Low protein diets are a widespread problem in the developing world. A low protein diet in a pregnant mother could affect a developing fetus. Other mammals are used as a biomedical model for energy metabolism and malnutrition in humans.

In an experiment to study the effect of protein levels in the diet, pregnant mammals were fed diets with different ratios of protein to carbohydrate:

- low protein : high carbohydrate (LP),
- adequate protein : adequate carbohydrate (AP),
- high protein : low carbohydrate (HP).

The table shows the average birth mass of the offspring and the body mass gain of the mother during the pregnancy. The concentration of several substances in the plasma of the mothers was also recorded. LDL (low density lipoprotein) is considered “bad cholesterol” and HDL (high density lipoprotein) is considered “good cholesterol”.

<table>
<thead>
<tr>
<th></th>
<th>Offspring birth mass / kg</th>
<th>Mother’s body mass gain / kg</th>
<th>LDL cholesterol / mmolL⁻¹</th>
<th>HDL cholesterol / mmolL⁻¹</th>
<th>Glucose / mmolL⁻¹</th>
<th>Urea / mmolL⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP</td>
<td>1.19</td>
<td>42.1</td>
<td>0.59</td>
<td>0.96</td>
<td>4.24</td>
<td>1.7</td>
</tr>
<tr>
<td>AP</td>
<td>1.41</td>
<td>68.3</td>
<td>0.70</td>
<td>0.87</td>
<td>4.04</td>
<td>3.0</td>
</tr>
<tr>
<td>HP</td>
<td>1.21</td>
<td>63.1</td>
<td>0.85</td>
<td>0.78</td>
<td>4.20</td>
<td>7.1</td>
</tr>
</tbody>
</table>


1a. Identify the substance that varies the most in the plasma of the mothers.  

[1 mark]

1b. Calculate the difference between birth mass of offspring whose mothers were fed the AP diet and the HP diet.  

[1 mark]
1c. Distinguish between LDL cholesterol and HDL cholesterol in relation to the diet. [1 mark]

1d. Explain the low birth mass of offspring born to mothers who were fed the LP diet. [2 marks]

1e. In many societies doctors may recommend an HP diet for pregnant humans. Using the data, evaluate this recommendation. [3 marks]

2a. State one source of vitamin D in the diet. [1 mark]
2b. State how vitamin D can be obtained other than through the diet. [1 mark]

3a. State two symptoms of type II diabetes. [2 marks]

3b. Explain the causes and consequences of phenylketonuria (PKU). [4 marks]
4a. Water and minerals are essential in the human diet. List two other types of nutrient in a human diet. [1 mark]
   1: .................................................................
   2: .................................................................

4b. Outline the benefits of using iodine as a dietary supplement. [2 marks]
   .................................................................
   .................................................................
   .................................................................
Nationally representative data was collected on body mass index (BMI) from 1985 to 2004. The graph shows overweight and obesity patterns in adult males and females from seven countries.

5a. State which country has the lowest total percentage of overweight and obese adults. [1 mark]

5b. Distinguish between the levels of male obesity and female obesity. [2 marks]
5c. Compare the overweight and obesity patterns in Australia and Morocco. [2 marks]

5d. Suggest two possible reasons for the differences in BMI from the reported countries. [2 marks]

6. List two natural food sources of vitamin D in human diets. [1 mark]
The following are from the labels of a bag of all purpose white flour (wheat) and a bag of parboil long grain rice. Amounts shown are per serving.

<table>
<thead>
<tr>
<th></th>
<th>Flour</th>
<th>Rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serving size</td>
<td>30 g</td>
<td>30 g</td>
</tr>
<tr>
<td>Fat</td>
<td>0.4 g</td>
<td>0.2 g</td>
</tr>
<tr>
<td>Saturated</td>
<td>0.1 g</td>
<td>0 g</td>
</tr>
<tr>
<td>Trans fat</td>
<td>0 g</td>
<td>0 g</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>0 mg</td>
<td>0 mg</td>
</tr>
<tr>
<td>Sodium</td>
<td>0 mg</td>
<td>0 mg</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>22 g</td>
<td>24 g</td>
</tr>
<tr>
<td>Fibre</td>
<td>1 g</td>
<td>0 g</td>
</tr>
<tr>
<td>Sugars</td>
<td>0 g</td>
<td>0 g</td>
</tr>
<tr>
<td>Protein</td>
<td>4 g</td>
<td>2 g</td>
</tr>
</tbody>
</table>


7a. Using your knowledge of the energy content of nutrients, calculate the protein energy value of a serving of rice, [2 marks] showing the units.
7b. Compare wheat flour and rice as main dietary sources of energy for humans. [2 marks]

7c. Evaluate the benefits of reducing dietary cholesterol in lowering the risk of coronary heart disease. [2 marks]

8a. Outline the control mechanism for appetite in humans. [2 marks]
8b. Explain the possible health consequences of a diet rich in protein. [3 marks]

9a. Malnutrition affects the body mass index (BMI) of mothers. The height and mass of over 7000 mothers in Ethiopia and the sex of their most recently born child was recorded. The graph shows the percentage of mothers with a BMI below 18.5 and the percentage of their most recent births that were males in 11 regions across Ethiopia.

State the regions with the highest and lowest percentage of male offspring.

Region with highest percentage: .................................................................
Region with lowest percentage: ............................................................... [1 mark]

9b. Comment on the variation in BMI of mothers in Ethiopia. [2 marks]
9c. Discuss whether the data supports the hypothesis that malnutrition affects the sex ratio of offspring. [2 marks]

9d. Suggest one limitation of the data. [1 mark]

9e. Suggest one factor that could cause malnutrition in mothers. [1 mark]

10. Evaluate the health consequences of a diet rich in polyunsaturated fatty acids. [2 marks]
The cholesterol-lowering effect of *Lactobacillus* bacteria was studied. Forty rats were divided into groups and fed either a normal or high cholesterol diet. Some rats fed the high cholesterol diet were also supplemented with *L. fermentum* or *L. plantarum*. After a six week feeding period, the concentration of cholesterol in liver tissue and the mass of bile salts in feces were measured.

11a. State the concentration of cholesterol in liver tissue and the mass of bile salts in feces for the normal diet, giving the units.

**Concentration of cholesterol:**

**Mass of bile salts:**

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11b. Calculate the percentage increase in the concentration of cholesterol in liver tissue, caused by feeding the rats a high cholesterol diet without supplementing with bacteria. Show your workings.
11c. Deduce the effects of supplementing the diet with *Lactobacillus* on the concentration of cholesterol in liver tissue and on the mass of bile salts in feces. [2 marks]

11d. Scientists hypothesized that *Lactobacillus* could be used in diets to reduce the incidence of coronary heart disease (CHD). Evaluate the evidence for and against this hypothesis provided by the data. [3 marks]

12a. List **two** consequences of anorexia nervosa. [1 mark]

1. 
2. 
12b. Explain the causes, consequences and treatment of phenylketonuria (PKU).

13a. Outline the molecular structure of different types of fatty acids.
Evaluate the benefit of reducing cholesterol in the diet.