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NZQA
NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Scholarship 2007
Biology

2.00 pm Wednesday 21 November 2007
Time allowed: Three hours
Total marks: 24

QUESTION BOOKLET

You should write ALL your answers in the Answer Booklet 93101A.

Show ALL working. Start each question on a NEW page. Number each question carefully.

Check that this booklet has pages 2–6 in the correct order.

YOU MAY KEEP THIS BOOKLET AT THE END OF THE EXAMINATION.

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QUESTION ONE (8 marks)

Barnacles are filter feeders that populate the coastlines of countries around the world. Fertilisation is external, and microscopic larvae develop. The larvae live for a time as plankton in the surface layer of the sea before settling and cementing onto rocks, where they metamorphose into the sessile adults.

The adults of two species of barnacle, *Chthamalus stellatus* and *Balanus balanoides*, are found on rocks in the inter-tidal zone of exposed shores in Scotland. *Chthamalus*, the smaller of the two barnacle species, is found in the upper tidal zone, whilst the larger *Balanus* extends to the low-tide mark. If *Balanus* is absent, *Chthamalus* can grow throughout the inter-tidal zone.

Predators of the adult barnacles are found throughout and below the inter-tidal zone. Predatory starfish are predominantly found below the low-tide mark, whilst predatory whelks and fish may feed in the inter-tidal zone.

Algae are dominant below the low-tide mark.

Question

Discuss how different **biotic and abiotic factors** act to **determine the fundamental and realised niches** of these two species, *Chthamalus stellatus* and *Balanus balanoides*.

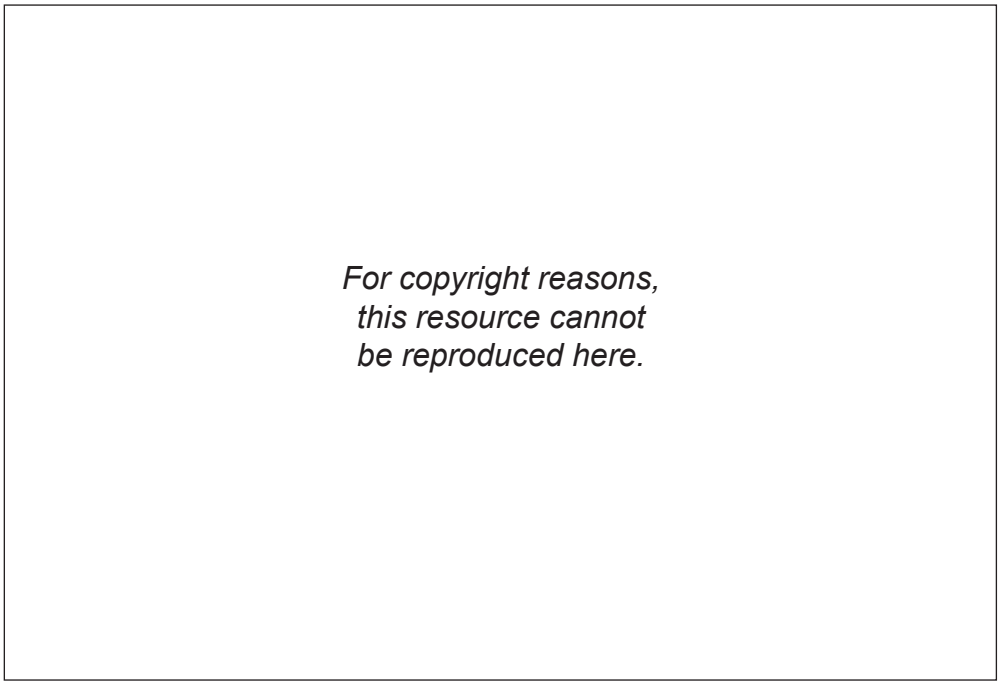

Image from: N.A. Campbell & J.B. Reece (2002) *Biology* (6th edition), Pg 1177, Pearson Education Ltd.

QUESTION TWO (8 marks)

Introduction

Huntington's Disease (HD) is a progressive disease of the central nervous system in humans. It causes degeneration of brain cells, resulting in progressive loss of control of physical movements, loss of mental abilities and eventually death.

Huntington's Disease is caused by a single autosomal mutation to the *IT15* gene. Most people with HD are heterozygotes. Homozygotes for HD are very rare.

The *IT15* gene is normally expressed as a protein that helps to ensure the survival of brain cells. The HD mutation in this gene results in an increase in the number of repeats of the DNA triplet, CAG. This is translated into an unusually long sequence of glutamines, which interferes with the protein's normal function.

Development of Huntington's Disease

Research shows that the development of HD is related to the number of CAG repeats, as shown in Table 1 below.

Table 1

Number of CAG Repeats in an Individual	Development of Huntington's Disease in Individuals
26 and below	Individual unaffected; offspring unaffected
27–35	Individual unaffected; offspring and future generations possibly affected
36–39	Most individuals affected
40 and above	All individuals affected

Age at Onset

The age for the onset of HD varies between individuals, as is shown in Table 2 and Table 3 below.

Table 2

Number of CAG Repeats	39	40	41	42	43	44	45	46	47	48	49	50
Median Age at Onset of HD (years)	66	59	54	49	44	42	37	36	33	32	28	27
95% Confidence Interval (years)	72–59	61–56	56–52	50–48	45–42	43–40	39–36	37–35	35–31	34–30	32–25	30–24

Acknowledgement: (Brinkman et al., 1997; *Am. J. Human Genetics*. 60:1202–1210).

Table 3

Genotype of Individual with HD	Median age (years) at onset of uncontrolled movements for individuals with the same number of CAG Repeats ($P \geq 0.05$)
Homozygous	51.3 years ± 2.7 years
Heterozygous	48.6 years ± 3.9 years

Acknowledgement: Modified from "Homozygosity for CAG mutation in HD", *Brain* (2003) 126, 946–955.

Progression of HD

A study, involving homozygotes and heterozygotes for the mutated *IT15* gene, monitored the severity and progression of HD over time.

Figure 1 on the opposite page shows the results for 6 homozygotes and 13 heterozygotes from this study.

The disease is classified into 5 stages (I–V):

- Stages I and II represent early stages of the disease.
- Stages III–V represent advanced stages of the disease.

The number of individuals at each stage is given in brackets.
The difference in numbers between stages is due to death.

Figure 1: Progression of HD

Acknowledgement: "Homozygosity for CAG mutation in HD", *Brain* (2003) 126, 946–955.

Gender and Transmission of HD

A study conducted on mice that had been made transgenic with the mutated human *IT15* gene, looked at the effect of the offspring gender on the inheritance of the CAG repeats. It is known that the HD transmission pattern in mice is similar to that in humans.

Table 4 below shows the changes in the CAG repeat length in the male and female offspring of one transgenic male mated with females with the normal *IT15* gene.

Table 4

	Number of offspring	% of offspring with any change in the number of CAG repeats compared with the father	% of offspring with an increase in the number of CAG repeats compared with the father	% of offspring with a decrease in the number of CAG repeats compared with the father
TOTAL			P< 0.001	
Male Offspring	34	76.5	55.9	20.6
Female Offspring	35	74.3	11.4	62.9

Acknowledgement: Modified from "Gender of embryo contributes to CAG instability in transgenic mice", *Human Molecular Genetics*, 2000, Vol. 9, No. 18, 2767–2775

Question

Analyse and discuss the inheritance of Huntington's Disease in humans.

In your discussion consider the following:

- the **genetics** involved in the inheritance of HD
- **factors** affecting the expression of HD and how the **likelihood of inheriting** HD is affected by these factors.

QUESTION THREE (8 marks)

Human disorders are increasingly being diagnosed and treated using biotechnological applications such as:

- Genetic testing, including testing of adults through to pre-birth diagnosis (for example: pre-implantation genetic diagnosis (PIGD) of embryos, amniocentesis or chorionic villus testing)
- Gene therapy
- Stem cell research
- Xeno-transplantation.

Question

Discuss how the use of **named** biotechnological applications may **impact** on the **gene pool** and the **future biological evolution** of *Homo sapiens*.