7.4 Trophic levels and food security

Name: _____ Class: _____ Date: _____ **Total: 21 marks**

KEY WORDS trophic level • biomass • food security

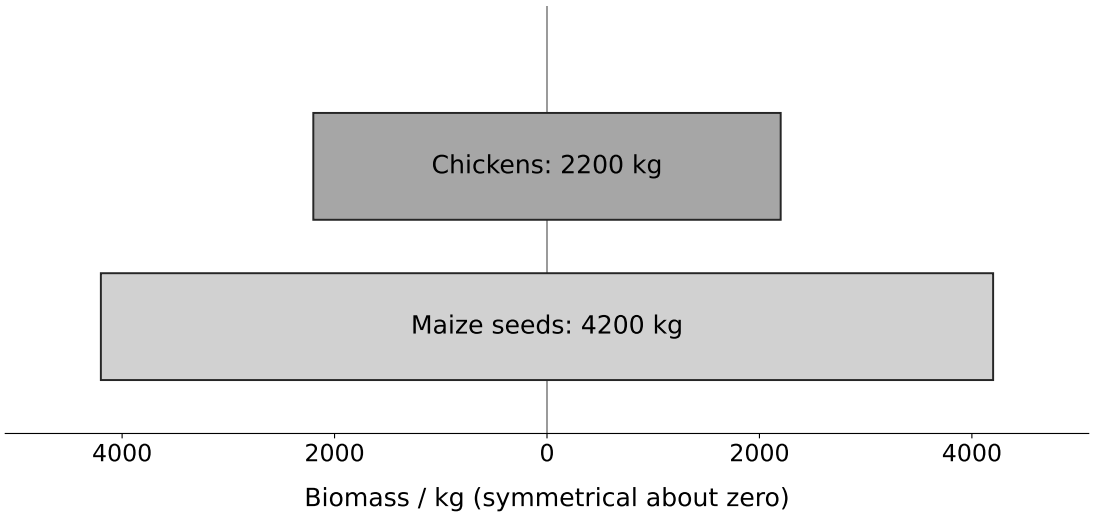
Objective

Use trophic levels, pyramids of biomass and efficiency calculations, and evaluate food-security measures. Biology only. Original questions for spec statements 4.7.4–4.7.5.

1 Key knowledge and worked examples

Trophic levels: 1 producers; 2 primary consumers; 3 secondary consumers; 4 tertiary consumers. Apex predators have no predators. Decomposers secrete enzymes and absorb small soluble molecules from dead material at different levels.

In a biomass pyramid, producers are at the bottom and bar widths represent relative masses. Use the supplied data, not an assumed exact 10%. **Teacher answer drawing using original 2024 Q07.2 data; not original Figure 11.**



Original Q07.2–Q07.3: 1000 chickens × 2.2 kg = 2200 kg. Label biomass / kg and both bars; use a suitable symmetrical scale. Chicken : maize = 2200 : 4200 = **11 : 21**. The supplied masses need not imply exactly 10% transfer.

$$\text{transfer efficiency} = \frac{\text{biomass transferred}}{\text{biomass available}} \times 100\%$$

Authored worked example [2]: 200 kg producers → 18 kg herbivores: 18/200 × 100% = **9%** (method, then value). For Q2.2 use the same method with 40 kg and 500 kg. Original Q02.2: 10% of 340 g/m^2/year = **34 g/m^2/year**.

About 1% of incident light energy is transferred for photosynthesis; this is different from the approximate 10% biomass transfer between feeding levels. Biomass losses include unabsorbed material **egested as faeces**, carbon dioxide/water from respiration and water/urea in urine. Glucose is used in respiration; progressively less biomass can support higher-level populations. Original Q07.4 already allocates 80% to respiration/growth: the remaining 20% is **faeces**, not respiration or urine.

Food security means enough food for the population. Pressures: increasing birth rate/demand; changing diets and transport of scarce food; pests/pathogens; environmental change such as failed rains; input costs; conflict affecting water/food. Explain the effect on supply or demand.

Limiting movement reduces muscle activity; suitable temperatures reduce extra respiration needed to maintain body temperature. Respiration continues. More food resource can contribute to growth; protein supplies growth material. Weigh efficiency against welfare and cost.

Original Q07.1 calculation: 1000 × 46 = 46 000 MJ required. One hectare gives 16 400 × 16 × 0.80 = 209 920 MJ usable energy. Area = 46 000/209 920 × 10 000 = **2190 m^2 (3 s.f.)**. Use the 80% fraction before finding area.

Larger mesh lets young fish escape to grow/breed; quotas limit catch and leave breeding adults. **Fusarium**, grown on glucose syrup aerobically, is harvested/purified for protein-rich **mycoprotein**. GM crops can increase supply or nutritional value; golden rice illustrates nutrition. GM bacteria produce insulin for treating diabetes, not hunger. Farming, fisheries and biotechnology here apply to **both tiers**.

2 Practice

2.1 Name trophic levels 1 to 4. [4]

2.2 500 kg of primary consumers supports 40 kg of secondary consumers. Calculate the transfer efficiency. [2]

2.3 Name the fungus that produces mycoprotein. [1]

3 Exam-style questions

3.1 Explain why a food chain rarely has more than four or five trophic levels. [4]

3.2 Explain how restricting the movement of cattle and controlling the temperature of their sheds improves food-production efficiency, and give one ethical objection. [4]

3.3 Fish stocks in the North Sea are falling. Explain how net size and fishing quotas help maintain stocks, and describe one biotechnological solution to food demand. [6]

Solutions

2.1 Producers; primary consumers; secondary consumers; tertiary consumers.

2.2 $40 \div 500 \times 100 = 8$ %.

2.3 Fusarium.

3.1 Only about 10 % of the biomass of each level is transferred to the next; biomass is lost in faeces – not all ingested material is absorbed; and in waste – carbon dioxide and water from respiration, water and urea in urine; so after four or five levels too little biomass remains to support another breeding population.

3.2 Limiting movement reduces energy transferred to the environment as movement/muscle work; so more of the food's energy becomes biomass – meat or milk; keeping the shed at a suitable temperature reduces extra respiration needed to maintain body temperature; respiration does not stop. Objection – restricted movement and confinement are considered cruel / unnatural welfare conditions.

3.3 Larger mesh lets young fish escape so they can grow and breed before capture; quotas limit the catch, leaving breeding adults; together these help maintain stocks where breeding continues. One described food solution: the fungus Fusarium is cultured, on glucose syrup in aerobic conditions, then biomass is harvested/purified to produce protein-rich mycoprotein for food. Alternatively, accept a correctly described GM crop with a mechanism improving food supply or nutrition. Insulin treats diabetes; it does not answer the food-demand part. This is an authored key, not an official scheme.