22 · Exam-morning plan [BRIEF · PRACTICE]

1. **Formula sweep:** cover the right column of the formula table; recite symbols, direction, units and boundary.
2. **Contrast sweep:** innate/adaptive; richness/H′; exponential/logistic/source–sink; observation/mechanism.
3. **One full path:** redo the 100-organism Hardy–Weinberg example to 36/48/16.
4. **Tree + curve sweep:** common nodes, thermal optimum, K and diffusion levers.
5. **Stop cramming:** verify current exam instructions and organise the practical details in the LMS.

FINAL CHECK	PASS CONDITION
Definition	Object, scale and condition named
Formula	Symbols, denominator, units/sign checked
Mechanism	Start and outcome joined by a process

1 FORM. → 2 COMPARE → 3 WORKED → 4 LMS

Final pass: retrieve, discriminate, execute one complete calculation, then verify instructions.