1 The Horse as a Herbivore

Food is the material ingested by horses; it is then broken down into its constituent parts during the process of digestion before being absorbed into the body for use. Essential nutrients are the chemical substances in food, which cannot be made in sufficient amounts by the horse itself. These substances are required for life and growth and work.

Various foods contain different nutrients that are used within the horse's body in different ways. The growth of a foal into an adult horse requires important building blocks provided by many different nutrients, as does the production of milk by a lactating mare. For muscles to work and move the horse forward (or sideways or backward!), they must be supplied with energy giving nutrients. The horse needs nutrients to move, work, reproduce, breathe and lactate.

Horses, like all living organisms, need to take in substances in order to make new cells and tissues, repair old ones or release energy. This is known as nutrition or feeding.

The nutrients in the natural diet of the horse are supplied mostly by herbage such as grass. Grass is a green plant and all green plants are able to take in simple substances such as water, carbon dioxide and nitrogen (in the form of nitrate or ammonia) and inorganic minerals and build them into more complex organic substances such as carbohydrates and proteins.

Green plants are able to harness the energy from the sun combining it with other chemical elements to provide complex organic substances. These organic substances made by plants provide nutrients for animals grazing upon them (Figure 1.1). Plants make carbohydrates from carbon dioxide and water using energy from sunlight. This process is called *photosynthesis* and takes place in the leaves of all green plants. Plant leaves could therefore be considered as carbohydrate factories.

Figure 1.1 Horses grazing, taking in nutrients provided by plants.

The balanced chemical equation for photosynthesis is:

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll (green plants)}]{\text{sunlight}} C_6H_{12}O_6 + 6O_2$$

The carbohydrates produced by photosynthesis are either used straight away or converted into substances that provide structural support to the plant cells. Any remaining are stored as complex carbohydrates. Most of the carbohydrates though are made into supporting tissues to maintain the structural cell walls. The cell walls are made up of a fibre matrix of cellulose with hemicellulose and lignin (see Chapter 3). Plants are therefore able to feed themselves, a process known as *autotrophic* nutrition.

Horses similar to all other animals have a limited ability to make their own carbohydrates although they can make lactose and glycogen. In their simplest form, carbohydrates such as glucose are soluble so they can be transported around the horse's body to the tissues where they are needed. Here, they are oxidised back to carbon dioxide and water by the process of respiration, which releases the energy for cellular processes.

Horses must feed or take in the organic substances described above that are originally manufactured by green plants. This is known as *heterotrophic* nutrition. Horses are herbivores and so eat green plants, mostly grass with a large proportion of leaf.

DIET

Everything horses eat and drink daily is known as the *diet*. A diet that contains all the nutrients in the correct proportions is known as a *balanced diet*. A *ration* is the food allowance for one day supplied to the horse; it may have been previously evaluated by the horse owner. A *feedstuff* is any material used as food.

Complex molecules such as carbohydrates, fats and proteins are required to provide energy and other materials for growth, repair, movement and general life functions of the horse. These are known as macronutrients. Other nutrients such as vitamins and minerals are required in much smaller amounts and these are called micronutrients.

Horses need the following essential nutrients in the diet:

- Carbohydrates
- Fats (lipids)
- Proteins (amino acids)
- Vitamins
- Minerals (inorganic elements)
- Water (not actually classified as a nutrient).

Malnutrition results from an unbalanced diet where some nutrients are deficient or completely lacking. In addition, over-supply of some nutrients such as carbohydrates may result in ill health or chronic problems such as insulin resistance and laminitis.

Individual horses have different nutrient needs depending upon age, height, workload, stage of life, and breed and external factors such as temperature.

EVOLUTION

The horse evolved to roam grasslands foraging on fibrous grasses, weeds and occasional browsing of small bushes. Extensive fossil records have revealed the evolutionary pathway of *Equus*. This was not a straight evolutionary line, but a sort of tree shaped evolution with many dead ends resulting in the loss of that particular ancestor of the modern horse (see Figure 1.2).

Horses can be traced back to the Eocene period 50–60 million years ago, to a small fox like animal known as *Hyracotherium* (also referred to as dawn horse or Eohippus) (Figure 1.3). This small animal weighed around 5 kilograms (12 pounds). In the Miocene period, approximately

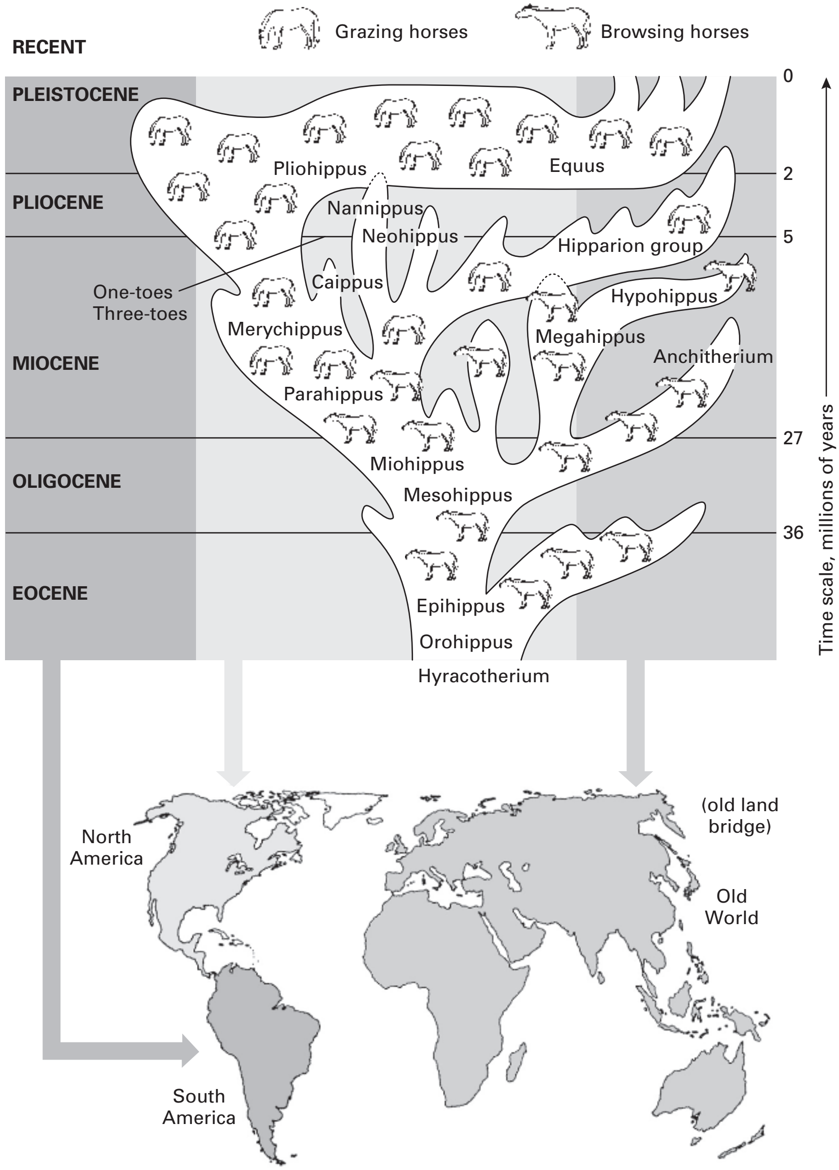

Figure 1.2 Evolutionary tree of the horse.

27 million years ago, many of the horse's ancestors moved away from the tropical swampy forests they inhabited on to the plains in order to survive, although some remained behind to carry on living in the forests. This was due to changes in the global climate producing drier grasslands and plains. Changes in the genetic makeup over a long

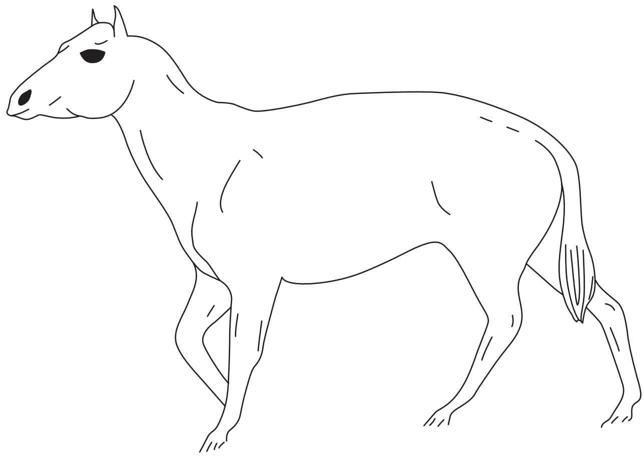

Figure 1.3 Hyracotherium (Eohippus, Dawn Horse).

period of time helped these ancestors to adapt to their new grazing diets. Grass plant cells contain cellulose within the cell walls, a complex carbohydrate which is basically indigestible to all mammals including horses unless they develop some way of breaking down the cellulose to unlock the nutrients contained within.

Grass also contains silica, which is an extremely hard substance and so grazing horses would need to evolve teeth capable of withstanding the grinding of herbage containing silica and also the frequent presence of soil particles attached to the grass. This was a 'gritty' diet! The head became bigger in order to house the longer grinding teeth. The jaw increased in depth to house more powerful muscles for 'grinding'. To this end, the jaws became sideways moving to more efficiently break down and tear the fibrous food. Teeth also became coated with cement and became higher crowned or *hypsodont*. Eventually these teeth undertook continuous growth or *hypselodont*. The neck became longer to allow the animal to reach down and graze. The limbs also became longer allowing them to run faster away from predators.

The digestive system also evolved in several ways to adapt to the diet. In order to break down cellulose many herbivores have adopted a symbiotic arrangement with millions of microbes in their guts which are able to produce an enzyme, namely cellulase, which breaks down cellulose contained in plant cell walls. The horse in turn provides a safe environment in which the microbes can live in a specialised digestive area. Most herbivores therefore evolved large fermentation areas within the gut in which the millions of bacteria live and ferment the ingested plant material anaerobically (i.e. in the absence of oxygen).

The ruminant stomach developed into a large multi-compartmented section of the digestive tract known as the fore stomachs. Perhaps the most well known of these is the rumen, but the reticulum, omasum and abomasum also support fermentation. The fore stomachs are situated between the oesophagus and the small intestine. Horses, however (and rabbits, tapirs and rhinoceroses), have developed an exceptionally large fermentation area (caecum) within the large intestine or hindgut, following the simple stomach and small intestine (see Figure 1.4). Ruminants are consequently known as foregut cranial fermentors, or pregastric digesters or fermentors and horses as hindgut caudal fermentors, or postgastric fermentors.

The basic breakdown of cellulose in the rumen and caecum is essentially the same, however the position of the fermentation area relative to the small intestine has implications for the amount of nutrients absorbed. The small intestine is the only part of the digestive tract that allows simple carbohydrates and amino acids, the products of breakdown by digestive enzymes secreted by the horse, to be absorbed. For horses, sugars and dietary starch are broken down by enzymes within the small intestine and absorbed. Ruminants, however, ferment sugars and starch within the fore stomachs.

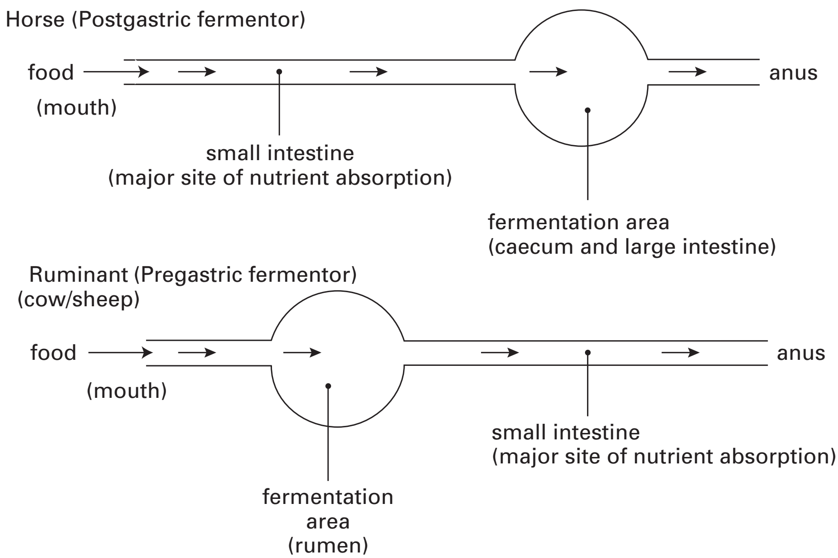

Figure 1.4 Comparison of the position of the foregut in ruminants and horses.

Dead and dying bacteria from the rumen are passed into the true stomach and small intestine of the ruminant where they are further digested and component nutrients are utilised by the ruminant (Figure 1.5). Thus ruminants are able to use microbial protein whereas microbial protein produced in the hindgut of the horse is largely wasted. Therefore the ruminant is more efficient at digesting forage than the horse. A comparison of nutrition in ruminants and horses is shown in Table 1.1.

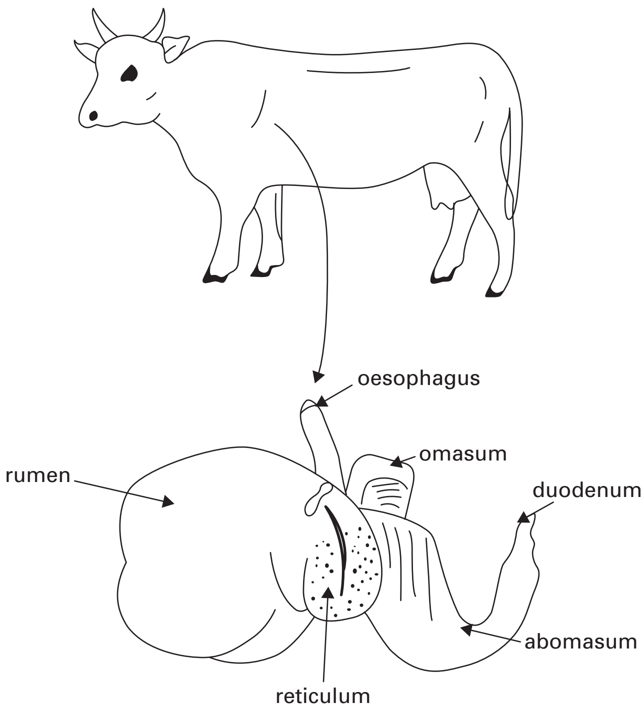

Figure 1.5 The forestomachs of the ruminant.

Table 1.1 Comparison of equine and ruminant nutrition.

Digestive function	*Horses*	*Ruminants*
Remove energy from plant cellulose through fermentation	√	√
Use dietary sugars directly	√	X
Break down microbial material for further nutrients in small intestine	X	√

Figure 1.6 A horse in excellent condition. (Courtesy Jo Prestwich)

The caecum and colon must retain digesta (food swallowed for digestion) for a long time to give the microbial population time to break down the fibre.

Essentially the physiology of the digestive tract of the modern day horse is exactly the same as that of its ancestors, which developed the ability to ferment complex carbohydrates from herbage via a hindgut fermentation chamber.

The practice of feeding horses and the nutrients required are at all times based upon this principle in order to maintain the health of both the digestive tract and the horse itself. Horses receiving optimal nutrition visibly appear in excellent condition (Figure 1.6).

Summary points

- Essential nutrients are the chemical substances in food that cannot be made in sufficient amounts by the horse itself.
- Green plants are able to harness the energy from the sun combining it with other chemical elements to provide complex organic substances.
- Everything horses eat and drink daily is known as the *diet*.
- A diet that contains all the nutrients in the correct proportions is known as a *balanced diet*.
- Macronutrients are complex molecules such as carbohydrates, fats and proteins that are required to provide energy and other materials for growth, repair, movement and general life functions of the horse.
- Micronutrients are required in much smaller amounts, for example vitamins and minerals.
- The horse's digestive system evolved to adapt to the forage diet. In order to break down cellulose, many herbivores have adopted a symbiotic arrangement with millions of bacteria in their guts.
- Essentially the physiology of the digestive tract of the modern day horse is exactly the same as that of its ancestors which developed the ability to ferment complex carbohydrates from herbage via a hindgut fermentation chamber.