MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD
UNIVERSITY OF MALTA, MSIDA

MATRICULATION CERTIFICATE EXAMINATION
ADVANCED LEVEL
SEPTEMBER SESSION 2004

Subject:	**BIOLOGY**
Paper Number:	**Paper 2**
Date:	**3rd September 2004**
Time:	**9:00 a.m. to 12:00 noon**

Directions to Candidates

- *Answer ALL questions in Section A, any TWO questions from Section B and ONE question from Section C. Write all your answers in the separate booklet provided.*
- ***If more than two questions from Section B are attempted, only the best two answers shall be taken into consideration.***
- ***If more than one question from Section C is attempted, only the better answer shall be taken into consideration.***
- *The mark allocation is indicated at the end of each question. Marks allocated to parts of questions are also indicated.*
- *You are reminded of the necessity for good English and orderly presentation in your answers.*
- *In calculations you are advised to show all the steps in your working, giving your answer at each stage.*
- *The use of electronic calculators is permitted.*

SECTION A (Answer **ALL** questions in this section):

1. Read the extract below carefully and afterward, from the information given and from your knowledge of biology, answer the questions that follow. The numerals in the left-hand margin are line numbers.

Life without Sex: So, how many millions of years has it been?

Biologists have long held that asexuality is an evolutionary dead end. But new methods of genetic analysis are suggesting that certain groups of species have avoided sex and still have done quite well over the eons. Mark Welch and Matthew Meselson of Harvard University reported genetic evidence that an entire class of organisms, containing 360 species, seems to have evolved perfectly well without sex. This group of tiny aquatic invertebrates, called bdelloid rotifers, is thriving with seemingly no sex for at least 40 million years. The female's ovaries make eggs containing the full genome. These eggs require no sperm to develop into adults that are essentially genetic copies of their mothers.

Since then, geneticists and paleontologists have been focusing their most advanced methods on questions of asexuality and have found some 2,000 living species in which they haven't seen a trace of sexual behaviour.

The fossil record so far hasn't said much about the history of bdelloid rotifers—only that some specimens found in amber dating from 35 to 40 million years ago didn't include any obvious males. To explore bdelloid history further, Meselson and Welch looked at modern rotifers. No males have turned up in the whole bdelloid group, suggesting a long evolutionary history of asexuality. For a genetic test, the researchers proposed that one distinctive sign of millennia without sexual reproduction might be a pattern of abundant variability between copies of genes. The researchers focused on versions of the same gene in different species and it was reported that the two copies of the gene in the asexual species differ from each other far more than do copies of genes in rotifers that evolved sexually.

After the unveiling of the bdelloid oddity, researchers threw themselves into testing more predictions about the genetics of asexuality. Meselson and Irina Arkhipova, a geneticist in his lab, looked at the bdelloid pattern of transposable elements. These snippets of genetic material shoehorn themselves into a variety of spots in a host's DNA. Such pushiness can secure an element's place in subsequent generations, but it can also mess up the gene in which it lands. Arkhipova refers to transposable elements as sexually transmitted parasites. Two decades ago, a theorist predicted that a species that changed from sexual to asexual reproduction would lose transposable elements. To explore this prediction, Arkhipova and Meselson surveyed genetic sequences from representatives of 24 phyla of animals, including the lab fruit fly *Drosophila melanogaster*, the tiny lab worm *Caenorhabditis elegans*, and the waterborne pathogen *Giardia lamblia*. Traces of two large groups of transposable elements that copy themselves and proliferate when a species reproduces sexually showed up in most of the animals but not in the bdelloid rotifers.

Now that biologists regard asexuality as being as interesting as sexuality, researchers are looking for similar examples among creatures as varied as clams, mites and fungi.

Welch and Meselson tested another genetic prediction about asexuality. Some scientists had speculated that asexual species would accumulate more mutations than sexual species. Welch and Meselson addressed this notion by comparing sequences of a gene in bdelloids with its counterpart in sexual rotifers. Contrary to the theory, though, the sexual rotifers showed about the same abundance of glitches in their genes.

The ancient asexuals then, if they really are asexuals, are giving mixed results for the theories explaining sex. Bdelloids seem to be getting rid of menacing transposable elements, but so far as biologists know, don't seem bothered by an abundance of other mutations. This undermines the view that mutation build-up is a major problem solved by sex.

1.1 Why is asexuality typically regarded as "*an evolutionary dead end*"? (line 1)

[two marks]

1.2 What is the term applied to growth of individuals without fertilisation of eggs?

[one mark]

1.3 Why are transposable elements referred to as "*sexually transmitted parasites*"? (lines 31-32)

[two marks]

1.4 Why should biologists now "*regard asexuality as being as interesting as sexuality*"? (line 41)

[two marks]

1.5 "*….researchers are looking for similar examples among creatures as varied as clams, mites and fungi.*" (lines 41-42). Investigating genetic sequences from the organisms mentioned in lines 41-42 may be more problematic than investigating genetic sequences from bdelloid rotifers. Suggest ONE reason for this observation.

[one mark]

1.6 "*….it was reported that the two copies of the gene in the asexual species differ from each other far more than do copies of genes in rotifers that evolved sexually.*" (lines 22-24). Why should a particular gene show more variety in an asexual species when compared to the same gene in a sexual species?

[three marks]

1.7 "*Two decades ago, a theorist predicted that a species that changed from sexual to asexual reproduction would lose transposable elements.*" (lines 32-33). Suggest a possible reason for the predicted loss of transposable elements by asexual species.

[three marks]

1.8 List **THREE** predictions made by scientists about the genetics of asexuality.

[three marks]

1.9 "*Contrary to the theory, though, the sexual rotifers showed about the same abundance of glitches in their genes.*" (lines 47-49). Why should the researchers have been expecting sexual species to comprise relatively fewer mutations than asexual species?

[three marks]

[Total: twenty marks]

2. Exposure to wave action is known to influence the morphology of a number of intertidal gastropods. In order to study this phenomenon, individuals of the sub-littoral gastropod *Gibbula cineraria* were collected along a gradient of wave exposure. Four shell characteristics, namely, shell height, shell width, aperture length and aperture width, together with soft body weight and foot muscle weight were measured and recorded. The table below summarizes the findings of this investigation:

Site	Mean shell height/mm	Mean Shell width/mm	Ratio of Shell height to shell width	Mean soft body weight/g	Foot weight as a percentage of body weight (%)	Ratio of aperture length to shell height	Ratio of aperture breadth to shell width
1	9.8	11.5	0.85	0.119	50.2	0.725	0.515
2	9.0	9.8	0.91	0.080	49.3	0.624	0.460
3	8.7	9.7	0.89	0.079	47.1	0.594	0.423
4	9.0	10.1	0.89	0.115	46.7	0.560	0.408
5	9.8	10.2	0.96	0.123	44.8	0.548	0.412
6	8.6	9.2	0.93	0.076	44.0	0.593	0.455
7	11.0	11.6	0.94	0.180	43.6	0.538	0.420

Gradient of wave exposure: site 1- high; site 3 – moderate; site 7 – sheltered.

2.1 What is a gastropod?

[two marks]

2.2 What is a sub-littoral environment?

[two marks]

2.3 Comment on the ratio of shell height to shell width in relation to exposure to wave action.

[two marks]

2.4 How may the observations made about shell height and width be related to a selective advantage in this species?

[three marks]

2.5 What factors, other than exposure to wave action, may be contributing to the observed differences in shell morphology and snail weight in the localities sampled?

[three marks]

2.6 What definite precaution would have to be taken when sampling these organisms?

[two marks]

2.7 Comment on the ratio of aperture breadth to shell width and the ratio of aperture length to shell height in the different sites sampled.

[two marks]

2.8 What general conclusions can you draw from the trends observed in your answer to question 2.7?

[four marks]

[Total: twenty marks]

SECTION B

(Answer any **TWO** questions from this section; your answers should take the form of essays. Each question carries twenty marks).

3. Give an overview of the different levels of structural organisation in protein molecules.

4. Compare and contrast the life cycles of a fern and a flowering plant.

5. The mammalian kidney is a homeostatic organ. Discuss.

6. Are the cells of unicellular eukaryotes any different from those found in multicellular eukaryotes? Discuss.

SECTION C
(Answer **ONE** question from this section).

7. It is often stated that life on Earth is based on the element carbon.

   7.1 Explain, using examples, the meaning of the statement above.
   7.2 Suggest reasons as to why life is based on carbon rather than on other chemical elements.
   7.3 Why is water often considered an essential prerequisite for the processes of life?
   7.4 Scientists have often constructed experiments designed to detect the presence of microbial life on other planets. Describe a simple experiment that you could carry out to detect whether a sample of soil from an unknown location may or may not contain living organisms. Bear in mind that direct microscopic observation of the life-forms would not be possible.

   [five marks each]

   [Total: twenty marks]

8. Briefly describe how the following adaptations have increased the evolutionary success of the organisms that possess them. Your discussion should refer to the structures and functions related to each adaptation.

   8.1 An endoskeleton versus a chitinous exoskeleton.
   8.2 Internal versus external fertilisation.
   8.3 A closed versus an open circulatory system.
   8.4 Seeds versus spores.

   [five marks each]

   [Total: twenty marks]