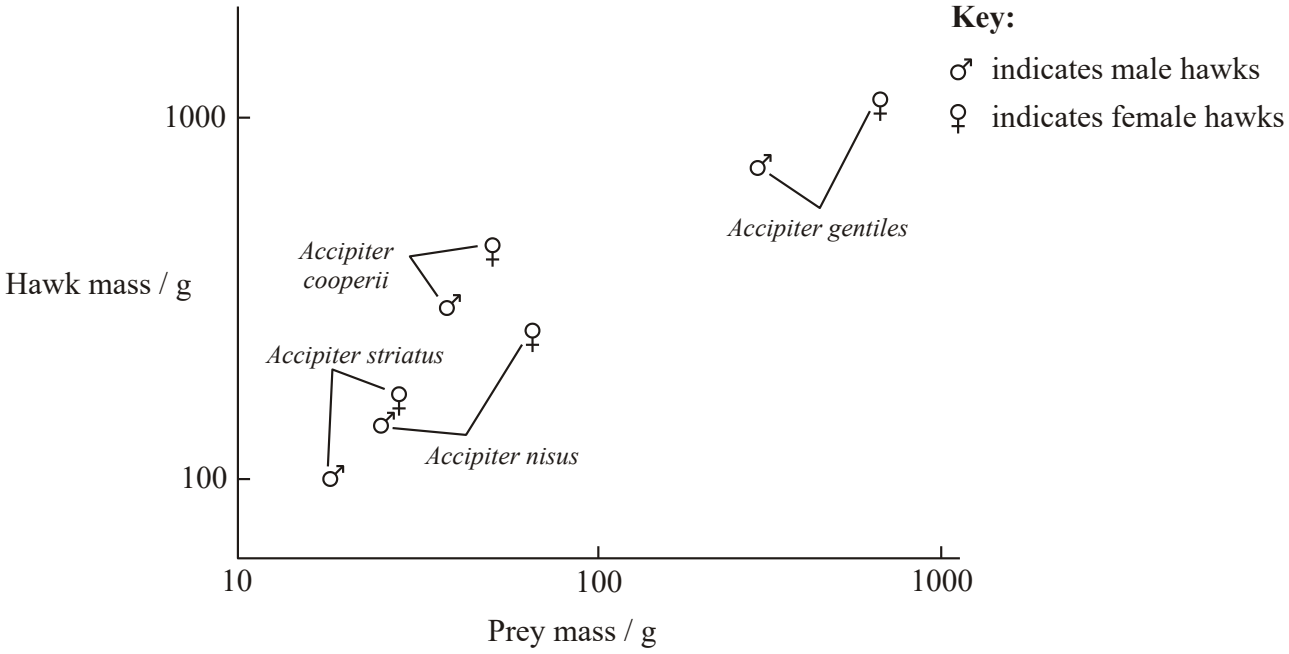
Predator/Prey (7 marks)

Ornithologists studied the size of birds of prey and compared them with the sizes of their prey. The diagram below shows the mean results for four species of hawk.



a. State the relationship between the mass of the hawks and the mass of their prey. *(1 mark)*

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b. Describe the differences between the masses of the hawks and the masses of their prey. *(2 marks)*

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c. Explain how the difference in the mass between the hawks and their prey can result in a lower biomass at higher trophic levels. *(1 mark)*

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d. Compare the masses of the different sexes of these species. *(1 mark)*

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e. Suggest reasons for the differences in the masses of the male and the female hawks. *(2 marks)*

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Nutrient Cycles (12 marks)

Ecosystems require an input of energy, water and nutrients to maintain themselves. Nutrients may be reused through recycling within ecosystems. Nutrient cycling within an ecosystem has been studied in many biomes. One factor studied is the mean residence time (MRT), which is the amount of time needed for one cycle of decomposition (from absorption by organism to release after death). The table below gives the mean residence time for certain nutrients in four different biomes. In addition, the plant productivity is also shown. (Plant productivity gives an indication of the quantity of biomass potentially available to consumers.)

	Mean residence time / years						
Biome	**Carbon**	**Nitrogen**	**Phosphorus**	**Potassium**	**Calcium**	**Magnesium**	**Plant productivity /g Cm**–2 **yr**–1
Sub-arctic forest	353.0	230.0	324.0	94.0	149.0	455.0	360
Temperate forest	4.0	5.5	5.8	1.3	3.0	3.4	540
Chaparral	3.8	4.2	3.6	1.4	5.0	2.8	270
Tropical rainforest	0.4	2.0	1.6	0.7	1.5	1.1	900

a. State which nutrient shows the shortest mean residence time in a temperate forest. *(1 mark)*

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b. Identify the biome in which potassium has the longest mean residence time. *(1 mark)*

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c. Compare the mean residence time for nutrients in the temperate forest and chaparral. *(2 marks)*

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d. Evaluate the relationship between the mean residence time and plant productivity for the different biomes. *(2 marks)*

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e. Suggest **one** reason for the difference in mean residence time of nutrients in the tropical rainforest and the sub-arctic forest. *(1 mark)*

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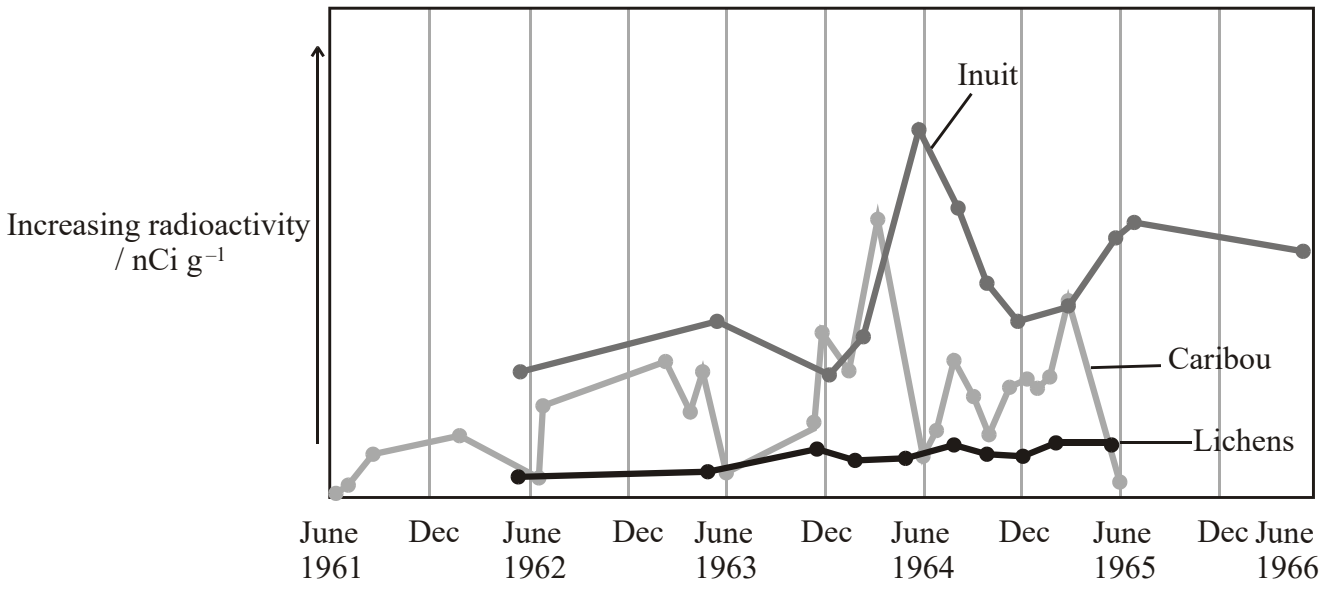
In addition to nutrients, other atmospheric elements may also enter the ecosystem. Radioactive cesium-137 was released into the atmosphere by atomic bomb tests in 1961. The cesium-137 was deposited in the soil and on to plants. The graph shows the amount of radioactivity found in the tissues of lichens (an alga and a fungus growing together), caribou (a member of the deer family) and the Inuit (people of Alaska and Northern Canada) in the Anaktuvuk Pass of Alaska.



f. Describe the level of cesium-137 in the Inuit from 1962 through to 1965. *(2 marks)*

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g. The three organisms form a food chain. Deduce the trophic level of the lichen and the Inuit. *(2 marks)*

i. lichen: .....

ii. the Inuit: .....

h. Suggest a reason for the difference in the levels of cesium-137 found in lichen, caribou and Inuit. *(1 mark)*

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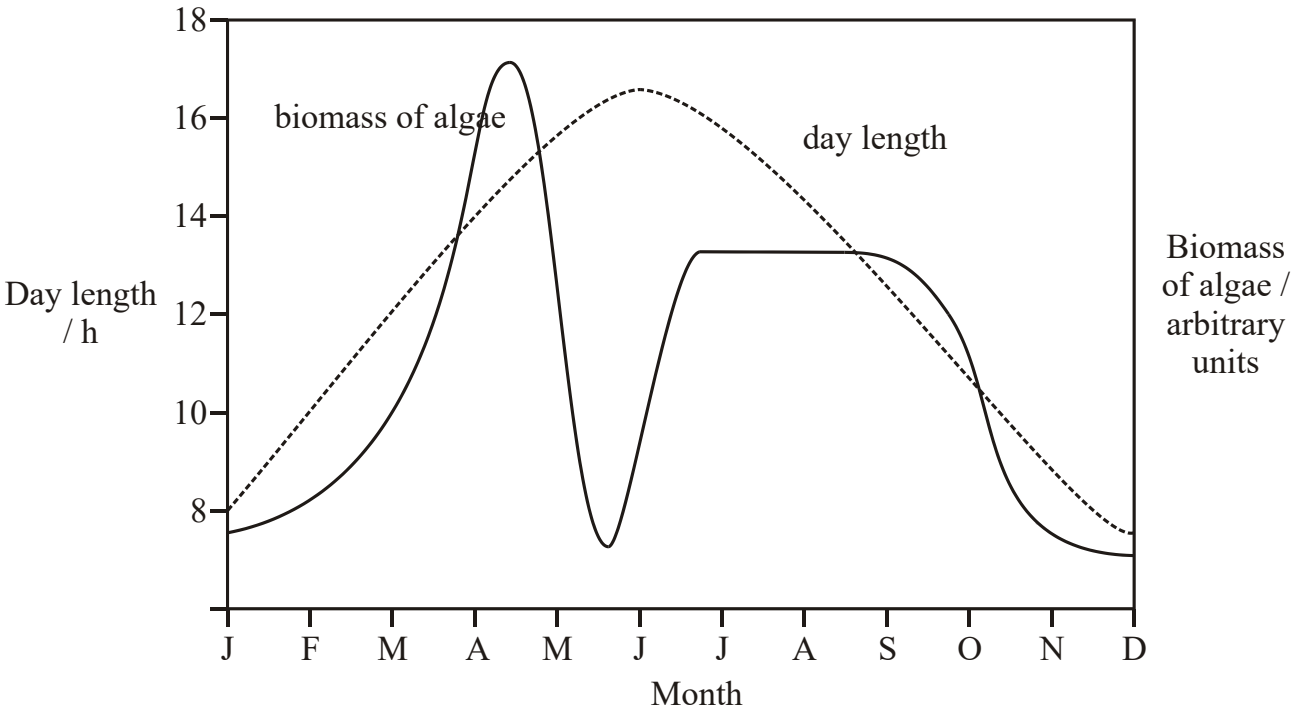
Alge Biomass (12 marks)

The water flea (*Daphnia sp*.) normally produces eggs asexually. Under certain conditions, *Daphnia* will switch to sexual reproduction, producing "resting" eggs that can survive dormant for many years. The graph below shows how the day length and biomass of algae (a food source for *Daphnia*) varies over the course of the year in the habitat of *Daphnia*.



a. Identify the month during which the quantity of food is at a maximum. *(1 mark)*

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b. Compare the changes in biomass of algae with the changes in day length from January to June. *(3 marks)*

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An investigation was conducted to determine how conditions experienced by one generation of *Daphnia* can affect resting egg production by the next generation. The investigation examined the influence of three variables on resting egg production: day length, quantity of food (photosynthetic algae), and conditions experienced by the previous generation. The table below shows the percentage of resting eggs produced under the various conditions.

Conditions experienced by 1st generation mother		**Conditions experienced by 2nd generation mothers**		**Percentage of resting eggs produced by 2nd generation**
Food Levels	**Day Length**	**Food Levels**	**Day Length**	
High	Short Day	High	Short Day	0.0
		High	Long Day	0.0
		Low	Short Day	52.3
		Low	Long Day	38.0
High	Long Day	High	Short Day	0.0
		High	Long Day	0.0
		Low	Short Day	13.0
		Low	Long Day	11.0
Low	Short Day	High	Short Day	0.0
		High	Long Day	0.0
		Low	Short Day	7.5
		Low	Long Day	15.8
Low	Long Day	High	Short Day	0.0
		High	Long Day	0.0
		Low	Short Day	0.0
		Low	Long Day	30.7

c. Discuss the conditions in the 2nd generation which favour resting egg production. *(3 marks)*

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d. Using the graph, deduce, giving a reason, whether resting egg production is likely in April. *(1 mark)*

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e. Determine the change between the 1st generation and the 2nd generation which is most likely to trigger resting egg production. *(1 mark)*

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f. Suggest the advantages of having asexual and sexual reproduction in *Daphnia*. *(3 marks)*

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Answers

1a *(1 mark)*
a direct relationship / as the size of the hawk increases so does the size of the prey / positive correlation

1b *(2 marks)*
a. all the hawks take prey smaller / lighter than themselves
b. the difference between the mass of the hawk and its prey is greater for smaller hawks than for bigger hawks
c. females of *Accipiter cooperii* have the greatest difference between themselves and their prey

1c *(1 mark)*
even though the predators are larger than their prey their numbers / population density will be less than their prey

1d *(1 mark)*
female hawks always have a greater mass than the males

1e *(2 marks)*
a. female hawks and male hawks do not feed on the same prey
b. males hawks spend more energy than female hawks / male hawks are more active than female hawks so they do not grow so large / males invest more of their food energy in movement and less in growth / males are not egg laying
c. male hawks are adapted to be more agile than female hawks
d. male hawks spend more time defending their territory than female hawks / male hawks spend less time feeding
Accept a reasonable genetic answer

2a *(1 mark)*
potassium / K

2b *(1 mark)*
sub-arctic forest

2c *(2 marks)*
a. K and Ca have greater MRT in chaparral (than temperate forest)
b. K has the shortest MRT of all nutrients in both biomes
c. C, N, P and Mg greater MRT in temperate forest than chaparral
d. MRT values for K and C show little variation between these areas (chaparral and temperate)
e. P shows the greatest range / difference in MRT
f. temperate forest has higher MRT for all nutrients except K and Ca
g. average MRT for all nutrients in the temperate forest is 3.8 and for the chaparral is 3.5
h. temperate forest and chaparral have similar values for all nutrients compared to the other biomes

2d *(2 marks)*
a. generally plant productivity increases while MRT decreases / negative correlation
b. tropical rainforest biome with shortest MRT (for nutrients) has highest plant productivity / sub-arctic has low plant productivity and long MRT
c. (but) chaparral has lower plant productivity than sub-arctic forest but shorter MRT for nutrients / there are exceptions to the relationship
d. there is no relationship that holds true for all four biomes
Do not accept no correlation.

2e *(1 mark)*
a. higher temperatures in tropical rainforest / lower temperatures in sub-arctic forest
b. greater decomposition in tropical rainforest / more saprophytes; water availability

2f *(2 marks)*

a. (relatively) constant / slight increase until June 1963
b. peaks in June 1964
c. decreases until December 1964
d. rise and fall of Cs-137 happens within a year (1964)
e. increases again until June 1965

2g *(2 marks)*

a. *lichens:* producers / autotrophs / first trophic level
b. *Inuit*: secondary consumer / third trophic level

2h *(1 mark)*

a. caribou eat lichens and accumulate Cs-137
b. Inuit eat caribou and accumulate (more) Cs-137
c. toxins build up in food chain / bioaccumulation / magnification (other concepts of additive nature)

3a *(1 mark)*

April

3b *(3 marks)*

a. biomass of algae levels vary / fluctuate more than changes in day length
b. day length gets longer at the same time as biomass of algae increases / biomass of algae peaks before the day length peaks
c. from (late) April biomass of algae drops off, while day length continues to increase
d. from January to April day length increases linearly while biomass of algae increase exponentially
e. in May, biomass of algae reaches a minimum while day length continues to rise
f. mid May to June, biomass of algae starts to increase again while day length rises to its maximum

Only credit answers which include a comparison.

3c *(3 marks)*

a. low food (in 7 out of 8 / most cases)
b. day length does not appear to show a clear pattern
c. in three of the four groups, low food and short day results in resting egg production
d. low food and long day always result in egg production
e. high food never results in resting egg production

3d *(1 mark)*

in April there is high food which does not result in resting egg production

3e *(1 mark)*

high food to low food *(Do not credit "low food" only*)

3f *(3 marks)*

Advantages of sexual reproduction: ***[2 max]***

a. sexual reproduction produces resting eggs when food conditions worsen / high to low food / weather conditions worsen
b. resting eggs remain dormant / survive during bad weather conditions / drought / cold temperatures
c. increases chance of population surviving bad weather conditions / drought / cold temperatures
d. sexual reproduction increases variety
e. variety increases the chances of the population surviving bad weather conditions / drought / cold temperatures
f. day length changes represent seasonal weather changes

Advantages of asexual reproduction: ***[2 max]***

g. asexual reproduction faster when weather conditions are good / in warmer temperatures / water is available
h. asexual reproduction is faster than sexual reproduction
i. asexual reproduction does not require the need to find a mate