When providing food to cattle it is essential that the producer has an understanding of their requirements, so the animals will be able to produce at an optimum level.

In this part you will begin by revising ruminant and monogastric digestion from the preliminary course, then finding the similarities and differences between these digestive systems.

Next you will examine the feeding of cattle in both extensive and intensive production systems.

An important aspect of formulating rations is matching energy in the food with the energy requirements of the animal. You will be studying the ways that energy is lost during digestion, and how it is used by the animal.

This part contributes towards an understanding of Outcome H2.2 from the Agriculture Stage 6 HSC Course. The syllabus can be found on the Board of Studies, NSW website at http://www.boardofstudies.nsw.edu.au
Access an interactive version of Ruminant and monogastric digestion using this link. Resume with this material on page 8: Writing for an exam.

In the preliminary course you examined the digestion of ruminant and monogastric animals. In this part you will be comparing these different ways of digesting food, so you will first need to revise the structure and function of the tracts.

### Monogastric quiz

Test yourself! Revise monogastric digestion from Part 3 of Hands on and then try to answer the following quick quiz questions from memory. No cheating!

1. How many stomachs do monogastric animals have? ____________

2. What is the tube that food passes into after it has been swallowed? ____________________________________________

3. Name the nutrient type broken down by hydrochloric acid and pepsin in the stomach. _______________________

4. State the function of the first part (the duodenum) of the small intestine. __________________________________

5. State the function of the rest of the small intestine. ____________

6. Name the small folds found on the inside surface of the small intestine. ________________________________

   Bonus mark – state the function of these folds ________________________________

7. What is the function of the large intestine? __________________________

8. Are vitamins produced by microbes in the caecum then absorbed in the large intestine? ________________________________

9. Name the end section of the large intestine used for storage of faeces. ________________________________

10. Name the exterior openings at the end of the digestive systems for:
   a) poultry _______________________________________
   b) pigs. _______________________________________

---

Part 2: Feed intake
Check your answers and count up your score out of 10. If you scored less than 8 for the quiz you should have another look at the material in Part 3 of Hands on. You will need to learn both the names of the parts and what they do.

Ruminant quiz

Revise the sections on the rumen and the ruminant digestive system in Part 3 of Looking at ewe. Get ready for another quick quiz. Try to improve your score for this one!

1 Identify the fluid that keeps the rumen contents liquid. __________

2 Name the three types of microbe found in the rumen. __________

3 Identify where 60% of Volatile fatty acids (VFAs) go after being broken down by microbes. ________________________________
   Bonus mark: Identify the other fate of VFAs._________________

4 How are carbon dioxide and methane, produced by rumen microbes, released from the body? __________________________________

5 What happens to food in the rumen that is too coarse?___________

6 Identify the second stomach compartment of a ruminant. ________

7 What is the function of the folds inside the omasum? __________

8 What happens to microbes in the abomasum? _________________

9 Name the part of the digestive system that fits the following description of function: “Digestive enzymes break down the food further and the digestive products are then absorbed through the walls into the bloodstream.” ________________________________

10 Is the major function of the large intestine removal of water? _____

Check your answers. If you scored less than 8 out of 10 go back and revise the information again from Looking at ewe.
Comparing ruminants and monogastrics

Our task is to compare ruminants with monogastrics. The word *compare* is one of the key words used in the Board of Studies syllabuses and examinations. It has a particular meaning when used in HSC exam questions.

<table>
<thead>
<tr>
<th>Compare – Show how things are similar or different</th>
<th>BOS NSW 1999 The New Higher School Certificate Assessment support Document</th>
</tr>
</thead>
</table>

Use ticks in the table below to identify the parts of the monogastric and ruminant digestive systems that are structurally similar or different.

Note: Monogastric digestive tracts are not identical, for example, pigs and poultry, so you might find you need to tick both similar *and* different for some parts.

<table>
<thead>
<tr>
<th>Part</th>
<th>Similar</th>
<th>Different</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oesophagus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stomach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duodenum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small intestine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caecum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large intestine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External opening</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Check your answers.

Now that you have identified some differences in the structure of some parts, you need to understand the effects these differences have on the animal and what they eat.

Part 2: Feed intake
**Mouth**

The absence of teeth in a chicken affects the type of food that it can eat. The food must either be small enough to swallow whole or easily broken into smaller pieces. As the food passes down the oesophagus without being ground by teeth, the pieces are not as small and are not easily worked on by enzymes.

A ruminant produces significantly more saliva than a monogastric animal in order to keep the rumen contents liquid. Ruminant saliva is also different in constitution. It contains a large amount of bicarbonate that acts as a buffer against acidity in the rumen, and does not contain the amylase enzymes that begin starch break down in the mouth of a monogastric animal.

**Stomach**

The stomach is the most significant difference between ruminants and monogastrics. The presence of micro-organisms in the rumen means that the type of food that can be digested is different.

- Ruminant animals have the ability to digest cellulose, while it is indigestible to monogastrics and passes through the system as fibre. Monogastrics are not able to survive on a diet consisting mostly of cellulose.
- Rumen microbes synthesize, that is produce, B group vitamins and vitamin K, meaning that ruminants do not need to eat these vitamins. To remain healthy monogastrics need a supply of these vitamins in their food.
- Rumen microbes are important in altering dietary protein. In a monogastric animal some high quality (expensive) protein must be fed to the animal, while in the ruminant animal the microbes can upgrade lower quality (cheaper) protein, and even limited amounts of non-protein nitrogen sources (much cheaper) to high quality microbial protein for the animal to digest. The other side of this is that if a ruminant is fed high quality protein it is downgraded by the microbes. It is possible, although expensive, to treat protein before it is fed to the animal so that it is protected from microbial digestion and remains high quality. This is called bypass protein.
- In monogastric animals the type of fat they are fed will directly influence the type of fat in the body and products – this is how we can produce products containing specific types of fat such as Omega 3 eggs. Rumen microbes will alter fats that are eaten by the ruminant animal to saturated fats. It is possible to treat fat before it is fed to the animal so that it is protected from microbial digestion, meaning that unsaturated body fat and milk fat can be produced.
**External opening**

The external openings are really more similar than different. The major difference is that birds have a cloaca that combines the external openings of the reproductive and urinary tracts with the digestive tract (this may be part of an adaptation for weight minimization), and mammals have an anus as the external opening of the digestive tract.

**Writing for an exam**

Interpreting exam questions and writing good answers are skills that you can develop. Look at past exam questions and answers to gain a good understanding of what is required. These can be found on the Board of Studies website. Practice writing exam style responses without reference to your notes, and then check your answer.

Consider the following tips when you are planning a response.

- Look for key words in the question that have been given particular meaning by the Board of Studies. Tailor your answer to meet the requirements of these key words.
- Avoid rewriting the question. In agriculture you will not always need to use full sentences in your answer.
- Stick to the facts – avoid ‘padding’ and repetition.
- Link your answer back to the question for each point you make.
- Include relevant examples to help illustrate your answer. Sometimes including a diagram or graph can be helpful.
- Look at the mark value allocated to the question and check that your response has at least as many different points as the marks allocated.
- If appropriate, consider the wider implications of your answer. This might include brief references to an impact on such areas as the environment, sustainability, economics, animal welfare, ethics, the wider community or markets.
- If a question asks you to write about more than one area make sure that you do not miss out on any parts of the question. A complete answer will address all aspects of the question.
- Read over your answer to check that it is legible, makes sense and answers the question.

Turn to Exercise 2.1 and answer the question as if you were answering a question in an exam. Use the tips given above to produce a high scoring response.
Extensive feeding

Cattle in a grazing system mostly depend on a mixture of grasses and legumes for their food. This is called an extensive agricultural production system. Cattle in an intensive agricultural production system are kept in pens in a feedlot. In a feedlot they mainly consume grain. You will be looking at the feeding management practices at *Ondiong* Murray Grey stud at Dorrigo in NSW.

*Ondiong* was established in the late 1960s. It produces stud Murray Grey animals for sale to commercial breeders or other studs. Commercial breeders choose a bull to suit their particular requirements, such as:

- early maturity
- good muscling ability
- optimum fat levels
- high fertility
- structural soundness
- good temperament.

Most commercial breeders use a computerised tool such as *Breedplan* to help them choose the best bull for their special needs. This system gives values to a wide range of characteristics, so buyers can more accurately compare one animal to another.

The following calendar shows some of the activities carried out at *Ondiong* stud during the year.
Month | Activities
--- | ---
January | 600 day weigh, EMA and fat scan of heifers, hay and silage making, pregnancy testing of heifers
February | pasture improvement, winter forage planted
March | wean, 200 day weigh, drench calves, vaccinate and delouse cows, Sydney Royal Easter Show
April | Sale bull selection, consign prime steers, Wodonga national show and sale
May | break in and handle bull weaners, Casino Beef Week steer show
June | 400 day weigh, calving commences
July | calving, weigh, drench, vaccinate yearlings
August | calving, vaccinate calves, artificial insemination begins, annual production sale
September | sires go out, vaccinate calves
October | 
November | drench calves
December | hay and silage making

Figure 2.1: Calendar of operations at Ondiong stud. Note: Some activities such as fencing, updating water systems, yard improvements and tree plantings are all year round jobs.

Cattle growth

The following table shows the average growth of Murray Grey cattle at Ondiong from birth to 400 days.

<table>
<thead>
<tr>
<th>Age (days)</th>
<th>Bull's weight (kg)</th>
<th>Heifer's weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>birth</td>
<td>37</td>
<td>33</td>
</tr>
<tr>
<td>200 days</td>
<td>260</td>
<td>220</td>
</tr>
<tr>
<td>400 days</td>
<td>470</td>
<td>350</td>
</tr>
</tbody>
</table>

Figure 2.2: The weight of bulls and heifers at birth, 200 days and 400 days on Ondiong Murray Grey stud.
The following graph shows a growth curve (marked herd A) for some Murray Grey heifers raised on a property further inland than *Ondiong*. These cattle are raised on lower quality pastures in much drier conditions.

![Growth curve for Murray Grey cattle](image)

Figure 2.3: Growth curves for Murray Grey cattle under different environmental conditions.

1. a) On the axes above, graph the growth of the *Ondiong* heifers from birth up to 400 days of age.
   
   b) Label this curve as herd B.
   
   c) Include a key on the graph.

2. Briefly describe the shapes of the two curves.

   __________________________________________________________

   __________________________________________________________

3. Account for the different shapes of the two curves.

   __________________________________________________________

   __________________________________________________________

   __________________________________________________________

4. Propose ways the farmer managing herd A could try to improve the growth of the cattle.

   __________________________________________________________

   __________________________________________________________

   __________________________________________________________

   [Check the answer section.](#)
Ondiong must manage its animals so they reach close to their full genetic potential. A very important aspect of this is meeting the nutritional needs of the cattle at the different stages of their lives.

Supply of nutrition

Cattle with a slow rate of growth and development will take a long time to reach saleable condition. The Murray Grey cattle at Ondiong grow quickly and mature early because Ondiong has a climate that allows good quality pasture to grow all year round.

Figure 2.4: Cattle grazing. (Photograph: Sue Francis)

The cattle on Ondiong receive most of their nutrition from pasture. Sometimes they are supplied with conserved feed such as silage or hay. They are generally not fed other concentrated feeds as buyers prefer to observe the performance of the animals under farm conditions.

Pastures

Pasture growth at Ondiong is good throughout the year. Eighty per cent of the pasture grown is improved species. Winter forage plants include oats, turnips and puna chicory. The different types of pasture can cater for the changing nutritional needs of the animals at different stages of their growth and development.

Pastures are resown every seven years as the clover begins to diminish and kikuyu dominates.
Hay

The cattle are fed hay as a supplement to pasture feed. It is particularly important in a drought.

Figure 2.5: Hay being fed to cattle in Forbes during the 1994 drought. (Photo: Ken Clipsham)

Hay is also used to help prevent bloat in seasons of lush clover or lucerne growth. Bloat is a possibly life threatening condition where a foam forms in the rumen that prevents the escape of gas. The rumen quickly swells up and the pressure that it exerts on vital organs, such as the heart and lungs, can cause death. The foam is most likely to form when the animal is eating legumes high in moisture. Adding roughage such as hay to the diet can help prevent the foam forming.

Find out more about bloat by reading Primefact 416: Bloat on the NSW Department of Primary Industries website at http://www.dpi.nsw.gov.au/.

Good quality pasture is selected to make into hay. This means a quickly grown even pasture with a good legume content.

Silage

Silage is made on Ondiong by contractors. They use their own machinery to cut the pasture when it reaches the correct moisture content.

Silage is produced by baling and wrapping pasture at a higher moisture content than hay. Wrapping the bales excludes oxygen and allows microbes to ferment the cut pasture, preserving it in a similar manner to pickled vegetables.
Nutritional requirements

The nutritional requirements of cattle must be met from an early age to ensure efficient growth and development. A growing animal will use nutrition first for skeletal development, then muscle development and finally fat development. These priorities mean that if nutrition is limited then the later developing tissues are affected first. This can be manipulated by producers to get the carcass type they want. For example, if a well muscled lean carcass is desired the animal is fed well early on, and feed is restricted later.

An early maturing calf, adequately nourished, will lay down fat at a younger age. However, young cattle which mature too quickly may not reach adequate market weight and will become over fat.

Breeding females

Heifers are weaned at 7.5 to 9 months onto good pasture to ensure adequate growth and development and a fat score of 2 to 3 at joining (mating). At Ondiong the heifers are first joined at 14 months of age. Research has shown that the condition score of cows and heifers at joining has a significant impact on the conception rates of the herd and the number of live calves born.
The nutrition of cows before calving needs to be monitored to prevent them becoming over fat. An over fat cow can have calving difficulties and udder problems. The cows are managed to keep them at a fat score of 2–3 before calving.

After calving, the cows are kept on the best pasture possible to provide a good milk supply for their growing calves. Cows are joined within two months of calving – while they are still lactating. To increase the success of joining, the level of nutrition is gradually increased. Increasing the level of nutrition helps return them to heat, that is, begin ovulating again. By managing the nutrition of the cows in this way the reproductive efficiency of each cow is maintained at a high level.

After the calves have been weaned the females, which are pregnant again, are put onto steep, rough paddocks to ensure plenty of exercise. This maintains them around the 2–3 score condition for their next calving.

1. Construct a time line for a female from her own birth to the birth of her second calf. Indicate the milestones of her life and the times when she needs a high level of nutrition along the line. Note: the length of pregnancy, that is, gestation period, of a cow is approximately nine months.
During drought the nutrition available to breeding cattle herds is reduced in many areas. There is little pasture growth and feed is very expensive.

2 Explain the impact this may have had on the reproductive efficiency of breeding herds in Australia.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Check the answer section.

**Bulls**

The sale of bulls is one of the main sources of income at *Ondiong*. After weaning, the young bulls are carefully maintained on improved pasture with adequate protein and energy to maximise their rate of growth and development. Young bulls get most of their nutrition from pasture because excessive and prolonged grain feeding can be detrimental to the later working life of a bull.

![Pastures at Ondiong provide the bulk of the nutritional requirements of the Murray Grey cattle that are produced there. (Photo: Sue Francis)](image)

Figure 2.7: Pastures at *Ondiong* provide the bulk of the nutritional requirements of the Murray Grey cattle that are produced there. (Photo: Sue Francis)
Intensive feeding

You are now going to examine the different rations provided for cattle at Tullimba. Tullimba is a cattle feedlot research facility near Armidale, NSW.

Managing a feedlot

Cattle that are grazing in a paddock can eat whenever they need or want to, provided there is plenty of available pasture. In a feedlot the cattle rely on people to supply them with their rations.

The following photograph shows where the feed ration is placed for cattle in a feedlot. The container for the food is called the **bunk**.

Figure 2.8: The feed ration is placed in the bunk at the feedlot. (Photograph: Iowa Beef Industry Council and the Beef Checkoff Program)
The job of deciding how much feed ration to mix and put out each day is an extremely important one. If the cattle are to grow at the fastest growth rates, then they need to have continual access to food. But considering the cost of the feed, the feedlot manager does not want to waste it. Cattle can be easily put off their food by changes in the weather. Cold and wet weather can lead to cattle needing more food to maintain their growth rates.

The **bunk reader** has the job of deciding on the amount of feed ration to go out each day. The bunk reader checks the amount of feed left in the bunk each morning, assesses the weather and then calls the feed.

In a feedlot, it is important that the same person carries out the bunk reading and calls the feed each day. This person gets a feel for the needs of the cattle so consistency is better assured and thus, efficiency is maintained.

**New cattle**

When cattle first arrive at *Tullimba*, they are given at least seven days in a paddock with access to pasture before they are penned. One of the major concerns when cattle arrive at the feedlot is adapting them to a different type of feed.

Ruminant animals are best suited to a cellulose based diet. The pH of the rumen of a pasture fed animal is normally between 6.5 and 7. When a ruminant animal eats large proportions of highly digestible carbohydrates such as grain, the acidity of the rumen increases and the population of micro-organisms changes. Grain fed cattle have a lower pH in their rumens because of the ease with which grain is digested.

If the dietary change occurs too quickly, ruminant animals develop a condition known as lactic acidosis. This can kill the animal.

Find out more by reading about lactic acidosis in the Agfact *Opportunity lotfeeding of beef cattle* from the NSW Department of Primary Industries website at http://www.dpi.nsw.gov.au/.

Because of lactic acidosis it is essential that changes from a mostly cellulose based diet (pasture) to a grain based diet (feedlot) are carried out slowly to allow conditions in the animal’s rumen to gradually adjust. This gradual change is the reason that different rations are needed when introducing cattle into a feedlot.
Rations

After seven days, the cattle are allocated to a pen and fed a starter ration. After seven to ten days on the starter ration, they move onto an intermediate ration. After another seven days, assuming the cattle are healthy and eating well, they are moved onto the finishing ration.

<table>
<thead>
<tr>
<th>Feed</th>
<th>Starter ration (%)</th>
<th>Intermediate ration (%)</th>
<th>Finishing ration (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>roughage</td>
<td>60 (usually hay)</td>
<td>40 (usually hay)</td>
<td>10 (usually forage sorghum)</td>
</tr>
<tr>
<td>grain (usually barley)</td>
<td>31</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>Molafos</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>limestone</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ammonium sulfate</td>
<td></td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>protein meal</td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>bicarb. soda</td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
</tbody>
</table>

Figure 2.9: Composition of rations for cattle being introduced into feedlotting.

Why are these feeds used?

- Roughage helps to keep the rumen healthy and functioning, but has a low nutrient content. Roughage is processed to a particle size of about 2 cm to assist with mixing the ration.

- Grain, such as barley, is usually rolled or hammer-milled before feeding to make the grain more digestible. The grain starch becomes more available to rumen microbes, so the rate of rumen fermentation can increase. Grains are high in energy and protein. Barley has a higher fibre content and is safer to feed than wheat.

- Molafos is a feed additive that consists of a molasses base and liquid concentrates of protein, vitamins and minerals (see table following). Molasses is a sweet, thick liquid by-product of sugar processing (it is a bit like treacle or golden syrup). As well as having nutritional qualities, a major reason for using molasses is that it is palatable (tastes good) and the cattle will want to eat more of any food that it is mixed with.
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>crude protein</td>
<td>30%</td>
</tr>
<tr>
<td>salt (NaCl)</td>
<td>3%</td>
</tr>
<tr>
<td>calcium (Ca)</td>
<td>0.8%</td>
</tr>
<tr>
<td>phosphorus (P)</td>
<td>0.3%</td>
</tr>
<tr>
<td>sulphur (S)</td>
<td>0.5%</td>
</tr>
<tr>
<td>potassium (K)</td>
<td>3.6%</td>
</tr>
<tr>
<td>magnesium (Mg)</td>
<td>0.4%</td>
</tr>
<tr>
<td>manganese (Mn)</td>
<td>150 mg/kg</td>
</tr>
<tr>
<td>iron (Fe)</td>
<td>250 mg/kg</td>
</tr>
<tr>
<td>copper (Cu)</td>
<td>30 mg/kg</td>
</tr>
<tr>
<td>cobalt (Co)</td>
<td>3 mg/kg</td>
</tr>
<tr>
<td>iodine (I)</td>
<td>5 mg/kg</td>
</tr>
<tr>
<td>zinc (Zn)</td>
<td>250 mg/kg</td>
</tr>
<tr>
<td>selenium (Se)</td>
<td>2.2 mg/kg</td>
</tr>
<tr>
<td>vitamin A</td>
<td>30 000 IU*/kg</td>
</tr>
<tr>
<td>vitamin D₃</td>
<td>2 000 IU/kg</td>
</tr>
<tr>
<td>vitamin E</td>
<td>150 mg/kg</td>
</tr>
<tr>
<td>monensin (rumensin)</td>
<td>25 mg/kg</td>
</tr>
</tbody>
</table>

Figure 2.10: The constituents of Molafos, a component in feedlot rations. (*IU – international unit; unit of measure for very small amounts of vitamins)

- Monensin is a drug that suppresses methane production by rumen bacteria. It is added to the diet of feedlot cattle as a growth stimulant. Research shows liveweight gains of 5% as a result of using this additive.

- Grains are quite low in calcium, so limestone, which is 37% calcium, is an important addition to feedlot diets. The aim is to maintain a balance of calcium and phosphorus.
• Ammonium sulfate is added as a source of sulfur. It helps to balance blood calcium levels.
• Protein meal is a concentrated source of protein for development of muscle.
• Sodium bicarbonate (bicarb soda) is used in grain based diets to buffer acidity in the rumen and so reduce the incidence of acidosis. Another common buffer is sodium bentonite.

The constituents of the feeds are stored in silos. Ingredients are measured out and mixed to make the feed rations. Rations, when mixed, are stored in sheds ready for use.

Now answer the following questions.

1 Outline the changes in the roughage percentages as the rations change from starter to intermediate to finishing.

2 Outline the changes in the grain percentages as the rations change from starter to intermediate to finishing.

3 Using your knowledge of the functioning of the rumen, explain the reasons for the changing percentages of grain and roughage in the three different rations.

4 Explain why lime is added to these feedlot rations.

5 Identify the vitamin that is present in the greatest quantity in Molafos.

6 Identify how many milligrams (mg) of iron are present in each kilogram of Molafos.
7 Identify the percentage of calcium in *Molafo*s.

**Market**

Fat is an important feature of a beef carcase. It is more expensive to produce than muscle, so it is important that the animal has just the right fat for the destination market.

Different market requirements reflect the different and changing tastes and preferences of the consumers in that market. If you compare the Japanese grainfed market with the domestic (Australian) supermarket market, they require two different products. The Japanese grainfed market requires 300 kg carcase weight and 12–17 mm fat, while the domestic supermarket market requires 180 kg carcase weight and 7–12 mm of fat.

Figure 2.11: Markets for grainfed beef.

Source: John Bertram et al (1993), *Breeding for Profit*, ISBN 07 2425 400 5, published by the Department of Primary Industries Queensland; used by permission.

Fat under the skin, that is subcutaneous fat, tends to be a wasted part of the carcase as it is often trimmed off.

Fat within the muscle, that is intramuscular, will melt as it cooks and improves the flavour and juiciness of meat. This fat is also called marbling. Marbling is important in specialist markets like Japan that require at least 200 days lot feeding. The higher the marble score the higher the value of the carcase, assuming other specifications are also met.
There are some predictable developmental rules in the way that fat is deposited in an animal.

- As cattle age and their liveweight increases, they tend to deposit a greater amount of fat.
- The fat cattle deposit first tends to be subcutaneous fat.
- The fat that cattle tend to deposit at a later age tends to be intramuscular fat. It is this marbled fat that Japanese consumers desire and are prepared to pay well for.

These rules can be manipulated by a manager to ensure that the fat in a carcase is suitable for a particular market.

It is possible to achieve liveweight gains of 1.7 kg per day in cattle fed over a 100 day period. This type of weight gain is suitable for cattle being grown for the domestic market that requires lower fat levels. Feedlot managers choose higher percentages of grain in the ration to do this.

Cattle being grown for the Japanese heavy steer market require smaller liveweight gains per day. Large carcases are produced by feeding animals for a greater length of time. The carcases of these older animals show marbling. Feedlot managers choose higher percentages of roughage in the ration to achieve this.

Figure 2.12: Liveweight increases with cattle age.
Consider a feedlot manager who is targeting a high quality market, such as Japanese heavy steer. Identify the specifications that must be met, and propose management strategies to achieve them.

Check your answer.

Read the method used for a feedlot weight gain experiment in the Additional resources section, and then complete Exercise 2.2.
Food that is eaten by an animal has a certain amount of energy in it. This energy comes from the digestion of carbohydrate, protein and fat. As food energy is digested and used by the animal there are losses. You should familiarize yourself with the diagram below that summarises the ways that energy is lost from the body.

You will now investigate each part of this diagram.
Gross energy

If we were to burn a sample of food we could measure the total amount of energy contained in that food. This is called gross energy (GE).

Some examples of gross energy values are shown in the following table.

<table>
<thead>
<tr>
<th>Food</th>
<th>GE Value (MJ/kg dry matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize grain</td>
<td>18.9</td>
</tr>
<tr>
<td>Barley grain</td>
<td>18.3</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>19</td>
</tr>
<tr>
<td>Lucerne hay</td>
<td>18.3</td>
</tr>
</tbody>
</table>

Figure 2.14: Examples of gross energy values. The unit used is megajoules per kilogram of dry matter. (Source: McDonald et al, 1988, pp 219)

As you can see from the examples many foods for farm animals have similar gross energy levels. However, these numbers do not show the full picture. Animals are not efficient in their use of the energy in food, and different foods vary in how much of the energy can be used by the animal.

Digestible energy

As food is processed by the digestive tract not all of the energy is removed and some energy is lost in the faeces of the animal. The energy that is available for digestion is called digestible energy (DE).

Metabolisable energy

Losses in urine and in methane gas production also remove energy. The energy that is left after these losses is called metabolisable energy (ME). In Australia the usual way of measuring and describing energy levels in a feed is by stating the metabolisable energy (a different system is used in the USA).
The following table shows the energy losses for cattle (ruminants) and pigs (monogastrics) from some feeds.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Feed</th>
<th>GE</th>
<th>Faeces losses</th>
<th>Urine losses</th>
<th>Methane losses</th>
<th>ME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>Maize grain</td>
<td>18.9</td>
<td>2.8</td>
<td>0.8</td>
<td>1.3</td>
<td>14</td>
</tr>
<tr>
<td>Cattle</td>
<td>Barley grain</td>
<td>18.3</td>
<td>4.1</td>
<td>0.8</td>
<td>1.1</td>
<td>12.3</td>
</tr>
<tr>
<td>Cattle</td>
<td>Wheat bran</td>
<td>19</td>
<td>6</td>
<td>1</td>
<td>1.4</td>
<td>10.6</td>
</tr>
<tr>
<td>Cattle</td>
<td>Lucerne hay</td>
<td>18.3</td>
<td>8.2</td>
<td>1</td>
<td>1.3</td>
<td>7.8</td>
</tr>
<tr>
<td>Pigs</td>
<td>Maize grain</td>
<td>18.9</td>
<td>1.6</td>
<td>0.4</td>
<td></td>
<td>16.9</td>
</tr>
<tr>
<td>Pigs</td>
<td>Barley grain</td>
<td>18.3</td>
<td>5.5</td>
<td>0.6</td>
<td></td>
<td>13.3</td>
</tr>
</tbody>
</table>

Figure 2.15: Energy losses from some feeds in MJ/kg dry matter. (Source: McDonald et al, 1988, pp 219)

Notice that although gross energy is similar for these feeds, their metabolisable energy is different. Think about the different types of food in the table above and the types of animal that are eating the food.

Write down your observations on the following aspects, and use your knowledge of nutrition and digestion to explain them.

1. Energy lost in the faeces from grains compared to other feeds.

2. Methane energy losses by cattle compared to pigs.
3 Efficiency of energy digestion of concentrates by cattle compared to pigs.

Check your answers.

Net energy

Some metabolisable energy is lost as heat produced by the animal in the chewing and digestion of the food. This is called the heat increment. The remaining energy or net energy (NE) is used to keep the animal alive and functioning (maintenance), and for production purposes.

Maintenance energy

The energy needed for maintenance is used for muscular work like walking about, keeping the body warm, breathing and the action of the heart and intestines.

The maintenance energy required by a particular animal is influenced by many factors including the species and breed of animal, liveweight, body composition and surrounding climate. Approximate values can be estimated for groups of animals.

<table>
<thead>
<tr>
<th>Dairy cow live weight (kg)</th>
<th>Maintenance energy required (MJ of ME/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>350</td>
<td>40</td>
</tr>
<tr>
<td>400</td>
<td>45</td>
</tr>
<tr>
<td>450</td>
<td>49</td>
</tr>
<tr>
<td>500</td>
<td>54</td>
</tr>
<tr>
<td>550</td>
<td>59</td>
</tr>
<tr>
<td>600</td>
<td>63</td>
</tr>
<tr>
<td>650</td>
<td>68</td>
</tr>
<tr>
<td>700</td>
<td>73</td>
</tr>
</tbody>
</table>

Figure 2.16: Maintenance energy requirements for dairy cows of different live weights. From Dairylink – Realistic Rations Table 1.4 NSW Agriculture 2000.

1 Identify the daily maintenance energy requirement of a 400 kg dairy cow.

2 Calculate the kgs of dry matter for the following feed types that need to be fed to the cow per day to satisfy maintenance requirements. Also calculate the quantity of intake if the feed is not dried, by multiplying the kg of dry matter per day by 100/dry matter %.

a) A grass and clover pasture with a ME of 10 MJ/kg dry matter, and a dry matter percentage of 20%.

b) A good quality lucerne hay with a ME of 8.2 MJ/kg dry matter, and a dry matter percentage of 85%.

c) Barley with a ME of 15 MJ/kg dry matter, and a dry matter percentage of 86%.

Check your answers.

Production energy

Energy can be stored by animals in products such as body fat, muscle, milk, eggs and wool. In mature animals most of the energy is stored as fat while in growing, younger animals up to 60% is stored as protein (muscle).

The same 400 kg dairy cow producing average quality milk would need an additional 5.0 to 5.5 MJ of energy for every litre of milk she produced.

Calculate how much energy she would need in her food per day if the 400kg cow were producing 16 litres of milk per day.

Check your answer.
There is a practical limit to the amount of food that can be physically eaten by an animal. If the volume that needs to be consumed to meet nutritional requirements is more than the animal can manage then the animal can be undernourished even with food freely available.

In dairy cows it is common for them to lose weight and condition when they are in a high production period. These cows use their body reserves to maintain milk production. Most dairy farmers provide concentrates for milking cows as a supplement to pasture to reduce this drop in body condition.

**Matching the food to the animal**

Now you have the chance to use your understanding of digestive tracts and nutritional requirements to match up the following feed descriptions with the appropriate animals. First look for clues that will tell you if the food is for a monogastric or a ruminant animal, then narrow it down by identifying particular requirements of the listed animals.

<table>
<thead>
<tr>
<th>Feed Description</th>
<th>Animal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feed 1</strong>: Ingredients mostly grains, meat meal. Additives include shell grit,</td>
<td>30 kg growing pig</td>
</tr>
<tr>
<td>calcium and vitamins K and B group. Formed into a pellet.</td>
<td></td>
</tr>
<tr>
<td><strong>Feed 2</strong>: Ingredients include molasses, urea (non-protein nitrogen source),</td>
<td>Free range laying hen</td>
</tr>
<tr>
<td>oats and bicarb.</td>
<td></td>
</tr>
<tr>
<td><strong>Feed 3</strong>: High quality protein supplied by mixture of wheat, lupins, soybean</td>
<td>Ration for lotfed beef steer</td>
</tr>
<tr>
<td>meal, meat meal and synthetic amino acids lysine and methionine. Low roughage</td>
<td></td>
</tr>
<tr>
<td>level. Additives include vitamins A, B group, D, E and K, as well as crushed</td>
<td></td>
</tr>
<tr>
<td>limestone.</td>
<td></td>
</tr>
<tr>
<td><strong>Feed 4</strong>: Ingredients include hay, wheat, cottonseed meal, vitamin and mineral</td>
<td>Supplementary feed for high producing dairy</td>
</tr>
<tr>
<td>premix, monensin</td>
<td>cow on pasture</td>
</tr>
</tbody>
</table>

[Check your answers.](#)
• Ruminant and monogastric animals have many similarities. Their major difference is the presence of a rumen and rumen microorganisms. These micro-organisms affect the ruminant animal by:
  – increasing the quantity of saliva produced
  – enabling the digestion of cellulose
  – reducing the need for vitamins K and B group in the diet
  – allowing use of low quality protein and small amounts of non-protein nitrogen in the diet
  – degrading high quality protein.

• Cattle kept in an extensive production system mostly consume pasture.

• Mixed pastures are grown and managed to meet the changing nutritional needs of the cattle.

• Pasture can be supplemented with stored feed or concentrates when needed by the animals.

• Cattle kept in an intensive production system mostly consume grain.

• To avoid acidosis a grain based diet must be slowly and carefully introduced to feedlot cattle.

• Other feedstuffs are included in the ration to meet particular dietary requirements of the animal.

• Market requirements influence the way that cattle are fed and kept in the feedlot.

• Fat is deposited in the body of an animal in a predictable way, and can be manipulated by management practices.

• Energy is lost from food as it is digested by the animal.

• The remaining energy is used for maintenance and production.

• Feed ingredients can be used to predict the type of animal that a ration is intended for.
Weight gain experiment

A feeding trial was carried out to assess the effect of a feed additive on carcase quality. The feed additive was advertised as being a liveweight gain promotant.

If added in the directed quantities, it was said to promote weight gain in a given period, in comparison with cattle not eating the feed additive.

Read the details below outlining the trial, then complete Exercise 2.2.

Aim

To determine if the use of a new feed additive increases weight gain in steers in a feedlot.

Method

• 100 steers of similar age and the same breed (Hereford) were used in the feeding trial.
• All steers had been routinely drenched and vaccinated.
• All steers were raised on the same property, pasture fed, then fed the standard feedlot ration for four weeks prior to the start of the trial.
• The steers were randomly allocated to two groups.
• The group of steers fed the standard feedlot ration were the control (C) group.
• The group of steers fed the feed additive in their standard ration were the additive ration (AR) group.
• The steers in each treatment group were in turn randomly allocated to five pens with each pen holding ten steers. The arrangement of the pens is shown on the next page.
The arrangement of the pens in a investigation to find out if a new feed additive increases weight gains of feedlot cattle. (AR = additive ration; C = control)

- Treatments were allocated to pens in the following way. Ten pieces of paper were labelled. Five had control written on them and five had additive ration written on them. These pieces of paper were placed into a container. On another ten pieces of paper were recorded numbers from 1 to 10. These numbered slips were placed in a second container.
- Simultaneously, a piece of paper was drawn from each container. These were then matched, for example pen 2 and control. This is continued until each pen has a treatment allocated to it. You should notice that each steer is not a replication, only each pen of steers.
- After 74 days all steers were weighed, and the results of the feeding trial were shown as weight gained over the 74 days.

Now complete Exercise 2.2.
Monogastric quiz

1. One stomach (mono = one; gastric = stomach).

2. The oesophagus.

3. Protein.

4. Further breakdown of food.

5. Absorption of nutrients through the walls of the small intestine into the bloodstream.

6. The small folds are called villi. Bonus: Their function is to increase the absorption surface area of the small intestine.


8. No. The vitamins produced by microbes in the caecum are only available to the animal if the food passes through the digestive system again.

9. The rectum.

10. The external opening for poultry is called the cloaca, and for pigs is called the anus.
Ruminant quiz

1. Saliva.

2. Bacteria, protozoa and fungi.

3. Most of the volatile fatty acids (VFAs) are absorbed directly through the wall of the rumen into the bloodstream. Bonus: Other VFAs are incorporated into the bodies of microorganisms.

4. By belching (burps).

5. It is returned to the mouth for further chewing (rumination).

6. The reticulum.

7. The folds increase the surface area that is used for water absorption in the omasum.

8. The acidic gastric juices in the abomasum kill and break down the microbes.

9. The small intestine.

10. Yes.

Comparing ruminants and monogastrics

<table>
<thead>
<tr>
<th>Part</th>
<th>Similar</th>
<th>Different</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouth</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Oesophagus</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Stomach</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Duodenum</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Small intestine</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Caecum</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Large intestine</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>External opening</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Both graphs form a stretched S–shaped curve. The top graph shows cattle with a faster growth rate reaching a 400 day weight approximately 50 kg heavier than the cattle from herd A.

The slower growth rate of cattle in herd A is likely to be due to poorer nutrition because of drier conditions and lower quality pasture. It could also be due to the genotype of the cattle.

The farmer of herd A could implement management strategies such as conserving feed, for example hay, during good seasons, selecting pasture species adapted to drier conditions, reduce stocking rates during poor seasons or consider introducing a later maturing breed into the herd.
Breeding females

1. Reproductive efficiency would drop during prolonged drought. Fewer cows would become pregnant due to reduced nutrition affecting their ovulation rates. Those cows that did conceive may miscarry due to nutritional stress, lose the calf at birth or soon after due to low milk production. Young heifers under nutritional stress would take longer to reach puberty.

Why are these feeds used?

1. The percentage of roughage is decreased (from 60% to 40% to 10%) as the rations change.

2. As the rations change from starter to intermediate to finishing, the percentage of grain is increased from 31% to 50% to 75%.

3. Changing the percentages of grain and roughage allows the rumen to change slowly enough for the animal to be unaffected. If this change does not occur slowly enough, the cattle develop the condition known as lactic acidosis, which can be fatal.

4. Lime is added to the feedlot rations to help control the risk of the rumen pH rising to dangerous levels, as the percentages of roughage are decreased and percentages of grain are increased.

5. Vitamin A is present in the greatest quantity in Molafos.

6. 250 mg of iron are present in each kilogram of Molafos.
7 There is 0.8% calcium in Molafos.

Market
- 300 kg carcase – feed for a longer time; will need 200+ days in the feedlot to achieve this heavier weight.
- 12–17 mm fat, marbling – thick layer of white subcutaneous fat and marbling achieved by feeding a nutritious grain based diet for a long period.

Metabolisable energy
1 Grain feeds that have most of their carbohydrate as starch lose less energy in the faeces. This is because starch is more easily broken down than cellulose (fibre).
2 There is no value given for methane losses in the monogastric animal – this is not an error! In Ruminant animals a lot of methane is produced by the microbes in the rumen. This constitutes a substantial loss of energy. Most of the methane production in monogastric animals occurs in the rectum when microbes attack faeces (this energy loss has already been accounted for).
3 The monogastric animal is more efficient in energy digestion of concentrates than the ruminant because the ruminant microbes reduce efficiency and produce significant losses from methane.

Maintenance energy
1 A dairy cow weighing 400 kg would require 45 MJ of energy per day for maintenance.
2 a) 45 MJ/kg / 10MJ = 4.5 kg dry matter.
   The pasture is 20% dry matter, so 4.5 x 100/20 = 22.5 kg pasture
   To obtain this energy she would need to eat approximately 22.5 kg of pasture every day.
   b) 45 MJ/kg / 8.2 MJ = 5.5 kg dry matter.
   The hay is 85% dry matter, so 5.5 x 100/85 = 6.5 kg hay
   To obtain this energy she would need to eat approximately 6.5 kg of lucerne hay every day.
   c) 45 MJ/kg / 15 MJ = 3 kg dry matter.
   The barley is 86% dry matter, so 3 x 100/86 = 3.5 kg barley
   To obtain this energy she would need to eat approximately 3.5 kg of barley every day.

Notice the big difference in the quantity of pasture and barley. These figures show the value of feeding concentrates, as the amount of food eaten is influenced to a large extent by the volume of the feed. The grain is also digested faster. These factors result in a grain fed animal having a greater intake of food and therefore a higher level of nutrition.
Production energy
The dairy cow needs 45 MJ/day of maintenance energy.
16 x 5 MJ = 80 MJ/day of additional energy for production.
80 MJ/day (production energy) + 45 MJ/day (maintenance energy) = 125 MJ/day
16 x 5.5 MJ = 88 MJ/day of additional energy for production.
88 MJ/day (production energy) + 45 MJ/day (maintenance energy) = 133 MJ/day
The cow would need between 125 MJ and 133 MJ of energy per day to meet maintenance and production requirements at this level of production.

Matching the food to the animal
Feed 1:
Grains indicate that the feed is concentrated and the food is in pelleted form, so the feed may be a supplement for ruminants, or the diet of monogastrics. Meat meal is a high quality protein source, so the feed is likely to be for a monogastric. B group and K vitamins indicate the feed is for a monogastric that cannot synthesize these for itself. Shell grit indicates that the feed is for a bird, as this is used to grind food in the gizzard. Vitamins A and D are not mentioned; these could be obtained from green feed and sunlight by a free ranging hen. A laying hen is also a high user of calcium in eggshells, indicating the feed is suitable for this animal.

Feed 2:
Urea and bicarb indicate that the feed is for a ruminant animal as urea is poisonous to monogastrics. The absence of roughages means that the feed is not the major feed for the ruminant, but is only a supplementary feed. This would indicate the feed is a supplementary feed for the grazing dairy cow.

Feed 3:
Mixture of essential amino acids (high quality protein) indicates that the protein will not be degraded by a rumen, so the feed is for a monogastric animal. Other indicators that the diet is for a monogastric are the low roughage level and the presence of B group and K vitamins. Vitamin D indicates the diet is for a housed animal. Crushed limestone and meat meal are good sources of calcium and phosphorus for the growing bones of a young animal. These factors indicate the diet is for the 30 kg growing pig.

Feed 4:
Roughage (hay) and monensin indicate diet is for a ruminant. Roughage indicates it is not a supplement to pasture, so not for the dairy cow. Includes roughage, energy, and protein needed for growing animal. Feed is for the lotfed beef steer.
Exercises – Part 2

Exercises 2.1 to 2.2  
Name: _________________________________

**Exercise 2.1**

Compare the anatomy and physiology of ruminants and monogastrics.  

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
Exercise 2.2: Effect of feed additive on weight gain

1 Results from the feeding trial using a control (standard feed ration) and additive ration, are shown below. Calculate the mean weight gain for each pen, and complete the tables.

<table>
<thead>
<tr>
<th>Pen number</th>
<th>Control group weight gain (kg)</th>
<th>Mean weight gain (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>56, 112, 105, 118, 88, 102, 102, 88, 99, 91</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>120, 100, 110, 102, 108, 84, 74, 104, 92, 76</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>89, 74, 74, 72, 78, 86, 104, 111, 84, 86</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>70, 63, 67, 51, 82, 80, 73, 69, 70, 87</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>137, 106, 121, 95, 108, 102, 101, 96, 109, 113</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pen number</th>
<th>Additive ration group weight gain (kg)</th>
<th>Mean weight gain (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80, 131, 110, 84, 90, 82, 70, 92, 89, 67</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>62, 96, 92, 52, 86, 93, 84, 104, 86, 64</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>97, 86, 102, 110, 88, 82, 96, 104, 104, 114</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>88, 110, 104, 111, 103, 127, 106, 100, 110, 114</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>84, 77, 66, 74, 88, 88, 102, 94, 96, 88</td>
<td></td>
</tr>
</tbody>
</table>

2 Calculate the mean weight gains (kg) for each treatment and complete the table below.

<table>
<thead>
<tr>
<th></th>
<th>Control group</th>
<th>Additive ration group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3 Describe a method that could be used to randomly allocate steers into the two groups.

4 Identify six features of this feeding trial that demonstrate standardisation of conditions.

5 Assess the experimental results to write a conclusion for the experiment.

6 Outline recommendations for the feedlot based on the conclusion reached in the experiment.