Name: _____

IGCSE BIOLOGY 0610 & 0970 · Topic 19 · Weekly Homework

Energy flow, pyramids of biomass and trophic cascades across a riparian food web

____ / 19 marks

Investigation: How do stored chemical energy and dry biomass change across four trophic levels along a mountain stream following apex predator restoration?

Method: 1. Harvest ten 1.0 m^2 riparian willow stem quadrats in July and dry to constant mass at 80 °C. 2. Record grazer and aquatic trout population density across five stream reaches. 3. Bomb-calorimetry subsamples convert dry mass into annual stored energy per square metre.

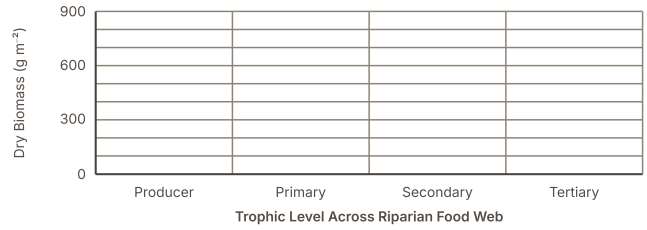
Variables: IV = Trophic level | DV = Energy stored (kJ m^{-2} yr^{-1}), dry biomass (g m^{-2}) | Controlled = Summer sampling window, catchment reach area

Key Words & Units: trophic level = feeding position in a food chain · dry biomass = organism mass excluding water (g m^{-2}) · ecological efficiency = percentage of energy transferred cleanly between adjacent levels

Method tip: For percentage transfer efficiency, divide energy at the higher trophic level by energy at the lower level, then multiply by 100.

EAL sentence frame: Dry biomass decreases sharply from [Producer] to [Consumer] because …, whereas only [X]% of stored energy enters the next level.

Trophic Level & Taxon	Feeding Role	Energy Stored (kJ m^{-2} yr^{-1})	Mean Dry Biomass (g m^{-2})
Level 1 · Riparian Willow	Producer	12,500	840
Level 2 · Elk & Stream Grazers	Primary Consumer	1,450	98
Level 3 · River Trout	Secondary Consumer	168	12
Level 4 · Grey Wolf Pack	Tertiary Consumer	19	1.4



Grid for plotting a bar chart of Mean Dry Biomass (g m^{-2}) across trophic levels

Part A · Data Processing & Quantitative Skills [Core & Supplement]

Q1. Analyse energy transfer from producers to primary consumers. **[5]**

(a) Calculate the energy lost between Riparian Willow and Elk & Stream Grazers with units. [2]

(b) Calculate percentage energy transfer efficiency from Producers to Primary Consumers to 1 d.p. [3]

Q2. Plot and describe the dry biomass dataset on the grid above. **[4]**

(a) Draw bars for all four trophic levels accurately [2] · (b) Describe the biomass pattern below. [2]

Part B · Explain Biological Mechanisms

Q3. Explain why stored chemical energy falls at each feeding transfer. **[5]**

(a) Explain why over 88% of chemical energy is lost between Riparian Willow and Elk grazers. [3]

(b) Explain why food chains in this ecosystem rarely contain more than five trophic levels. [2]

Part C · Experimental Evaluation & Paper 6 Critique

Q4. Evaluate field sampling methods and trophic cascades in this riparian web. **[5]**

(a) State one limitation of harvesting willow biomass in July only, and suggest one improvement. [3]

(b) Evaluate how removing the apex predator (grey wolf) changes willow cover and stream bank stability. [2]

Optional Challenge (+3 marks · Supplement Extension)

Explain why a pyramid of energy is always upright even when a pyramid of numbers is inverted. [3]

IGCSE BIOLOGY 0610 & 0970 · Topic 19 · Mark Scheme & Teacher Notes

Matched 1:1 to Student Worksheet pp. 1–2 · British Academic English **19 + 3 marks**

Part A · Q1 & Q2 Mark Scheme (Data Processing & Plotting) [9 marks]

Q1(a) [2]

- Subtracts Primary Consumer energy from Producer energy: 12,500 − 1,450 **[1]**
- Energy lost = **11,050 kJ m^{-2} yr^{-1}** with explicit units **[1]**

Q1(b) [3]

- Divides Primary Consumer energy by Producer energy: 1,450 ÷ 12,500 **[1]**
- Multiplies ratio by 100 (= 11.60%) **[1]**
- States correctly to 1 d.p.: **11.6%** **[1]**

Q2(a–b) [4]

- Bar heights plotted within half a small grid division (840, 98, 12, 1.4 g m^{-2}) **[1]**
- Four separated bars drawn cleanly over x-axis trophic labels **[1]**
- Describes sharp decline in dry biomass across each higher trophic level **[1]**
- Quotes paired values with units, e.g. 840 g m^{-2} (Producer) vs. 1.4 g m^{-2} (Tertiary) **[1]**

Accept: Rounding note explaining Level 4 bar (1.4 g m^{-2}) sits just above baseline.
Do not accept: Inverting ratio (12,500 ÷ 1,450) or dropping area-time units in Q1(a).

Part B · Q3 Mark Scheme (Energy Flow Mechanisms) [5 marks]

(a) [3]

- Not all plant parts are eaten by herbivores (woody stems and deep roots remain) **[1]**
- Indigestible cellulose passes out in faeces (egestion) unassimilated **[1]**
- Assimilated glucose releases thermal energy during aerobic respiration and supports movement **[1]**

(b) [2]

- Approximately 90% of chemical energy is lost at every trophic transfer step **[1]**
- Too little usable energy remains above level five to sustain a breeding predator population **[1]**

Accept: Urinary excretion of nitrogenous waste alongside faecal egestion in Q3(a).
Do not accept: Claiming energy is destroyed rather than transferred to heat, or energy lost only to sun.

Part C · Q4 Mark Scheme (Experimental Evaluation & Cascades) [5 marks]

(a) [3]

- Limitation: July-only quadrat harvests reflect peak summer foliage and ignore winter die-back **[1]**
- Improvement: replicate quadrat harvests across spring, summer, autumn, and winter **[1]**
- Justification: yields a representative annual mean standing biomass across seasons **[1]**

(b) [2]

- Apex release: removing wolves increases elk grazing pressure on young riparian willow shoots **[1]**
- Abiotic cascade: loss of stabilising willow root networks accelerates stream bank soil erosion **[1]**

Accept: Measuring aquatic macroinvertebrate biomass across seasonal water temperatures in (a).
Do not accept: Vague responses such as repeating quadrats more carefully without seasonal timing.

Optional Challenge Mark Scheme (Supplement Extension) [+3 marks]

(+3)

- One large mature willow tree can support hundreds of herbivorous insects, inverting a numbers pyramid **[1]**
- A pyramid of energy quantifies chemical energy flow per unit area per year (kJ m^{-2} yr^{-1}), not headcount **[1]**
- Irreversible respiratory heat and waste losses at every link ensure each higher bar is strictly smaller **[1]**

Accept: Contrasting standing-crop biomass snapshot vs. annual energy flux productivity.
Do not accept: Stating pyramids of energy invert when producers reproduce rapidly (true for biomass, not energy).

Teacher Pacing & EAL Check: Allow 35 minutes Core + 10 minutes Supplement extension. Drill the difference between *egestion* (undigested cellulose in faeces) and *excretion* (metabolic waste) during Friday Slide 6 peer marking. Remind candidates on Paper 4 never to write that energy is used up without naming respiration and heat.