1 B [1]

2 D [1]

3 **a)** Any two from:

- (circular) chromosome structure;
- absence of membrane-bound organelles;
- peptidoglycan in cell walls; [2]

b) An explanation including three of the following:

- RNA is found in all cells so will always be available;
- rRNA is vital for protein synthesis so most mutations will not survive;
- (therefore) there are relatively few changes in rRNA;
- new methods mean RNA sequence can be quickly analysed; [3]

c) An explanation including any two problems and any two adaptations from the following:

Problems:

- High temperatures cause changes in proteins;
- Example denaturation of enzymes;
- Example disrupting membrane structures;
- By breaking hydrogen bonds holding DNA strands;

Adaptations:

- Archaea have fewer membranes;
- Phospholipids in Archaea have stronger (ether) bonds;
- Archaea cell walls have resistant outer protein layer;
- Archaea have temperature-resistant enzymes;

A maximum 2 problems and 2 adaptations [4]

4 **a)** 12 (amino acids) [1]

b) **i)** Mole : dog = 7 differences

ii) Mole : marsupial mole = 13 differences [2]

c) The mole and the dog are most closely related;

because they have less differences in their RNA; [2]

d) An explanation including the following in a logical order:

- Marsupial mammals are a more primitive/older form of mammal;
- Placental mammals evolved from marsupial mammals (at a later time);
- The dog and the mole are both placental mammals;
- Therefore closer together in evolutionary history; [4]

e) **i)** Dog = 2 fragments;

Mole = 3 fragments;

Marsupial mole = 3 fragments;

All 3 correct for 1 mark [1]

ii) An explanation that includes the following four points in a logical sequence:

- the dog sample;
- because the dog sample has the largest fragment/a fragment 28 bases long;
- and larger fragments move through the gel more slowly;
- because the gel has a pore-like structure, which makes it more difficult for larger fragments to move; [4]

Stretch and challenge questions

5 The purpose of this question is to provide a case study in how scientific knowledge is built in a reliable way. You will see that it includes many examples of the process described in Chapter 7 but also it illustrates that scientific progress does not always proceed in a logical dispassionate way. All scientists are likely to consider their own career and standing in the scientific community and hence human emotions also play a part in the process. Sometimes it helps to have a passionate advocate for some important model but it can also be a hindrance to progress. Fortunately, as you can see in this example, so many scientists are often involved that, eventually, logic and evidence prevail.

There are many answers to some of the questions so in these cases examples are given but your similar example may also be correct.

a) Warren and Marshall suggested that *Helicobacter pylori* infection was at least part of the cause of PUD not just excess acid in the stomach.

b) You can find references to bacteria and PUD in the following:

- 1906 – Krienitz
- 1915 – ref. to bacterial association
- 1919 – Kasai and Kobayashi
- 1925 – Hoffman
- 1936 – Russian medical Encyclopaedia

and so on.

The main point here is that Warren and Marshall were not the first to recognise the possible link, but that the recognised model was that excess acid was the main (and possibly only) cause. Also that even in the first part of the 20th century such research was an international activity.

c) The peer review process is not just limited to experts checking research papers before they are published. Scientists often present their findings and ideas face-to-face with other researchers at meetings and conferences where they will be subject to detailed questioning

and sometimes criticism. There are lots of examples here of how this works in this particular case:

- 1982 – A local meeting where their first results are presented. Notice that there is some criticism suggesting that the first papers might not have been rigorously presented or there may not be enough repeated data, etc.
- 1983 – The major national society does not even accept the paper for presentation at their meeting. We don't know if this was because of weaknesses in the paper or if it was because it was challenging a well-accepted idea of the cause of PUD. Notice they don't give up but get letters published in *The Lancet* (one of the top journals on medical research in UK) but only describing their findings in outline, not a full research paper. However, you will see that it starts others thinking.
- 1984 – Marshall and Warren get to present their paper to the Australian society and have it published in *The Lancet.*
- 1990 – The World Congress on Gastroenterology recommends that treatment for PUD should include eradication of *H. pylori.* This means that the world's doctors are advised to change the form of treatment for this disease, vindicating Warren & Marshall's work.

So you can see that such conferences play a vital role in challenging new ideas and ensuring they are rigorously checked.

d) Marshall swallowed a culture of H. pylori himself and started to suffer from PUD. This would be considered unethical in medical research, partly because of the risks and partly because any results he reported would be subjective and biased.

(It's interesting to note that his colleague Morris did the same, but unlike Marshall he was not cured by antibiotics and suffered for several years.)

e) The simple answer here is that most of the drugs used treat PUD were sophisticated gastric acid-reducing compounds. PUD is common throughout the world so there was a huge market for these drugs. However, large pharmaceutical companies are not allowed to keep the copyright on their discoveries forever and after about 20 years other companies are allowed to copy it and sell it cheaper. Therefore, many doctors who might receive support from large pharmaceutical companies may be unwilling to accept ideas that might undermine their products. However, as usual, the story is not that simple. It costs pharmaceutical companies over £100 million to bring a drug on to the market. To sustain this level of research and development they need to make a reasonable profit over time and we all benefit from this process.

If you are interested in this story you might like to follow the current debate about attempts to develop new antibiotics in the face of increasing bacterial resistance, and also the debate of whether drug companies should sell important drugs to poorer countries at reduced prices.