Basic small animal nutrition
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Learning outcomes

This chapter covers the basic terminology and concepts of nutrition and how these can be applied. By the end of this chapter, you will have gained a set of skills that will enable you to:

- define and explain basic terminology like proteins, amino acids, energy etc.
- advise clients with the best possible recommendations based on your understanding of the importance of the different nutrients
- compare two different pet foods based on calculations on dry matter basis and energy basis
- provide correct recommendations for how much food to feed per day by calculating the Daily Energy Requirement (DER)
- explain the reason why cats and dogs need different types of food.

To help you see how you are doing, self-evaluation questions are given throughout the text. Answering these questions will also be good practice for the final exam.

If you are doing well with these questions, the final exam may prove a piece of cake. Remember, VNA is supposed to be a lot of fun on which you can build your daily work and maybe future career.
Nutrients

Let your client know

Some nutrients provide energy. Protein, fats and carbohydrates provide the body with fuel, just like petrol in a car. Different nutrients are needed in varying amounts per day. For example, both humans and animals require kilograms of water but only micrograms of certain vitamins.

Definition

**Nutrient:** A metabolically useful component of food, which may be essential or non-essential.

**Essential nutrient:** Any required nutrient that cannot be synthesised in the body and must be obtained from the food.

Nutriments is both food and poison. The dosage makes it either poison or remedy.

T. B. von Hohenheim

The six basic nutrients. Carbohydrates, fats and proteins may be used for energy but also serve as structural components.
1.1 Water

Water is the most important nutrient of all and essential for life. Animals can lose almost all their fat and half their protein and still survive, but if they lose 15% of their water, it will mean death.

The amount of water an animal should consume per day is roughly equivalent to its daily energy intake in kilocalories. This means that a healthy dog or cat would normally need around 50 ml per kg bodyweight per day; e.g., 200 ml for a 4 kg cat.

**Definition**

The proportion of energy producing nutrients in food determines its **energy content** or **energy density**. Water has no energy value, so a food with a high moisture content will usually have a low energy density.

**Let your client know**

1. Clean, fresh water should always be freely available except if the pet is persistently and excessively vomiting.
2. The amount of water a cat or a dog drinks will vary depending on what food it eats. For example, canned food has a higher water content than dry food, so it provides part of the daily water requirement.

**Clinical note**

A pet needs extra water when water losses increase. This could be due to:

- increased temperature of the surroundings (causes panting and loss of moisture)
- lactation
- increased body temperature
- polyuria (increased urine production)
- diarrhoea
- vomiting
- severe bleeding.
Energy-producing nutrients
The nutrients that supply us with energy are carbohydrates, proteins and fat.

1.2 Carbohydrates

Carbohydrates are:
1. Simple sugars
   - Monosaccharides (e.g., glucose) 
     (Mono: one; saccharide: sugar)
   - Disaccharides (e.g., lactose) which consist of two sugar units 
     (di: two)
2. Oligosaccharides (oligo: few)
   - 3–9 sugar units (e.g., raffinose)
   - If they contain fructose, they are called fructooligosaccharides (FOS)
3. Polysaccharides (poly: many)
   - Starches (e.g., amylose, glycogen)
   - Fibres (e.g., cellulose, pectins)

Polysaccharides are also called complex carbohydrates and can be defined based on digestibility.

Composition of the dietary carbohydrate, glucose. Glucose is classified as a monosaccharide.

<table>
<thead>
<tr>
<th>Carbohydrate</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugars</td>
<td>Fruits</td>
</tr>
<tr>
<td></td>
<td>Honey</td>
</tr>
<tr>
<td>Lactose</td>
<td>Milk</td>
</tr>
<tr>
<td></td>
<td>Dairy products (milk sugar)</td>
</tr>
<tr>
<td>Starches</td>
<td>Corn</td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
</tr>
<tr>
<td></td>
<td>Rice</td>
</tr>
<tr>
<td></td>
<td>Barley</td>
</tr>
<tr>
<td></td>
<td>Oats</td>
</tr>
<tr>
<td></td>
<td>Potatoes</td>
</tr>
<tr>
<td>Slowly fermentable fibre like cellulose</td>
<td>Wheat bran</td>
</tr>
<tr>
<td>Moderately fermentable fibre</td>
<td>Rice bran</td>
</tr>
<tr>
<td></td>
<td>Pea fibre</td>
</tr>
<tr>
<td></td>
<td>Wheat bran</td>
</tr>
<tr>
<td>Rapidly fermentable fibre</td>
<td>Apples</td>
</tr>
<tr>
<td></td>
<td>Citrus pulp</td>
</tr>
<tr>
<td></td>
<td>Guar gum</td>
</tr>
</tbody>
</table>

Interesting fact
When glucose is metabolised as energy, ATP (the ‘gasoline of the cell’), carbon dioxide and water are the end products.
1.2.1 Function of simple carbohydrates and starches

Simple carbohydrates and starches in foods are used by the body as a source of glucose. As such, they have several major functions, they:

1. provide energy
2. produce heat when they are metabolised for energy
3. can be used as building blocks for other nutrients (e.g., certain amino acids, lactose (the sugar in milk) and vitamin C)
4. provide storage of energy in the form of glycogen or fat.

Function of fibre

Fibre has two major functions:

1. to promote and regulate normal bowel function:
   - in dogs with slow transit time, fibre shortens it
   - in dogs with rapid transit time, fibre increases it
2. to help maintain the health of the colon, e.g., by providing fuel for cells.

Clinical note

Excess carbohydrates will be converted into body fat.

Interesting fact

Sugars in starches are linked in such a way that the enzymes in mammals’ digestive systems can break them down. Sugars in fibre are linked so that only enzymes from bacteria can break them down.

Let your client know

Fibre increases bulk and water in the intestinal content, which means that fibre helps prevent both constipation and diarrhea. Remember that a pet with constipation needs to drink lots of water for the fibre to have an effect.
1.2.2 Digestion of simple carbohydrates and starches

Digestion of simple carbohydrates and starches occurs throughout the digestive tract and involves:

a. mechanical processes:
   - break down in the mouth

b. enzymatic processes:
   - the stomach – gastric juices (e.g., hydrochloric acid and peptic acid) – only a little carbohydrate digestion occurs here
   - small intestine – enzymes – most of the carbohydrate digestion takes place here

c. microbial processes:
   - large intestine – intestinal microbes (bacteria) produce enzymes
   - additional energy is produced here by fermentation of fibres.

Clinical note
Dogs and cats lack the enzyme amylase in their saliva. Therefore, starch does not break down in the mouth. This is one of the reasons that cats and dogs do not develop caries as much as humans.

Interesting fact
Enzymes secreted by the pancreas digest the majority of starches and sugars in the lumen of the small intestine. Enzymes at the small intestinal mucosal brush border are important in the final stages of carbohydrate digestion and absorption.

Digestion of fibre

Fermentation is the process where carbohydrates are broken down in an environment with little or no oxygen in such a way that they yield energy. The bacteria (microbes) in the large intestine are called anaerobes (an: without) because they can live without oxygen. To produce energy for survival, they have to use fermentation. The microbes only use part of the energy that becomes available through fermentation and the rest can benefit the mucosal cells of the intestine.

Clinical note
The very edge, towards the lumen of the lining of the gut is called the ‘brush border’. This area produces enzymes used in digestion. One of the brush border enzymes is lactase – the enzyme that breaks down lactose. Adult dogs and cats produce very little lactase and therefore have problems with digesting milk.

Interesting fact
The energy that microbes produce is in the form of smaller, energy-containing compounds called short-chain fatty acids, and in the form of gases. Short-chain fatty acids are valuable substrates for the host animal as they can be used for energy by the mucosal cells.
Some fibres are more rapidly fermented than others (see figure below). The more rapidly a fibre is fermented, the more gases and short-chain fatty acids are produced in a short period of time. The rate and extent of fibre fermentation are important characteristics when discussing physiologic functions of fibre.

1.2.3 Recommended levels

Dogs and cats do not have an absolute requirement for carbohydrates in their diet in the way that essential amino acids or fatty acids must be provided. They do, however, have a requirement for adequate glucose or glucose precursors to provide essential fuel for the central nervous system. Without dietary carbohydrates, there is added strain on lipid and protein metabolism to supply the glucose precursors. Sugars and starches are an economical and easily digested energy source.

Clinical note

Moderately and slowly fermentable fibres bulk up the faeces by holding water. Slowly fermentable fibre has several advantages:

Helps to manage obesity:
- by reducing interactions of food particles with digestive enzymes and epithelial surfaces, so the nutrients are digested less and therefore provide fewer calories
- by slowing down the absorption of nutrients
- by delaying gastric emptying, thus providing a sensation of fullness for longer

Helps to control diabetes mellitus:
- by reducing the surge in blood sugar that happens after meals (beneficial in diabetes mellitus)

Increases faecal bulk which helps alleviate the symptoms of:
- inflammatory bowel disease and other GI disorders
- constipation.

Let your client know

The more rapidly a fibre is fermented, the more intestinal gas is produced – in short, the pet will tend to fart more.

Clinical note

A high level of fermentable fibre in the diet may have a laxative effect. This can cause unpleasant flatulence and even diarrhoea if the pet is fed indiscriminately.
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Dry dog foods typically contain 30–60% carbohydrate, mostly starch and this causes no adverse affect. Research in dogs has shown that gestation and lactation increase the need for glucose to support foetal growth and lactose synthesis in milk. Diets with no or low content of carbohydrates cause a variety of problems:

• reduced number of live births
• lethargy
• reduced mothering abilities of the bitch
• foetal abnormalities
• embryo resorption
• reduced milk production

Normally, cats can maintain adequate blood glucose levels when fed a diet with a low carbohydrate content and a high protein content. Cats also have some unique metabolic differences that limit their ability to efficiently use large amounts of absorbed dietary carbohydrates. Levels of carbohydrate up to 35% of the food on a dry matter basis (see p.55 for explanation of dry matter basis) are tolerated well by cats but if levels of carbohydrates are more than 40% dry matter basis, problems can occur.

More than 40% carbohydrate on dry matter basis causes problems in cats, such as:

a. malnutrition:
   • diarrhoea
   • bloating
   • gas.

b. adverse metabolic effects:
   • hyperglycaemia
   • excretion of significant amounts of glucose in the urine.

To make a protein, amino acids are linked together in a long chain. The chain is then bundled into a three-dimensional structure, like a tangled ball of yarn. Although there are hundreds of different amino acids, only 21 are used in animal proteins.

These 21 amino acids can be arranged in any combination giving an almost infinite variety of naturally occurring proteins, each with its own characteristic properties, e.g., the proteins of hair, skin, muscle, hormones or antibodies.
Many amino acids can be synthesised from others within the body but there are some that cannot be synthesised in sufficient quantities and therefore must be supplied by food. These are called essential amino acids.

### ESSENTIAL AMINO ACIDS

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Amino Acid</th>
<th>Amino Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arginine</td>
<td>Histidine</td>
<td>Isoleucine</td>
</tr>
<tr>
<td>Leucine</td>
<td>Lysine</td>
<td>Methionine</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>Taurine</td>
<td>Threonine</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>Valine</td>
<td></td>
</tr>
</tbody>
</table>

**Clinical note**

Taurine, which is an essential amino acid for cats but not for dogs, is only found in animal tissue.

**Clinical note**

All tissue is made up of protein, but some contains it in higher quantities than others. Muscle tissue, for example, is very rich in protein whereas fat tissue has a relatively low protein content. This is why the ingredient meat meal is such an important source of protein.

**Interesting fact**

Amino acids always contain four groups:

1. A hydrogen (H) atom
2. A carboxyl group (COOH – one carbon (C), two oxygen (O) and a hydrogen (H) atom)
3. An amino group (NH₂ – one nitrogen (N) and two hydrogen (H) atoms)
4. A chemical group that is specific for each individual amino acid, e.g., Sulphur or SO.

**Protein structure.**

\[ \text{R} = \text{different chemical groups and thus amino acids} \]
1.3.1 Function

Proteins are the essential building blocks of all tissues and organs of the body including:
1. cartilage, tendons and ligaments (collagen and elastin)
2. the element of muscles that contract (actin and myosin)
3. skin, hair and nails (keratin)
4. blood proteins (haemoglobin, transferrin, albumin and globulins)
5. enzymes
6. hormones
7. antibodies.

Proteins are often described as the ‘backbone’ of cells because they have a structural role in all cell walls. Proteins are required for all tissue growth, replenishment and repair.

If there is more protein available than necessary for building blocks, proteins may also be used as a source of dietary energy.

Clinical note
Cats have a higher total protein requirement than dogs. This is because, even if there is not enough protein available in the diet for replenishing ‘building blocks’, protein will still be used to produce energy. This can cause health problems if a cat starves or doesn’t get enough to eat, especially if it is ill, because protein will be used for energy instead of repair.
The quality of a protein is indicated by its Biological Value (BV). A protein is said to have a high biological value if it supplies the essential amino acids (EAAs) in amounts which:

a. closely match an animal’s requirements for them
b. and when most are absorbed and retained (has a high digestibility).

When a food protein has a high biological value, it is usually more expensive. However, the pet needs less of it compared to a protein with a low biological value because the necessary amino acids will be supplied more easily and efficiently.

### 1.3.2 Digestion

Dietary protein must be digested to be absorbed from the gut (see figure on the next page).

Digestion has several steps:

- Proteins are broken down in the stomach forming smaller fragments consisting of many amino acids (polypeptides). This stage is performed by the action of the enzyme pepsin in the presence of hydrochloric acid. Little or no absorption occurs here.

- In the small intestine, the polypeptides are broken down into amino acids that can be absorbed through the intestinal wall. This takes place through the action of enzymes produced by the pancreas and by the cells lining the small intestine.

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**Definitions**

<table>
<thead>
<tr>
<th>EAA: Essential Amino Acid</th>
<th>BV: Biological Value.</th>
</tr>
</thead>
</table>

**Interesting fact**

Biological value depends on:
- amino acid profile
- protein digestibility.

**Clinical note**

The profile of EAAs in egg matches the requirements of most animals. Egg is very easily digested in the intestines and has therefore been assigned a biological value of 100. All other protein percentages are relative to that of egg.

**Definition**

Gelatine: a protein source derived from animal collagen. Gelatine has very high digestibility but the biological value is low because it is deficient in the essential amino acid tryptophan.
The absorbed amino acids are reassembled into ‘new’ proteins by the liver and other tissues of the body. The fate of amino acids after absorption falls into three general categories:
1. tissue protein synthesis
2. synthesis of enzymes, albumin, hormones and other compounds
3. surplus used for energy.

1. DIGESTION
   Hydrochloric acid produced in the stomach
   Protein $\rightarrow$ Polypeptides

2. DIGESTION
   Enzymes from pancreas and lining of small intestine
   Polypeptides $\rightarrow$ Amino acids

3. ABSORPTION
   Into the blood
   Blood flow from small intestine to liver via portal vein
   Amino acids pass through blood

4. ACTIVITY IN THE LIVER
   • Synthesis of tissue proteins
   • Synthesis of:
     • enzymes
     • albumin
     • hormones
     • etc.
   • Surplus used as energy
Even if you feed a diet with a high protein content, the excess protein cannot be stored in the body. If the body has a need for more amino acids than it gets from food, it will break down muscle tissue first and then body organ tissues.

Protein breakdown leads to the production of ammonia, which is toxic to body cells. Ammonia is then converted to the less toxic urea in the liver and excreted in the urine.

**1.3.3 Recommended levels**

Adult animals need dietary protein to replace the amino acids that are used in the body for tissue repair and new cells, to replenish old blood proteins and to replace the loss of nitrogen via faeces, urine, sweat, hair etc.

The amount of dietary protein that must be consumed each day is termed ‘the maintenance protein requirement’.

The pathophysiological state of the pet can also mean that there is an increased need of protein, e.g., patients with cancer, burns and trauma may need extra daily protein, because they are in a hypermetabolic state. (For more information, read VNA 3). In simple terms, in these conditions you need a lot of extra protein as building blocks for tissue repair.

Not only the amounts of protein but also the proportion of amino acids need to be correct. When amino acids are used for protein synthesis, all the amino acids that are necessary to synthesise a specific protein must be present in the required proportions. In other words, the closer the biological value is to 100, the better it is.

**Definition**

The build-up of new protein is called **protein anabolism** and the breakdown is called **protein catabolism**.

**Pathophysiology:** the physiology of disordered function, i.e., the physiology of disease.

**Let your client know**

Young animals and pregnant and lactating animals need higher amounts of protein to promote growth.

**AAFCO:** the agency that develops official pet food regulations in the United States.

**CANINE PROTEIN REQUIREMENTS**

The absolute minimum dietary protein requirement for dogs that are fed an extremely high-quality protein is 6.0% on a dry matter basis for adult dogs and 9.5% on a dry matter basis for growing dogs. However, this is extremely low. The American Association of Feed Control Officials (AAFCO) has established that a recommended daily allowance of protein with an average biological value for growing dogs should be at least 22% and for adult dogs 18% on a dry matter basis.
FELINE PROTEIN REQUIREMENTS

Let your client know
Both growing kittens and adult cats have higher protein requirements than most other pets.

Clinical note
Dogs and cats with chronic renal disease are usually sub-clinical until the disease has progressed to the point that two-thirds or more of functional renal tissue is lost.

Protein excess may contribute to acidaemia (low blood pH – like the worst case of hangovers...) as the disease progresses.

Let your client know
Not all dogs and cats that appear to be healthy are free of disease. Therefore, the client should always feed a good quality pet food to ensure the best possible support for a healthy life.

Clinical note
In certain diseases, like Protein-Losing Nephropathy or Protein-Losing Enteropathy, the body loses excessive amounts of protein through either the kidneys or the gastrointestinal tract. This causes the typical symptoms of protein deficiency to occur.

The minimum requirement has been estimated to be around 24% protein on dry matter basis for growing kittens, and 14% for adult cats. Again, these are the minimum requirements. For commercial food using commonly available protein sources, AAFCO has recommended that foods for kittens and adult cats contain at least 30% and 26% protein on a dry matter basis, respectively, as a daily allowance. Notice that this is a daily allowance and not a minimum requirement. Some commercial cat foods contain 2–4 times the minimum protein requirement, which is not appropriate for healthy cats.

Let your client know
Both growing kittens and adult cats have higher protein requirements than most other pets.

Clinical note
Dogs and cats with chronic renal disease are usually sub-clinical until the disease has progressed to the point that two-thirds or more of functional renal tissue is lost.

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Not all dogs and cats that appear to be healthy are free of disease. Therefore, the client should always feed a good quality pet food to ensure the best possible support for a healthy life.

Clinical note
In certain diseases, like Protein-Losing Nephropathy or Protein-Losing Enteropathy, the body loses excessive amounts of protein through either the kidneys or the gastrointestinal tract. This causes the typical symptoms of protein deficiency to occur.
1.3.4 Protein excess or deficiency in cats and dogs

High levels of protein can be damaging to patients with kidney problems. Therefore, an excess of dietary protein should be avoided in the older pet where kidney disease is more prevalent than in younger pets.

For both dogs and cats protein deficiency can result from insufficient dietary protein or from a deficiency of a particular amino acid.

Protein deficiency may lead to:

- poor growth or weight loss
- anorexia
- anaemia
- dull hair coat
- muscle wasting
- increased susceptibility to disease
- oedema (fluid accumulating in the body tissues)
- death.

**Clinical note**

A fatty liver can also be a sign of protein deficiency. This is because the specific proteins that are needed to package and export fat from the liver are not synthesised in adequate quantities, if at all, during protein deficiency. Cats are especially susceptible to this condition.

A: Normal, healthy liver.  
B: Fatty liver. Notice the plump edges of the liver and the swollen appearance.

1.4 Fats

Dietary fats (lipids) mainly consist of triglycerides. A triglyceride consists of three molecules of a certain fatty acid combined with a molecule of the alcohol glycerol. The specific fatty acids present determine the physical and nutritional characteristics of the lipid.
There are two relevant series of polyunsaturated fatty acids, called omega-3 (or n-3) and omega 6 (or n-6) fatty acids that are essential in the diet and for that reason are called essential fatty acids (EFA). Dogs and cats are unable to synthesise the precursors of both series.

**Definition**

A bond results from the sharing of four electrons (two pairs) between two atoms.

**Definitions**

The placement of the bonds, the number of double bonds and the number of carbon molecules involved, all assist in placing the lipids in different groups. The main groups are as follows:

1. **Saturated**: Fatty acids with no double bonds in the hydrocarbon chain.
2. **Monounsaturated**: One double bond.
3. **Polyunsaturated**: More than one double bond.

**Interesting fact**

The way fat is named (nomenclature) specifies the number of carbon atoms and the location and number of double bonds. For example, a fat with 18 carbons, that is polyunsaturated and has three double bonds, the first of which is between carbons 6 to 7 would be named 18:3n-6. This particular fat is also known as γ-linolenic acid.

**Definitions**

- **PUFA**: Polyunsaturated Fatty Acid.
- **EFA**: Essential Fatty Acid.
1.4.1 Function

Dietary fats are required to:

a. supply energy:  
   dietary fat provides the pet with 2.25 times more calories per weight unit than protein or carbohydrates

b. aid absorption of the fat soluble vitamins (vitamins A, D, E and K):  
   dietary fat provides a physical environment in the gut that enhances the absorption of fat-soluble vitamins. Dogs and cats need at least 1–2% dietary fat in their food to absorb fat-soluble vitamins

c. supply essential fatty acids:
   omega-3 and omega-6 fatty acids.

The essential fatty acids are needed:

• as constituents of cell membranes to maintain fluid membranes that allow passage of molecules
• for the synthesis of diverse, active substances in the body, i.e., prostaglandins
• to control water loss through the skin.

Dogs have two essential fatty acids:
1. Alpha-linolenic Acid
2. Linoleic Acid.

As well as these two essential fatty acids, cats also need Arachidonic Acid, as they cannot synthesise this from Linoleic Acid.
1.4.2 Digestion

Fats and oils must undergo digestion via enzymatic and physical processes before they can be absorbed from the lumen of the gut. Digestion of dietary fats primarily takes place in the stomach and the small intestine. It is important to remember that the digestion of dietary fat is the most complex digestion process in the body, explaining why we often see problems with this in disease processes.

**Location**

<table>
<thead>
<tr>
<th>Location</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomach</td>
<td>Gastric lipase</td>
</tr>
<tr>
<td></td>
<td>Bile salts</td>
</tr>
<tr>
<td></td>
<td>Pancreatic lipase</td>
</tr>
<tr>
<td></td>
<td>Colipase</td>
</tr>
<tr>
<td>Small Intestine</td>
<td>Pancreatic juice:</td>
</tr>
<tr>
<td></td>
<td>Contains pancreatic lipase, which again breaks down fat into fatty acids and glycerol</td>
</tr>
<tr>
<td></td>
<td>Bile:</td>
</tr>
<tr>
<td></td>
<td>• Contains bile salts that act as detergents: they break the surface tension between fats and water so the fats are broken into small droplets. This makes it easier for the lipase to reach and break down the fat</td>
</tr>
<tr>
<td></td>
<td>• The longer the fatty acids are, the more difficult it is for the lipase to break them down. This is why short chain fatty acids are more easily digested than long chain fatty acids.</td>
</tr>
</tbody>
</table>

Fatty acids enter the cells, but in order to be useful as energy supply, they must reach the energy factory of the cell: the mitochondrion. This is achieved with the help of the important L-carnitine. L-Carnitine helps transport the fatty acids into the active part of the mitochondrion, so the fatty acids can be used for energy.

**Definition**

**Chylomicron**: A large lipoprotein formed in intestinal cells following the absorption of dietary fats. A chylomicron has a central core of triglycerides and cholesterol surrounded by phospholipids and proteins.

1.4.3 Recommended levels

Because fat has a higher energy content than carbohydrate and protein, a diet high in fat may meet the energy demands more easily than a diet low in fat. This is especially important in cases of high-energy demand such as large amounts of exercise or certain diseases where the energy concentration of the food can limit total caloric intake.

**Definition**

**L-Carnitine**: A water soluble, vitamin-like amino acid that helps convert fatty acids into energy.
1.4.4 Fatty acid excess or deficiency in cats and dogs

If a pet receives an excessive amount of fat, they will often also receive an excessive amount of energy. This can make them predisposed to obesity. Another consequence of a high dietary fat concentration is that it requires increased antioxidant protection, such as added vitamin E (See antioxidants).

Essential fatty acid deficiency may cause:

- impaired wound healing
- dry lacklustre coat
- scaly skin
- predisposition to pyoderma
- alopecia
- oedema
- moist dermatitis
- reduced reproductive function.

**Definitions**

- **Pyoderma**: Purulent skin disease
- **Alopecia**: Thin or missing coat
- **Oedema**: Abnormal accumulation of fluid in the body
- **Dermatitis**: Inflammation of the skin
- **Inflammation**: A localised protective response elicited by injury or destruction of tissues, which serves to destroy, dilute, or wall off both the injurious agent and the injured tissue
1. Water, carbohydrates, proteins, fat, minerals and vitamins are nutrients.
2. Not all nutrients provide energy.
3. Proteins, fats and carbohydrates are energy producing nutrients.
4. Carbohydrates are divided into three main groups: monosaccharides, oligosaccharides and polysaccharides.
5. Polysaccharides are complex carbohydrates and include starches and fibres.
6. Simple carbohydrates and starches are sources of glucose and provide energy, help to produce other nutrients and can be stored.
7. Excess carbohydrates are stored as fat.
8. Fibre provides bulk and reduces the energy content of food, and can help prevent constipation and diarrhoea.
9. Both dogs and cats require an adequate level of glucose (simple sugar) or glucose-precursors.
10. In dogs, low carbohydrate diets can result in problems such as stillbirth, lethargy, reduced mothering ability and foetal abnormalities.
11. Simple carbohydrates and starches are digested throughout the entire digestive tract.
12. Fermentable fibre is broken down through the process of fermentation by intestinal microbes.
13. Proteins are complex molecules consisting of many amino acids.
14. Only ten (dog) or eleven (cat) amino acids are essential for animals. They are called Essential Amino Acids because they need to be present in the food.
15. Proteins are required for tissue growth and repair and are a source of dietary energy.
16. The quantity and proportion of amino acids has to be correct.
17. On a dry matter basis the minimum allowance of protein for adult dogs is 6% and 9.5% for growing dogs. Recommended Daily Allowances (RDA) are 18% and 22% respectively.

18. For kittens, the minimum allowance of protein is 24% and 14% for adult cats on a dry matter basis (RDAs are 30% and 26% respectively).
19. Signs of protein deficiency include poor growth and weight loss, dull hair and coat, muscle wasting and oedema.
20. The quality of a protein is determined by its Biological Value (BV), which is an indicator of both how well the amino acids match an animal’s requirements as well as how well it is digested.
21. Proteins are digested in the stomach and small intestine by enzymes.
22. Fats or lipids provide energy, aid absorption of fat-soluble vitamins, enhance palatability and are a source of essential fatty acids.
23. Essential fatty acids (EFA) are omega-3 (n-3) and omega-6 (n-6) fatty acids. These are needed to maintain cell membranes, for the synthesis of diverse, active substances such as prostaglandins and for controlling water loss through the body.
24. Excess dietary fat will with time result in obesity.
25. Deficiencies in EFA may result in impaired wound healing, dry coat, scaly skin, etc.
Self-assessment questions

1. Which nutrient is considered the most important for sustaining life?
2. What happens to excess carbohydrates in the body?
3. What are the major functions of fibre?
4. In dogs, what problems can a low carbohydrate diet cause?
5. Where and how are simple carbohydrates and starches digested in the body?
6. How are proteins structured?
7. Amino acids contain four groups. What are they?
8. Which essential amino acid is required by cats but not by dogs and where is it found?
9. What is the function of proteins?
10. When might recommended levels of protein vary?
11. Why are proteins called the ‘backbone’ of the cells?
12. Why is gelatine low in biological value?
13. What happens to amino acids after absorption?
14. What is the correct term for fats?
15. What do dietary fats contain?
16. Which two essential fatty acids does a dog require?
17. What is the name of the fatty acid that is required by cats but not by dogs and why do they need it?
18. How are fats and oils digested?
19. Which nutrients do not provide energy?
20. Which nutrient is considered the most important for sustaining life?
Building your portfolio

Photocopy and use the form below to keep a record of your answers to the questions below. Keep this information for your portfolio.

Exercise 1

| a. Explain to the client how protein differs depending on where it is utilised in the body. |
|-----|----------------------------------|
| Pet details |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

| b. Explain the importance and function of L-carnitine to the client. |
|-----|-------------------------------------------------|
| Pet details | Explanation |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

| c. How would you explain, in simple terms, the function and recommended amounts of each energy-producing nutrient to a client? |
|-----|------------------------------------------------------------------|
| Pet details | Explanation |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
The non-energy producing nutrients

Minerals, antioxidants and vitamins are nutrients that are essential for the health of the pet but they do not provide any energy.

1.5 Minerals

More than 18 mineral elements are believed to be essential for mammals. By definition, macrominerals are required by the animal in the diet in larger amounts and microminerals or trace elements in much smaller amounts. All the macrominerals, except sulphur, are described in the text.

There are 7 macrominerals:

- Phosphorus
- Calcium
- Sodium
- Chloride
- Sulfur
- Potassium
- Magnesium

Definition
The term mineral is generally used to describe all inorganic elements in a food.

Interesting fact
There is generally no dietary need for sulphur, as such, if the diet contains an appropriate mix of amino acids, since some of these contain sulphur.
There are at least 11 microminerals:
The major microminerals are iron, zinc, copper, and selenium.

1. Structural components of body organs and tissues:
   a. bones, teeth
      • calcium
      • phosphorus
      • magnesium.

2. Components of body fluids and tissues:
   a. maintenance of acid-base balance
   b. muscle contraction
   c. membrane permeability

All of the above:
   • sodium
   • potassium
   • chloride
   • calcium
   • magnesium.

3. Catalysts/co-factors in enzyme and hormone systems.

### 1.5.1 Function

<table>
<thead>
<tr>
<th>MINERALS REQUIRED FOR THE MAINTENANCE OF:</th>
<th>Calcium</th>
<th>Phosphorus</th>
<th>Magnesium</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skeletal structure</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Acid base balance</strong></td>
<td>Potassium</td>
<td>Sodium</td>
<td>Chloride</td>
</tr>
<tr>
<td><strong>Fluid balance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cellular function</strong></td>
<td>All</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nerve conduction</strong></td>
<td>Potassium</td>
<td>Magnesium</td>
<td></td>
</tr>
<tr>
<td><strong>Muscle contraction</strong></td>
<td>Calcium</td>
<td>Magnesium</td>
<td>Potassium</td>
</tr>
</tbody>
</table>
1.5.2 Absorption

A tremendous number of interactions between minerals exist. Most mineral interactions are antagonistic and can occur via a number of different mechanisms that take place:

1. in the food during processing
2. in the digestive tract
3. at the time of transport
4. at tissue level
5. in the excretory pathway.

This makes the correct balance of the different minerals in the food essential and complicated.

Apart from mineral-mineral interactions, many other factors help to determine how well a mineral is absorbed. These include:

a. the chemical form of the mineral
b. the amounts and proportions of other dietary components that has an effect on the mineral
c. the age and gender of the pet
d. intake of the mineral depending on the need (body stores)
e. environmental factors
f. other nutritional factors, like the fibre content of the food.

Interesting fact
Mineral to mineral interactions can be antagonistic (the presence of one mineral reduces the transport or biological efficacy of the other) or synergistic (the two minerals act in a complementary fashion either by sparing or substituting for the other mineral or the two together enhance a biological function).
### 1.5.3 Recommended levels

#### MINERAL FUNCTIONS AND RECOMMENDED LEVELS

<table>
<thead>
<tr>
<th>MINERAL</th>
<th>FUNCTION</th>
<th>RECOMMENDED LEVELS PER 1000 kcal (Minimum–Maximum. Adult dogs and cats)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium and phosphorus</td>
<td>• Structural part of bones and teeth&lt;br&gt;• Intracellular messengers&lt;br&gt;• Co-factor for enzymes and proteins&lt;br&gt;• Muscle contractions&lt;br&gt;• Nerve impulses</td>
<td><strong>Calcium:</strong>&lt;br&gt;Dogs: 1.5–6.3g&lt;br&gt;Cats: Minimum 1.4g&lt;br&gt;<strong>Phosphorus:</strong>&lt;br&gt;Dogs: 1.3–4.0g&lt;br&gt;Cats: Minimum 1.3g</td>
</tr>
<tr>
<td>Sodium, potassium and chloride</td>
<td>• Acid-base balance&lt;br&gt;• Osmotic balance&lt;br&gt;• Transmitting nerve impulses&lt;br&gt;• Muscle contractions</td>
<td><strong>Sodium</strong>&lt;br&gt;Dogs: Minimum 0.13g&lt;br&gt;Cats: Minimum 0.15g&lt;br&gt;<strong>Potassium</strong>&lt;br&gt;Dogs: Minimum 1.5g&lt;br&gt;Cats: Minimum 1.5g&lt;br&gt;<strong>Chloride</strong>&lt;br&gt;Dogs: Minimum 0.19g&lt;br&gt;Cats: Minimum 0.23g</td>
</tr>
<tr>
<td>Magnesium</td>
<td>• Component of bone, enzymes and intracellular fluids&lt;br&gt;• Neuromuscular transmissions</td>
<td>Dogs: 0.1–0.8g&lt;br&gt;Cats: Minimum 0.08g</td>
</tr>
<tr>
<td>Iron</td>
<td>• Essential component of haemoglobin and myoglobin</td>
<td>Dogs: 12.5–750mg&lt;br&gt;Cats: Minimum 20mg</td>
</tr>
<tr>
<td>Zinc</td>
<td>Important in: &lt;br&gt;• Immunocompetence&lt;br&gt;• Skin and wound healing&lt;br&gt;• Growth&lt;br&gt;• Reproduction</td>
<td>Dogs: 12.6–250mg&lt;br&gt;Cats: 12.5–502mg</td>
</tr>
<tr>
<td>Copper</td>
<td>Needed for: &lt;br&gt;• Red blood cells&lt;br&gt;• Pigmentation of skin and hair</td>
<td>Dogs: 1.0–63mg&lt;br&gt;Cats: Minimum 1.3mg</td>
</tr>
<tr>
<td>Selenium</td>
<td>• Important antioxidant</td>
<td>Dogs: Minimum 6mg&lt;br&gt;Cats: Minimum 25.1mg</td>
</tr>
</tbody>
</table>
1.5.4 Individual minerals

CALCIUM AND PHOSPHORUS

Calcium is the most common mineral in the body and phosphorus is the next most common. Calcium and phosphorus serve as structural components of the bones and the teeth.

Calcium is also important as:

1. a messenger:
   mediates the following:
   a. constriction and dilation of blood vessels
   b. nerve impulse transmission
   c. muscle contractions
   d. secretion of hormones
   e. blood coagulation

2. a co-factor for enzymes.

Since calcium participates in so many functions including keeping the heart beating, it is essential to keep the blood level of calcium at a steady level. This explains why, even when the food is quite deficient in calcium it is not reflected in the blood levels. Additional calcium is quickly released from the bones when the levels in the blood drop below a certain point to ensure that enough calcium is present to keep vital functions working.

It is the absolute concentration of these minerals that is of most importance but the ratio of calcium to phosphorus is also significant. The optimum ratio for growth is 1:1 and imbalance in this ratio can lead to skeletal deformities.

### Interesting fact
Calcium homeostasis is maintained by the co-ordinated actions of PTH (parathyroid hormone), calcitonin (also from the parathyroid gland) and active vitamin D.

### Clinical note
Hypocalcaemia (low levels of calcium in the blood) is a common problem in diseases such as:

- pancreatitis
- eclampsia
- etc.

Hypercalcaemia (high levels of calcium in the blood) is sometimes seen in patients with certain types of malignant cancer.

Calcium deficiency occurs most commonly when feeding foods that are high in phosphorus (high in meat and offal) and in lactating bitches.

Calcium excess is especially detrimental in rapidly growing pets, especially in large and giant-breed puppies that are already especially sensitive to higher levels of calcium in the food. (See Chapter 5 on Life Stage Feeding and read more in VNA 4.)
SODIUM, POTASSIUM AND CHLORIDE

Sodium, potassium and chloride are the major electrolytes in the body water. They are involved in:
- maintaining acid-base balance
- maintaining osmotic balance
- transmitting nerve impulses
- facilitating and transmitting muscle contractions.

A deficiency of these electrolytes can arise from excessive fluid loss, e.g., as occurs with vomiting and diarrhoea. Signs of deficiency include:
- muscle tremors
- anorexia
- decreased growth
- exhaustion
- inability to maintain water balance.

The supplementation of food with sodium chloride (salt) can be an effective method of stimulating water intake. However, breakthrough research has highlighted the danger of feeding a high sodium diet long-term. It has been shown that using a high sodium diet for the long-term management of cats can accelerate subclinical (undetected) renal disease.

Interesting fact
Electrolytes are minerals found naturally in the body that are present as electrically charged particles, or ions. Electrolytes are needed to keep the body’s balance of fluids at the proper level.

Clinical note
Electrolyte imbalances can be caused by:
- diarrhoea
- vomiting
- fever
- any problem that causes dehydration
- chronic heart disease
- kidney diseases
- chronic endocrine diseases, e.g., from the:
  - adrenal gland
  - pituitary gland
  - thyroid gland
  - parathyroid gland
- medicine, such as those used to get rid of excess fluid in the body (diuretics).

Let your client know
Many cat foods sold in grocery stores have a very high salt content.
MAGNESIUM

Because magnesium has a wide range of functions, deficiency gives a wide variety of signs, which include:
1. retarded growth
2. hyperirritability
3. anorexia
4. muscle incoordination
5. convulsions.

If a pet is fed a commercial pet food, it is unlikely to experience a magnesium deficiency. There is greater likelihood that the food will have a high content of magnesium. Excess dietary magnesium should be avoided to prevent the formation of struvite crystals in the urine of cats and dogs.

IRON

Iron deficiencies can occur with chronic blood loss, due to the loss of iron, or with the feeding of milk for a long time, due to the low content of iron in milk. Iron deficiency causes anaemia and fatigue.

ZINC

Zinc is a constituent or activator of more than 200 enzymes, so it is involved in a high number of diverse physiological functions. Some of zinc’s primary functions include:
- immunocompetence
- skin and wound healing
- growth
- reproduction.

Definition
Magnesium:
- is a component of bone, enzymes and intracellular fluids
- has influence on neuromuscular transmissions.

Definition
Iron is an essential component of:
1. haemoglobin: the oxygen-carrying pigment of the blood
2. myoglobin: the oxygen-carrying pigment of the muscles.
Foods that have a high level of calcium can increase the need for zinc. Older pets absorb zinc less efficiently and senior diets therefore need a higher zinc content than food for younger adults.

The most common signs of zinc deficiency are:
- anorexia
- alopecia
- scaly skin
- de-pigmentation of the hairs
- hyperkeratosis.

**Definition**

**Hyperkeratosis**: excessive growth (hypertrophy) of the upper horn-like layer of the skin.

**SELENIUM**

Selenium spares vitamin E in at least three ways:
1. preserves the integrity of the pancreas, which allows normal fat digestion and therefore normal absorption of vitamin E
2. reduces the amount of vitamin E required to maintain integrity of lipid membranes
3. aids retention of vitamin E in the blood plasma.

The incidence of selenium deficiency has not been reported in dogs and cats although it has been observed experimentally in dogs. Likewise, selenium toxicity has not been noted in dogs and cats despite high concentrations of selenium in seafood and fish-containing cat foods.

Let your client know

In some arctic breeds of dogs, such as the Alaskan malamute and the Siberian husky, zinc deficiency may occur even when the food contains adequate levels.

**Definition**

**Selenium**: an essential component of the naturally occurring antioxidant, glutathione peroxidase, which is present in all body cells.

**Interesting fact**

**Glutathione peroxidase** helps protect cellular membranes from oxidative damage, and works synergistically with vitamin E to reduce the destructive effects of oxidation by free radicals on living cells.

**COPPER**

Copper is needed for:
- the formation of red blood cells
- normal pigmentation of skin and hair.

Copper deficiency may occur with high levels of zinc and iron. Copper toxicity occurs mainly in specific breeds that cannot excrete copper from the body (e.g., Bedlington Terriers).

Let your client know

Bedlington Terriers and West Highland White Terriers are prone to hepatic copper storage defects. These defects cause excessive accumulation of copper in the liver. Copper is toxic to the cells, and accumulation results in liver cirrhosis (fibrosis, i.e., scar tissue formation).
1.6 Antioxidants

Oxygen is essential for life and, without it, dogs and cats could not survive. However, oxygen is also toxic and a constant potential threat to the health of all living cells. Animal cells are only able to tolerate oxygen because they have developed powerful defence mechanisms to minimise these toxic effects. These defence mechanisms constitute the body’s antioxidant defence system.

Free radicals are unstable and can start damaging chain reactions within the body in an attempt to produce more stable atoms and molecules. The damage caused by free radicals can lead to an impaired immune response and is an important contributory factor in many disease conditions such as accelerated ageing, cancer and heart disease. There is strong evidence that biologically active dietary antioxidants, by protecting against the damaging effects of free radicals, can play an important role in the management of animals with chronic diseases, since free radicals are produced during inflammation and chronic disease processes, as well as helping to combat ageing.

**Definition**

Free radicals: reactive, unstable molecules that cause cellular damage to proteins, nucleic acids (e.g., DNA) and membrane lipids through oxidation.

**Definition**

Antioxidants: enzymes or other molecules that can counteract the damaging effect of oxygen derivatives in food or tissue.

**Definition**

Oxidation is:
- loss of stability
- gain of oxygen.

Energy is released.

Clinical note

It is well known that oxidation of dietary fat causes food to go rancid, but it is less well known that oxidation of fat in the body also has adverse consequences.
To protect dietary fat from going rancid and to protect the body from the effect of free radicals, antioxidants are important. However it is important to appreciate that food antioxidants, used to prevent fats in the food from going rancid, are different to the biologically active dietary antioxidants that have the ability to counter the damaging effect of free radicals on living tissue.

**Antioxidants can be divided into two groups:**

1. **Biologically active antioxidants**
   - alpha-tocopherol (also known as vitamin E)
   - vitamin C (ascorbic acid)
   - carotenoids (e.g., beta-carotene)
   - flavonoids
   - alpha-lipoic acid
   - selenium
   - phenolic acid
   - glutathione.

2. **Food antioxidants preventing fat from going rancid**
   - rosemary oil
   - citric acid
   - mixed natural tocopherols (other members of the vitamin E family)
     i. delta-tocopherol
     ii. gamma-tocopherol
   - BHT/BHA.

---

**Let your client know**

Rosemary extract and vitamin E, naturally occurring food antioxidants, are used by Hill’s in most of their products.

---

**Let your client know**

Many of the Hill’s™ Prescription Diet™ products are enhanced with high levels of biologically active antioxidants that have been proved to help combat the effects of free radicals.
1.7 Vitamins

Vitamins can be divided into two main groups depending on whether they are soluble in fat or water. In addition, there is a group of vitamin-like substances that are similar to vitamins without fitting exactly into the categories.

<table>
<thead>
<tr>
<th>FAT-SOLUBLE VITAMINS</th>
<th>WATER-SOLUBLE VITAMINS</th>
<th>VITAMIN-LIKE SUBSTANCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>The Vitamin B complex</td>
<td>L-Carnitine</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>Thiamine (B1)</td>
<td>Carotenoids</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>Riboflavin (B2)</td>
<td>Flavonoids</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>Niacin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pyridoxine (B6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pantothenic acid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Folic Acid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cobalamin (B12)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biotin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Choline</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vitamin C</td>
<td></td>
</tr>
</tbody>
</table>

1.7.1 Function

Vitamins have very diverse physiological functions and are essential for the body. For specific functions see under the individual vitamin.

Definition

Substances must have five basic characteristics in order to be classified as vitamins:

1. It must be an organic compound different from fat, protein and carbohydrate
2. It must be a component of the diet
3. It must be essential in minute amounts for normal physiological function
4. Its absence must cause a deficiency syndrome
5. It must not be synthesised in quantities sufficient to support normal physiological function.
1.7.2 Absorption

Vitamins are absorbed in the body through a variety of pathways. Fat-soluble vitamins require bile salts and fat to be passively absorbed. They are then transported to the liver via the lymphatic system. Water-soluble vitamins are absorbed through active transport. Examples of vitamin-vitamin interactions are described in the table below.

### EXAMPLES OF VITAMIN-VITAMIN INTERACTIONS*

<table>
<thead>
<tr>
<th>One vitamin needed for optimal absorption of another</th>
<th>One vitamin needed for metabolism of another</th>
<th>One vitamin protects against excess catabolism or urinary losses of another</th>
<th>One vitamin protects against oxidative destruction of another</th>
<th>A high level of one vitamin can obscure the diagnosis of deficiency of another</th>
</tr>
</thead>
<tbody>
<tr>
<td>VITAMIN B₆ needed for VITAMIN B₁₂</td>
<td>VITAMIN B₁₂ needed for THIAMIN</td>
<td>RIBOFLAVIN needed for VITAMIN B₁₂ AND NIACIN</td>
<td>NIACIN</td>
<td>VITAMIN C spares VITAMIN B₁₂</td>
</tr>
<tr>
<td>FOLATE interferes with VITAMIN B₁₂</td>
<td>NIACIN interferes with VITAMIN B₁₂</td>
<td>VITAMIN B₁₂ interferes with NIACIN</td>
<td>VITAMIN A</td>
<td>VITAMIN C spares VITAMIN E</td>
</tr>
<tr>
<td>A high level of VITAMIN E interferes with VITAMIN K</td>
<td>THIAMIN interferes with RIBOFLAVIN</td>
<td>VITAMIN A spares VITAMIN E</td>
<td>VITAMIN B₁₂</td>
<td>FOLATE DEFICIENCY obscure VITAMIN B₁₂ DEFICIENCY</td>
</tr>
</tbody>
</table>

1.7.3 Recommended levels

Growing and reproducing pets are building new tissues and therefore need higher levels of vitamins for optimal performance.

Since the water-soluble vitamins are readily lost via the urine and are poorly stored in the body, a daily supply must be available in the food. Fat-soluble vitamins are more readily stored and so toxicity is more likely to arise than a deficiency.

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Function in</th>
<th>Recommended level per 1000 kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>• Vision&lt;br&gt;• Healthy skin, coat, mucous membranes and teeth</td>
<td>Dogs: 1,250–100,000 IU&lt;br&gt;Cats: 2,250–100,000 IU</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>• Calcium and phosphorus homeostasis</td>
<td>Dogs: 125–1,250 IU&lt;br&gt;Cats: 190–2,500 IU</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>• Biological antioxidant&lt;br&gt;• Membrane integrity</td>
<td>Dogs: Minimum 7.5 IU&lt;br&gt;Cats: Minimum 9.4 IU</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>• Clotting of the blood</td>
<td>None given for dogs and cats</td>
</tr>
<tr>
<td>Vitamin B complex</td>
<td>• Components of enzymes</td>
<td>Dogs: Min: 0.25 mg&lt;br&gt;Min: 1 mg&lt;br&gt;Min: 2.5 mg&lt;br&gt;Min: 2.8 mg&lt;br&gt;Min: 0.25 mg&lt;br&gt;Min: 45 μg&lt;br&gt;Min: 5.5 μg&lt;br&gt;Min: 300 μg&lt;br&gt;None given&lt;br&gt;Cats: Min: 1.2 mg&lt;br&gt;Min: 1 mg&lt;br&gt;Min: 1.2 mg&lt;br&gt;Min: 10 mg&lt;br&gt;Min: 0.63 mg&lt;br&gt;Min: 200 μg&lt;br&gt;Min: 5 μg&lt;br&gt;Min: 598 μg&lt;br&gt;Min: 17.5 μg</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>• Biologic antioxidant</td>
<td>None given for dogs and cats</td>
</tr>
<tr>
<td>L-Carnitine</td>
<td>• Helps to convert fat into energy</td>
<td>None given for dogs and cats</td>
</tr>
<tr>
<td>Carotenoids</td>
<td>• Biologic antioxidant</td>
<td>None given for dogs and cats</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>• Biologic antioxidant</td>
<td>None given for dogs and cats</td>
</tr>
</tbody>
</table>
1.7.4 Individual Vitamins

VITAMIN A

Vitamin A is also called retinol and is added almost universally to pet food. The precursors of vitamin A are the carotenes, especially β-carotene. Dogs can form vitamin A from the carotenes while cats require a direct source of ready-made vitamin A, which is only found in animal tissue.

Vitamin A is required for:
- normal vision
- healthy coat
- healthy skin
- healthy mucous membranes
- healthy teeth.

Deficiencies are uncommon but vitamin A toxicity is fairly common in cats receiving a diet high in liver or following over-supplementation with cod liver oil.

Clinical note

Signs of vitamin A toxicity (excess) in cats:
1. painful bone disease
   - cervical vertebrae
   - long bones of the forelimb
2. failure to groom due to pain upon flexing the neck
3. liver damage.

VITAMIN D

The primary function of vitamin D has to do with calcium and phosphorus and includes:
- enhancement of intestinal absorption and mobilisation
- retention and bone deposition.

Clinical note

Clinical signs of vitamin D deficiency include:
- in young animals
  - rickets
- in adult animals
  - enlarged junctions of the cartilage of the ribs
  - osteomalacia (soft bones)
  - osteoporosis (thin, brittle bones).

Definition

Rickets: a disease of young, growing animals caused by a nutritional deficiency of phosphorus or Vitamin D. The bones do not calcify normally, which leads to them becoming bowed and the joints to appear swollen. The animals are lame and the teeth show retarded development.
Deficiency is very rare but can cause rickets in young animals and bone problems in adult animals.

Toxicity can occur with over-supplementation and causes hypercalcaemia. The requirement for vitamin D depends on the dietary concentration of both calcium and phosphorus.

**VITAMIN E**

Vitamin E exists in different forms of which alpha-tocopherol is the most active form. Alpha-tocopherol functions as:
- a powerful biological antioxidant
- an aid to maintain membrane integrity.

The body produces harmful free radicals (oxidants) that cause damage to the cells as a by-product of normal metabolism. Free radicals weaken the immune system, accelerate signs of ageing and have an important role in the development of many different diseases. The biologically active antioxidants, of which vitamin E is one of the most significant, can protect the body from the harmful effects of free radicals, if the levels of antioxidants are high enough.

Signs of vitamin E deficiency are mostly attributed to dysfunction of cellular membranes and disruption of other critical cellular processes.

**Signs of vitamin E deficiency in dogs:**
- dysfunction of skeletal muscles due to degeneration
- reduced reproduction
- dysfunctional immune system.

**Signs of vitamin E deficiency in cats:**
- inflammation of the fat tissue – steatitis = yellow fat disease
- damage to the heart
- damage to the muscles.

Vitamin E is one of the least toxic vitamins. This means that the safety margin is much bigger than for vitamins A or D. The need for vitamin E is markedly influenced by dietary composition. The requirement increases with increasing levels of polyunsaturated fatty acids and decreases with increasing levels of selenium.

**VITAMIN K**

Vitamin K is synthesised by gut bacteria, and regulates the formation of several blood-clotting factors.

**Causes of vitamin K deficiency:**
- malabsorption diseases
- drugs that antagonise coagulation; e.g., coumarin (a rat poison)
- destruction of gut flora by antibiotic therapy (sulphonamides and broad-spectrum antibiotics).
VITAMIN B COMPLEX

The individual B-vitamins have specific functions but overall they:
• act as components of enzymes
• act as co-factors in the metabolic processes.

B-vitamins are relatively non-toxic. Deficiencies can occur due to specific antivitamins. Biotin deficiency can occur if a cat is fed raw egg white because this contains avidin that binds biotin. Since half of the biotin requirement is thought to be met by gut microbial synthesis, treatment with antibiotics that decrease the population of the intestinal microflora may also result in signs of biotin deficiency.

Signs of biotin deficiency in cats:
• dermatitis
• alopecia
• dull coat.

VITAMIN C

Because vitamin C can be synthesised from glucose in the body of healthy dogs and cats it is not technically essential. However, more recent research has shifted the focus from prevention of deficiency to the treatment and prevention of disease. Vitamin C plays an important role in immune function by:
• protecting against free radical damage, which the cells of the immune system are particularly susceptible to
• stimulating the leukocytes
• regenerating vitamin E, so more is available to act as an antioxidant.

L-CARNITINE

L-Carnitine is one of the best known vitamin-like substances. It is a natural component of all animal cells. Its primary function is to help convert fat into energy.

L-Carnitine transports fatty acids across the inner membrane of the mitochondria (the energy factories of the cell), so they can be oxidised and converted into energy.
With age, the mitochondria become less efficient and more free radicals are produced. L-Carnitine helps improve the efficiency of the mitochondria, so fewer free radicals are produced and mitochondrial health is maintained for longer.

Liver, skeletal and heart muscles contain 95–98% of the L-carnitine in the body and are significant storage sites.

**CAROTENOIDS**

A group of pigments called carotenoids also exhibit vitamin-like activity. More than 600 different compounds are classified as carotenoids but fewer than 10% can be converted into vitamin A. Carotenoids are found abundantly in orange and green vegetables. Carotenoids function as antioxidants.

**Clinical note**

L-Carnitine has been shown to increase the bone mass, the bone density and the muscle mass in large-breed puppies and to help prevent hepatic lipidosis (fatty liver) in cats during weight loss.

**FLAVONOIDS**

The flavonoids are another group of pigments (red, blue and yellow) that have vitamin-like activity. They are found in the peels and skins of coloured fruits and vegetables. The flavonoids have a sparing effect on vitamin C and further support the antioxidant system.
Summary of key points

1. Minerals, antioxidants and vitamins are non-energy-producing nutrients.
2. Minerals are inorganic elements in food.
3. Macrominerals are required in animal diets in larger amounts.
4. Microminerals are required in animal diets in smaller amounts.
5. Minerals provide structural components of body organs and tissues, maintain body fluids and tissues and are catalysts in enzyme and hormone systems.
6. Absorption of minerals can be influenced by mineral interactions.
7. Calcium is the most common mineral in the body.
8. Calcium and phosphorus are essential for healthy bones and teeth.
9. Sodium, potassium and chloride are the major electrolytes in the body water.
10. A deficiency of these minerals may arise from excessive fluid loss.
11. Antioxidants are enzymes or other substances that can combat the damaging effect of oxygen in food or tissue.
12. Vitamins are either fat-soluble or water-soluble.
13. Each vitamin serves a specific and essential function.
14. Vitamins are absorbed into the body through a variety of means.
15. Vitamin requirements vary according to the life stage of the pet.
16. L-Carnitine, carotenoids and flavonoids are vitamin-like substances.

Self-assessment questions

1. What are the seven macrominerals?
2. Why is there no dietary need for sulphur?
3. What are the four most important microminerals?
4. What functions do minerals serve?
5. What are the different mechanisms for mineral interactions?
6. What is the difference between antagonistic and synergistic interactions?
7. What are the two most common minerals and why are they important?
8. How is calcium homeostasis maintained?
9. When is calcium deficiency most likely to occur?
10. What function do electrolytes serve?
11. What may cause electrolyte imbalances?
12. Which breeds of dog are prone to zinc deficiency and copper storage deficits respectively?
13. What purpose does selenium serve?
14. What are antioxidants? Name two different types.
15. What are the three categories of vitamins?
16. In general, what function do vitamins serve?
17. What are the signs of vitamin A toxicity in cats?
18. What are the clinical signs of vitamin D deficiency?
19. Which fat-soluble vitamin is the least toxic?
20. Why is vitamin K important?
21. What are the signs of vitamin B deficiency?
22. Which vitamin is not considered essential for dogs and cats?
23. Which vitamin-like substance may help overweight pets lose weight?
24. What foods contain carotenoids and what function do they serve?
25. What foods contain flavonoids and why are they important?
Building your portfolio

Photocopy and use the form below to keep a record of your answers to the questions below. Keep this information for your portfolio.

Exercise 2

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<th>Dietary advice</th>
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</table>

a. What dietary advice would you give to a client who is feeding their dog mostly meat and offal?

b. What dietary advice would you give to a client whose cat presented signs of soft or brittle bones?

c. Mrs Unhealthycat brings Zippy in to the surgery because she is worried about the condition of his coat. His hair seems to be falling out and what remains is dull. His skin looks unhealthy too. The vet has found nothing wrong on diagnostic tests and concludes that this is a dietary problem. What could be the dietary cause of the skin and coat problems and what dietary advice would you give her?
Energy

All living organisms need energy to fuel the body. The energy content of the food is derived from fats, proteins and carbohydrates. Dietary fat is the most efficient source of energy and supplies 2½ times as much energy per gram as either protein or carbohydrate.

Energy intake must be controlled carefully to avoid the intake of either too much or too little energy.

Animals usually eat to satisfy their energy requirements. When an animal has consumed the correct amount of food to meet its energy needs then the requirements for all other nutrients should also have been met.

This is the ideal situation but as we all know, animals may eat beyond their energy requirements because the centre of the brain that controls hunger is different from the centre that controls satiety, and a lack of balance may occur between the two, so the animal feels hunger more strongly than it feels satiety.

Energy requirements vary from individual to individual. They also vary with age, reproductive status, breed, environment, gender, health status and activity level and this leads to a wide range of different energy requirements and food intake. Even within the same category, there are major individual variations.

### Definitions

**Appetite**: the desire for food. It is often used synonymously with hunger.

**Satiety** (satisfaction): the opposite of hunger, and means that hunger has been satisfied. The body is normally in a state of hunger that is intermittently relieved by eating.

### Clinical note

Excess energy can lead to obesity and growth abnormalities. Inadequate energy intake leads to weight loss and/or poor growth.

Let your client know

Some poor quality supermarket foods have a low energy density. This means that vulnerable pets such as lactating females or kittens may develop problems. Their stomachs become full before they have eaten enough nutrients to meet their needs, and the pet therefore does not receive adequate calories despite eating until it feels full.

### Variations in expected energy intake required to maintain optimal body weight in dogs and cats.

<table>
<thead>
<tr>
<th>Percent of average ME intake per kg metabolic body weight.</th>
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<tbody>
<tr>
<td><strong>Number of dogs</strong></td>
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<td>5%</td>
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<td>10%</td>
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<td>15%</td>
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<td>20%</td>
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<td>145%</td>
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<td>150%</td>
</tr>
</tbody>
</table>

**Variations in expected energy intake required to maintain optimal body weight in dogs and cats.**
2.1 Energy content of food

The energy content of food ultimately determines the quantity of food that is eaten each day. The total amount of potential energy in the food is called **gross energy**, but pets cannot use all the gross energy; some of it is lost in the form of heat or through faeces and urine.

**Definition**

**Gross energy** in food is determined by completely burning the food and measuring the heat produced.

**Definition**

**Calorie:** the amount of heat required to raise the temperature of 1g of water from 14.5°C to 15.5°C

**Interesting fact**

The hunger and the satiety centre are placed in two different areas of the hypothalamus. Many neuroendocrine and metabolic factors affect these centres, and therefore control appetite, such as the perception of food, sensors in the mouth, sensors in the gastrointestinal tract, nutrient levels in the blood as well as input from other areas of the brain. This means that the regulation of food intake is very complex and may partly explain why the number of overweight pets is quite high.

Because pets cannot use all the potential energy in the food, it is more convenient to adjust the gross energy to reflect the amount of energy that is actually available for the needs of the pet. This is called **metabolisable energy** (ME). The amount of metabolisable energy available is dependent on the digestibility of the food. The more digestible the food is, the less energy will be lost in faeces and the more will be available to the pet.

**THE ENERGY CONTENT OF NUTRIENTS**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Gross energy kcal/g</th>
<th>Metabolisable energy kcal/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>5.6</td>
<td>3.5</td>
</tr>
<tr>
<td>Fat</td>
<td>9.4</td>
<td>8.7</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>4.2</td>
<td>3.5</td>
</tr>
</tbody>
</table>

**Definition**

**Metabolisable energy (ME):** the energy that is available to the pet after energy from faeces, urine and combustible gases has been subtracted from the gross energy.

**Let your client know**

Animals of different species digest food differently. What has a high digestibility in a cow may have an extremely low digestibility in a dog. Digestibility tells us about how well a certain food is broken down in the gut. Raw carrots have a fairly low digestibility in dogs, as any pet owner will testify if they scoop the poop.
2.2 Calculation of energy requirements

In order to tell the client exactly how much food they need to feed their pet, it is important that you can calculate not just how many kilocalories the pet needs but also how much energy the food contains based on metabolisable energy. To be able to do that you need to know the proportions of the different nutrients in the food.

**Interesting fact**

The only really accurate way to determine the content of nutrients in a food is by laboratory analysis. Fortunately, pet food manufacturers have to give certain information on the label including an average

**Definition**

The Average Analysis on the label describes the content of protein, fat, fibre, water and ash but does not mention digestible carbohydrates. Fortunately, the carbohydrate content can be calculated based on the other values by adding up the percentage of protein, fat, fibre, water and ash and subtracting them from 100%. This gives you the percentage of carbohydrate in 100g of food.

**THE APPROXIMATE ENERGY CONTENT OF A FOOD**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Amount (as fed) (from label)</th>
<th>KcalME/g nutrient</th>
<th>KcalME/100g of diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>26%</td>
<td>x3.5</td>
<td>91</td>
</tr>
<tr>
<td>Fat</td>
<td>8%</td>
<td>x8.7</td>
<td>67</td>
</tr>
<tr>
<td>Fibre</td>
<td>2%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Water</td>
<td>10%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ash</td>
<td>6%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>48%</td>
<td>x3.5</td>
<td>168</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100%</td>
<td></td>
<td>326kcal/100g</td>
</tr>
</tbody>
</table>

When you know the average amount of metabolisable energy that you get from protein, fat and carbohydrates, (table) you can calculate the approximate energy content of a food.
2.3 Energy requirements

Knowledge of energy requirements is needed to determine how much food to feed a cat or a dog.

Basic terms are:
- Resting Energy Requirement (RER)
- Daily Energy Requirement (DER).

These are both helpful in determining how much food to feed to a pet depending on its status. The energy requirements are most often stated as metabolisable energy (ME), see next page.

**Definitions**

**Resting Energy Requirement (RER):** Energy requirement for a normal, fed animal at rest in a thermoneutral environment. Includes energy expended for recovery after physical activity and feeding. RER is measured *per day*.

**Daily Energy Requirement (DER):** Average daily energy expenditure of any animal dependant on life stage and activity. Includes activity necessary for work, gestation, lactation and growth. DER is also measured *per day*. 
The amount of energy a pet needs is related to body surface area rather than to body weight. Small animals have a larger surface area relative to their body weight and therefore have relatively greater heat loss and so a relatively greater DER. In order to determine RER and DER without the need to convert body weight to surface area, simple equations have been formulated which are roughly accurate.

**CALCULATION OF DAILY ENERGY REQUIREMENTS**

Due to the high degree of individual variance, these should be taken as a guide for a starting point and must always be followed up by individual evaluations. Even within one category, the actual requirements may vary up to three times.

<table>
<thead>
<tr>
<th>Feline DER</th>
<th>Canine DER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intact Adult</strong></td>
<td>1–2×RER</td>
</tr>
<tr>
<td><strong>Neutered Adult</strong></td>
<td>1.0×RER</td>
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<tr>
<td><strong>Obese prone</strong></td>
<td>1.0×RER</td>
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<tr>
<td><strong>Geriatric</strong></td>
<td>1.1×RER</td>
</tr>
<tr>
<td><strong>Gestation</strong></td>
<td>2.0×RER</td>
</tr>
<tr>
<td><strong>Week 1–4</strong></td>
<td>2.0×RER</td>
</tr>
<tr>
<td><strong>Week 7–9</strong></td>
<td>3.0×RER</td>
</tr>
<tr>
<td><strong>Lactation</strong></td>
<td>Ad libitum feeding (2.0–6.0×RER)</td>
</tr>
<tr>
<td><strong>Growth</strong></td>
<td></td>
</tr>
<tr>
<td>&lt;4 months</td>
<td>3.0×RER</td>
</tr>
<tr>
<td>4–6 months</td>
<td>2.5×RER</td>
</tr>
<tr>
<td>7–12 months</td>
<td>2.0×RER</td>
</tr>
</tbody>
</table>

**Clinical note**

During illness, energy requirements vary considerably. Pets are often less active and sleep more in a warm environment. The DER would therefore be lower. However, if the pet has suffered from trauma, surgery or sepsis, the DER rises sharply because of disease processes in the body.

**Definition**

**Ad libitum**: food is freely available at all times in unlimited amounts.
Now let’s work with Snarly…

From theory to practice

Now you know that the food in the table contains 326kcal/100g it is time to find out how much of this pet food your client needs to feed their dog or cat per day.

Mrs Healthydog has brought in her four-year-old intact male dachshund, Snarly, who weighs 8kg. How much of the food in table X does Snarly need per day?

1. Calculate Snarly’s resting energy requirement (RER).
   To calculate the resting energy requirement you use the equation:
   - RER = 30×(bodyweight in kg) + 70
   - RER = 30×(8) + 70
   - RER = 310kcal

2. Calculate Snarly’s daily energy requirement (DER) by multiplying RER with an appropriate factor.
   - Despite Snarly’s uncertain temperament, he is not really a very active dog. Therefore an appropriate factor from the table (calculation of DER) could be 1.8, which is the factor used for an intact, adult dog.
   - DER = RER×factor
   - DER = 310kcal×1.8
   - DER = 558kcal/day

3. Divide Snarly’s energy requirements by the amount of metabolisable energy in the food to determine the daily feeding amount.
   - Amount to feed: DER/ME per gram of food
   - There were 326kcal ME (metabolisable energy) in 100g.
   - Therefore, there is 3.26kcal ME in 1g
   - Amount to feed = 558÷3.26
   - Amount to feed = 171g per day

If Snarly were fed with a canned food that contained 500kcal/can, the calculations would be as follows:
1. DER = 558kcal/day
2. Amount to feed = DER/ME in can
   Amount to feed = 558/500 = 1.1 can

4. Make an appointment with Mrs Healthydog to come back in two weeks, so you can weigh Snarly and make sure that he is getting the amount of energy that is correct for his precise needs.
No matter how carefully you do them, the calculations are only a starting point. It is important to allow Snarly to show you exactly what he needs.
Summary

Summary of key points
1. Excess energy can lead to obesity and abnormalities.
2. Different pets require different amounts of energy producing foods.
3. RER and DER are terms used to describe the energy a pet needs.
4. Calories are used to measure the amount of energy in food.
5. Using RER and DER and calorie information from food it is possible to get an idea of how much food each pet requires.

Self-assessment questions
1. How is the energy content of food calculated?
2. What are the consequences of inadequate energy intake?
3. Is the regulation of food intake complex or simple?
4. Why does the energy requirement of pets vary?
5. What do DER and RER stand for?
6. Explain how body surface area is related to the energy requirement of a pet.
7. What information do you need when communicating exactly how much food a pet needs when speaking to a pet owner?
8. What method is used to calculate the content of nutrients in food?
Building your portfolio

Photocopy and use the form below to keep a record of your answers to the questions below. Keep this information for your portfolio.

**Exercise 1**

Over the next two weeks, calculate the DER and RER for any cats or dogs that you might consider prone to obesity and provide appropriate advice on calorie amounts for their owners.

<table>
<thead>
<tr>
<th>Client/Pet details</th>
<th>RER</th>
<th>DER</th>
<th>Calorie Advice</th>
<th>Amount of Hill’s™ Science Plan™ Light needed/day</th>
<th>Amount of Hill’s™ Prescription Diet™ w/d needed/day</th>
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</table>
The nutrient content of food

Now that we are familiar with the energy requirements of food and also with the individual nutrients, it’s time to look at how those nutrients actually fit into the food.

3.1 As fed comparisons

When you compare two different types of food, your comparison is often based on what the labels say. Chapter 3 – Speaking the language of labels, will help you understand what these labels state in greater detail, but for now, let us look at the basic nutrient information found on labels.

This is what the pet owner looks at when they compare two different types of food. Unfortunately, the values are not always directly comparable due to different moisture contents in the food.

These three different measurements will give very different values for the same nutrient. It is important to understand which method has been used to calculate nutrient content when comparing two different foods otherwise serious errors could be made in nutritional management.

Definition

The nutrient content of different foods is usually expressed in one of the following ways:
- as fed basis
- dry matter basis
- energy basis.

Interesting fact

All pet food labels must state an average analysis of the nutrients that contain the following:
- protein
- fat (oil)
- fibre
- ash (minerals)
- moisture (only legally required on label if the content is greater than 14%).

Definition

Dry matter basis: an expression of the nutrient content of the food on a moisture-free basis.

Let us look at a comparison where we remove the moisture, which will give us the exact content of the dry nutrients without water to fog the picture. This type of comparison is called a dry matter comparison and the result we get from them is called % dry matter basis or DMB.
3.2 Dry matter comparison

In order for us to do a dry matter comparison, we must first calculate how much dry matter there is in the food. Let us look at a 100g can of dog food:

- The label tells us that the can contains 70% moisture.
- This means that it contains 30% (100%–70%) dry matter.
- That means that 30% of the 100g is dry matter = 30g dry matter.
- The ‘as fed’ label states that the can contains 10% protein.
- The can is 100g. Therefore, there is 10g protein (10% of the 100g) in the can.
- If we remove the water, there is still 10g protein present, but now it is present in the 30g dry matter.
- This means that the dry matter content of protein is: 
  \[(10÷30)\times100 = 33.3\%\].

The equation we just used to calculate the dry matter content of a nutrient (in this case protein) looks like this:

\[
\frac{\text{\% nutrient}}{\text{\% dry matter}} \times 100 = \text{\% nutrient on a dry matter basis}
\]

Let us compare a dry product to the canned product above. The canned product contained 10% protein on an ‘as fed’ basis. This meant that in this product there was 33.3% protein.

The dry product that we wish to compare with contains 22% protein on an ‘as fed’ basis. To a pet owner this means that the dry product contains more protein. Let us do a dry matter analysis to see how much protein is in the dry food on a dry matter basis:

- The label of the dry food does not state any moisture. We must therefore assume a value and this is usually 10% with dry food
- If the dry food contains 10% moisture then there is 90% dry matter
- In 100g of dry food there is 22% protein. That means there is 22g of protein and 90% dry matter, which means 90g dry matter
- If we remove the moisture there is still 22g protein left in the 90g dry matter
- This means that the dry matter content of protein is: 
  \[(22÷90)\times100 = 24\%\].

Therefore, the canned food has 33.3% protein in it and the dry food has 24% in it, but to the pet owner the dry food was thought to have more protein!

A more precise type of comparison comes from comparing how much of the individual nutrients the pet gets when it consumes a set number of calories. This is because animals eat to satisfy their energy needs. Assuming the food is balanced, they will have consumed sufficient energy as well as the correct amount of all other nutrients needed for good health.
3.3 Energy basis comparison

With this method, nutrients are expressed in relation to the energy content of the food, e.g., 4g protein per 100kcal ME. This means that the food contains 4g of protein for every 100kcal of metabolisable energy consumed.

Consider the following two products:

- **Product A**: 100kcal ME per 100g food containing 10% protein as fed
- **Product B**: 400kcal ME per 100g food containing 22% protein as fed.

How much protein is ingested by the pet for every 100kcal consumed?

This can be calculated as follows:

**Product A**
- If there are 100kcal ME per 100g food, how many grams of food are there in 100kcal?
- Grams of food in 100kcal = \((100 ÷ 100)\times 100 = 100\)g food in 100kcal ME
- Each 100g food contains 10% protein as fed
- Grams of protein per 100kcal ME = 10% of 100g = 10g protein per 100kcal ME
- Product A therefore contains 10g protein per 100kcal ME.

**Product B**
- In product B there are 400kcal ME per 100g food. How many grams of food are there in 100kcal?
- Grams of food in 100kcal = \((100 ÷ 400)\times 100 = 25\)g food in 100kcal ME
- Each 25g food contains 22% protein as fed
- Grams of protein per 100kcal ME = 22% of 25g = 5.5g protein per 100kcal ME
- Product B therefore contains 5.5g protein per 100kcal ME.
Since animals eat to satisfy their energy needs, the pet will need to consume more of A to obtain the same number of calories. If a dog needs 600kcal per day it will consume 600g of product A and 150g of product B. Its daily protein intake will therefore be:

- for Product A: $6 \times 10 = 60g$
- for Product B: $6 \times 5.5 = 33g$

In order for the pet to meet its energy requirements it will not only need to eat far more of product A, but product A will supply it with an excessive amount of protein. The same process can be used for any nutrient, including minerals.

These calculations are useful tools for helping explain to clients why Hill’s products are the best. They can also be used to show clients that nutrition is about more than just what is written on the bag and finally, they will enable you to compare different products with the purpose of identifying potential problems with one or both of them.
Summary

Summary of key points
1. The nutrient content of different foods can be expressed in three ways.
2. The three ways are as fed basis, dry matter basis and energy basis.
3. As fed basis refers to the information on pet food labels.
4. Dry matter basis refers to what is left after the moisture has been calculated for.
5. Energy basis refers to the energy content of food.

Self-assessment questions
1. Who is most likely to use an as fed comparison?
2. How is the dry matter content of food calculated?
3. How does the energy based (kilocalorie) content of food affect the consumption of nutrients?
Building your portfolio

Photocopy and use the form below to keep a record of your answers to the questions below. Keep this information for your portfolio.

Exercise 4

a. What are the as fed nutrient details of the most popular pet food sold in your practice?

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b. Calculate the dry matter comparison of this product.

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c. How would you explain, in simple terms, the energy basis of this food compared to another similar product?

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Differences between dogs and cats

As you have read through this text, you have probably picked up that cats and dogs are quite different in their nutritional requirements.

Dogs are closely related to wolves and coyotes. Both are opportunistic predators and scavengers that hunt and eat whatever is available locally. Coyotes eat carrion and hunt rodents, other small mammals, birds, amphibians and other species. In addition, they have been reported to consume droppings of herbivorous prey. Domestic dogs will also happily consume herbivore faeces, e.g., horse droppings. For wolves, larger ungulates are the natural prey. The viscera are considered the preferred parts and therefore partially digested vegetable material is a normal part of the wolf’s diet. Both coyotes and wolves also eat plant matter such as fruits, berries, mushrooms and melons.

Dogs behave in a very similar way. They are opportunistic eaters and have developed anatomic and physiologic characteristics that permit digestion and usage of a varied diet.
On the other hand, cats are solitary hunters that have developed in dry, desert-like areas. Small rodents (e.g., voles and mice) make up 40% or more of the feral domestic cat’s diet and a variety of other prey (e.g., birds, reptiles, frogs and insects) are also taken. This means that the cat has evolved to eat 10–20 small meals throughout the day and the night.

The predatory drive is so strong in cats that they will stop eating to make a kill. This strategy allows for multiple kills, which optimises food availability and gives the cat its playful nature. Unfortunately, this behaviour may frustrate owners who confuse predatory behaviour with hunger.

Let your client know

Cats are strictly carnivorous, i.e., they require animal tissue to survive. This is due to the need for:
• taurine
• pre-formed vitamin A
• arachidonic acid.
All of these are present in animal tissue only.

Because the cat is strictly carnivorous, it has a need for extra protein, which is used as energy. This probably came about because cats always had access to a readily available protein source and therefore never developed any protein-saving mechanisms. Even in the wild, the feeding behaviour of cats reflects their preference for animal tissue. When ingesting their prey, wild cats avoid consuming the plant materials that are present in the entrails. These differences in feeding behaviour and subsequent needs for different nutrients explain why requirements of various nutrients are so different in dogs and cats. You can read more about this in the section on protein and amino acids.
Summary

Summary of key points
1. Dogs are **opportunist eaters**.
2. Dogs could even manage on a **vegetarian diet**.
3. Cats are strictly **carnivorous**.
4. Cats **need** protein for energy.

Self-assessment questions
1. To which other animals are dogs closely related?
2. What are the natural eating habits of cats?
3. Why do cats need animal tissue to survive?
4. How can a dog’s energy needs be met?
Building your portfolio

Photocopy and use the form below to keep a record of your answers to the questions below. Keep this information for your portfolio.

Exercise 5

a. Explain to Mrs Dung why her dog likes eating horse droppings.

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b. Explain to Mr Chat why his cat stops eating in order to hunt.

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