SECTION 1

STRUCTURE AND FUNCTIONS OF THE ORAL CAVITY

INTRODUCTION

This section looks at the structure and functions of the oral cavity in some detail. It includes the development of the oral cavity *in utero*, the structure of the tooth and its supporting tissues, plus eruption dates for primary and secondary dentitions.

It also includes the functions of the tongue in maintaining oral health and common conditions associated with it, plus the composition and role of saliva in keeping the mouth healthy.

Chapter 1

The oral cavity in health

LEARNING OUTCOMES

By the end of this chapter you should be able to:

1. Describe how the oral cavity, jaws and face develop *in utero*.
2. Explain the structure and function of the tissues and fluid of the oral cavity, including teeth, supporting structures, the tongue and saliva.
3. List primary and secondary dentition eruption dates.

INTRODUCTION

Before oral health educators (OHEs) can deliver dental health messages to patients, and confidently discuss oral care and disease with them, they will need a basic understanding of how the mouth develops *in utero*, the anatomy of the oral cavity (Figures 1.1, 1.2, 1.3 and 1.4) and how the following structures function within it:

- Teeth (including dentition).
- Periodontium (the supporting structure of the tooth).
- Tongue.
- Salivary glands (and saliva).

ORAL EMBRYOLOGY

A basic understanding of the development of the face, oral cavity and jaws in the embryo and developing foetus will enable the OHE to discuss with patients

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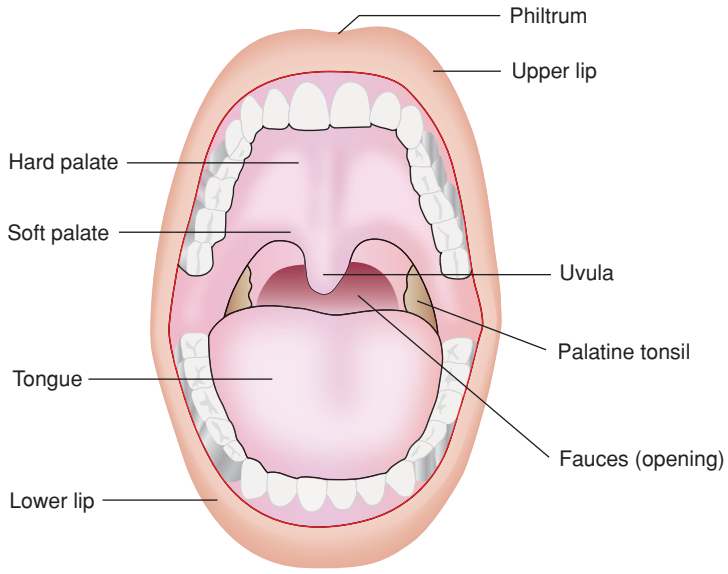

Figure 1.1 Structure of the oral cavity (© Elsevier 2002. Reproduced with permission from Reference 1)

Figure 1.2 A healthy mouth, white person (© John Wiley & Sons, Ltd 2003. Reproduced with permission from Reference 2)

Figure 1.3 A healthy mouth, black person (source: Alison Chapman)

Figure 1.4 A healthy mouth, Asian person (source: Alison Chapman)

Figure 1.5 Cleft lip (© iStockphoto.com/April Anderton)

certain oral manifestations of conditions that stem from *in utero* development (notably *cleft lip* and *palate* – Figure 1.5). (An *embryo* describes the growing organism up to 8 weeks *in utero*; a *foetus* describes the growing organism from 8 weeks *in utero*.)

Development of the face

At approximately week 4 *in utero* (Figure 1.6), the embryo begins to develop five facial *processes* (projections), which eventually form the face, oral cavity, palate and jaws by week 8 [3]:

- Frontonasal process – forms the forehead, nose and *philtrum* (groove in upper lip).
- Maxillary process (two projections) – forms the middle face and upper lip.
- Mandibular process (two projections) – forms the mandible and lower lip.

Development of the palate and nasal cavities

Week 5

The frontonasal and maxillary processes begin to form the nose and maxilla. However, if the nasal and maxillary processes fail to fuse a *cleft lip* and *palate*

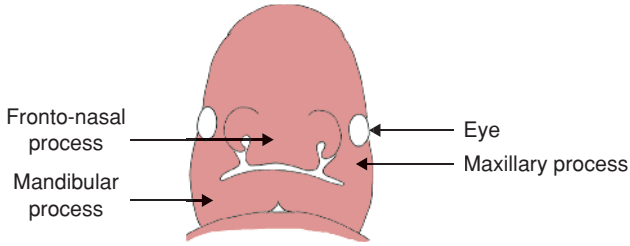

Figure 1.6 Facial development at 4 weeks *in utero* (© John Wiley & Sons, Ltd. Reproduced with permission from Reference 3)

will result [3]. A cleft lip can be anything from a small notch in the lip (incomplete cleft) to a wide gap that runs up to the nostril (complete cleft lip). One type of cleft palate (submucous) can be hidden.

There are two types of cleft lip:

- Unilateral – appears on one side of the lip at the philtrum.
- Bilateral – occurs on both sides of the lip, both sides of the philtrum.

Week 6

By week 6, the primary palate and nasal septum have developed. The septum divides the nasal cavity into two.

Week 8

By week 8, the palate is divided into oral and nasal cavities.

Development of the jaws (mandible and maxilla)

Week 6

By week 6, a band of dense fibrous tissue (Meckel's cartilage) forms and provides the structure around which the mandible forms.

Week 7

By week 7, bone develops, outlining the body of the mandible, and as the bone grows backwards two secondary cartilages develop; these eventually become the *condyle* and *coronoid* processes. As the bone grows forward, the two sides are separated by a cartilage called the *mandibular symphysis*. The two sides will finally fuse into one bone approximately 2 years after birth. Upward growth of bone begins along the mandibular arch forming the alveolar process, which will go on to surround the developing *tooth germs*.

Week 8

By week 8, ossification (bone development) of the maxilla begins.

Tooth germ development in the foetus

Tooth germ (tissue mass) develops in three stages known as *bud*, *cap* and *bell*. The developing tooth germ can be affected by the mother's health (see Chapter 20).

1. Bud – at 8 weeks, clumps of cells form swellings known as *enamel organs*. Each enamel organ is responsible for the development of a tooth.
2. Cap – the enamel organ continues to grow and by 12 weeks (the *late cap stage*), cells have formed the inner enamel epithelium and the outer enamel epithelium. Beneath the inner enamel epithelium, the concentration of cells will eventually become the pulp. The enamel organ is surrounded by a fibrous capsule (the dental follicle), which will eventually form the periodontal ligament.
3. Bell – by 14 weeks, the enamel organ will comprise different layers, which will continue to develop to form the various parts of the tooth.

MAIN FUNCTIONS OF THE ORAL CAVITY

The oral cavity is uniquely designed to carry out two main functions:

1. Begin the process of digestion. The cavity's hard and soft tissues, lubricated by saliva, are designed to withstand the stresses of:
   - Biting.
   - Chewing.
   - Swallowing.
2. Produce speech.

TEETH

Different types of teeth are designed (*shaped*) to carry out different functions. For example, canines are sharp and pointed for gripping and tearing food, while molars have flatter surfaces for chewing. Tooth form in relation to function is known as *morphology*.

Dental nurses and health-care workers may remember from their elementary studies that there are two types of *dentition* (a term used to describe the *type*, *number* and *arrangement* of natural teeth):

1. Primary (*deciduous*) dentition – consisting of 20 baby teeth.
2. Secondary (*permanent*) dentition – consisting of 32 adult teeth.

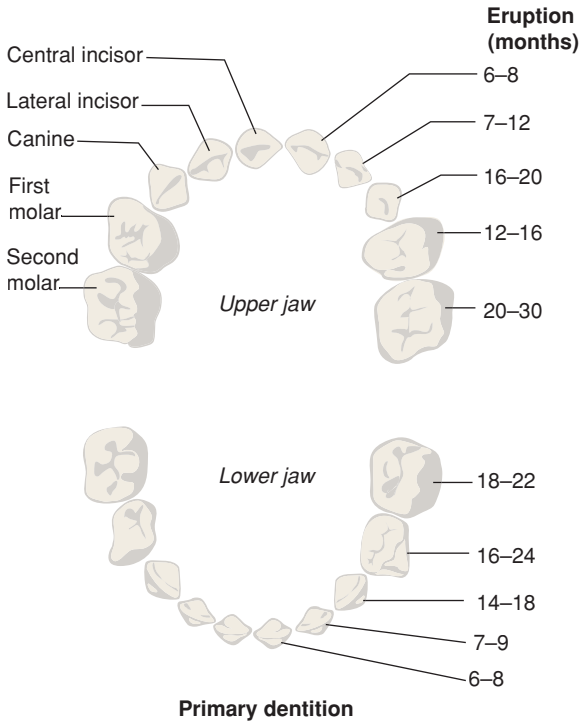

Figure 1.7 Primary dentition (© Elsevier 2002. Reproduced with permission from Reference 1)

Primary dentition

There are three types of deciduous teeth that make up the primary dentition (Figure 1.7): incisors, canines and molars (first and second). Table 1.1 details their *notation* (the code used by the dental profession to identify teeth), approximate eruption dates and functions.

Table 1.1 Primary dentition (notation, approximate eruption dates and functions)

Tooth	Notation	Approximate eruption date	Function
Incisors	(a and b)	6–12 months (usually lowers first)	Biting
First molars	(d)	12–24 months	Chewing
Canines	(c)	14–20 months	Tearing
Second molars	(e)	18–30 months	Chewing

Secondary dentition

There are four types of permanent teeth that make up the secondary dentition (Figure 1.8): incisors, canines, premolars and molars. Table 1.2 details their notation, approximate exfoliation/eruption dates and functions.

It is important to remember that these exfoliation/eruption dates are only approximate and vary considerably in children and adolescents. The educator should be prepared to answer questions from parents who are worried that their child's teeth are not erupting at the same age as their friends' teeth. Parents often do not realise, for example, that no teeth fall out to make room for the first permanent molars (sixes), which appear behind the deciduous molars.

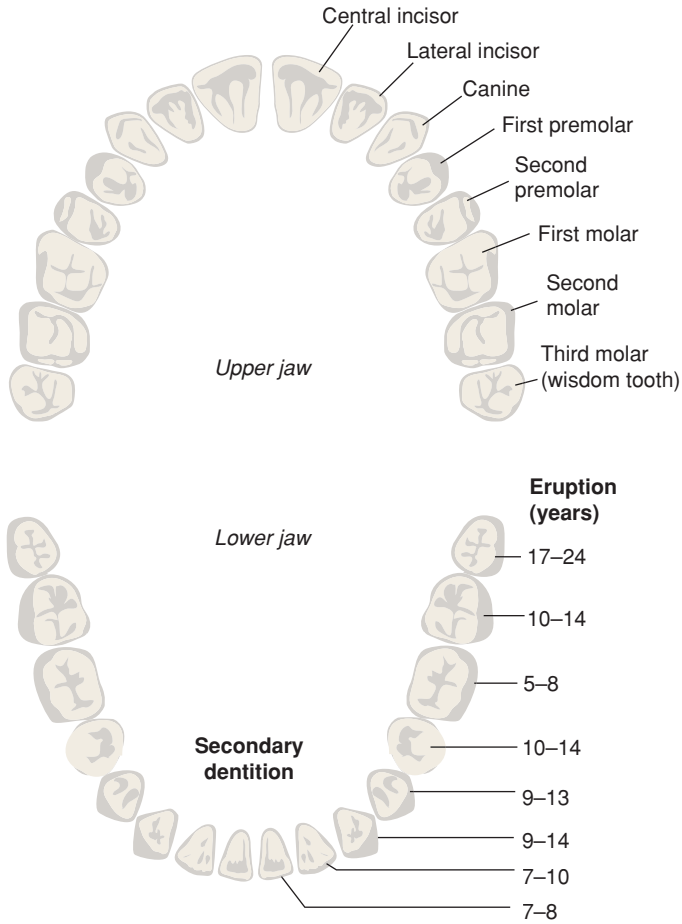

Figure 1.8 Secondary dentition (© Elsevier 2002. Reproduced with permission from Reference 1)

Table 1.2 Secondary dentition (notation, approximate exfoliation/eruption dates and functions)

Tooth	Notation	Approximate exfoliation/ eruption date	Function
First molars	(6)	5–8 years	Chewing
Lower central incisors	(1)	7–8 years	Biting
Upper central incisors	(1)	7–8 years	Biting
Lower lateral incisors	(2)	7–10 years	Biting
Upper lateral incisors	(2)	7–10 years	Biting
Lower canines	(3)	9–14 years	Tearing
First premolars	(4)	9–13 years	Chewing
Second premolars	(5)	10–14 years	Chewing
Upper canines	(3)	9–14 years	Tearing
Second molars	(7)	10–14 years	Chewing
Third molars	(8)	17–24 years	Chewing

Structure of the tooth

Tooth structure (Figure 1.9) is complex and comprises several different hard layers that protect a soft, inner pulp (nerves and blood vessels).

Organic and inorganic tooth matter

The words *organic* and *inorganic* are often mentioned in connection with tooth structure. Educators must know what these terms mean and their percentages in hard tooth structures.

Organic means *living* and describes the *matrix* (framework) of water, cells, fibres and proteins, which make the tooth a living structure.

Inorganic means *non-living* and describes the mineral content of the tooth, which gives it its strength. These minerals are complex calcium salts.

Table 1.3 shows the percentages of organic and inorganic matter in hard tooth structures.

Table 1.3 Percentages of organic and inorganic matter in hard tooth structures

Structure	Inorganic	Organic
Enamel	96%	4%
Dentine	70%	30%
Cementum	45%	55%

It is also important to know the basic details about these three hard tooth substances, and also pulp.

Enamel

Enamel (Figure 1.9) is made up of prisms (*crystals of hydroxyapatite*) arranged vertically in a wavy pattern, which give it great strength. The prisms, which resemble *fish scales*, are supported by a matrix of organic material including keratinised (*horny*) cells and can be seen under an electron microscope.

Properties of enamel

Enamel is:

- The hardest substance in the human body.
- Brittle – it fractures when the underlying dentine is weakened by decay (*caries*).
- Insensitive to stimuli (e.g. hot, cold and sweet substances).
- Darkens slightly with age – as secondary dentine is laid down and stains from proteins in the diet, tannin-rich food and drinks and smoking are absorbed.

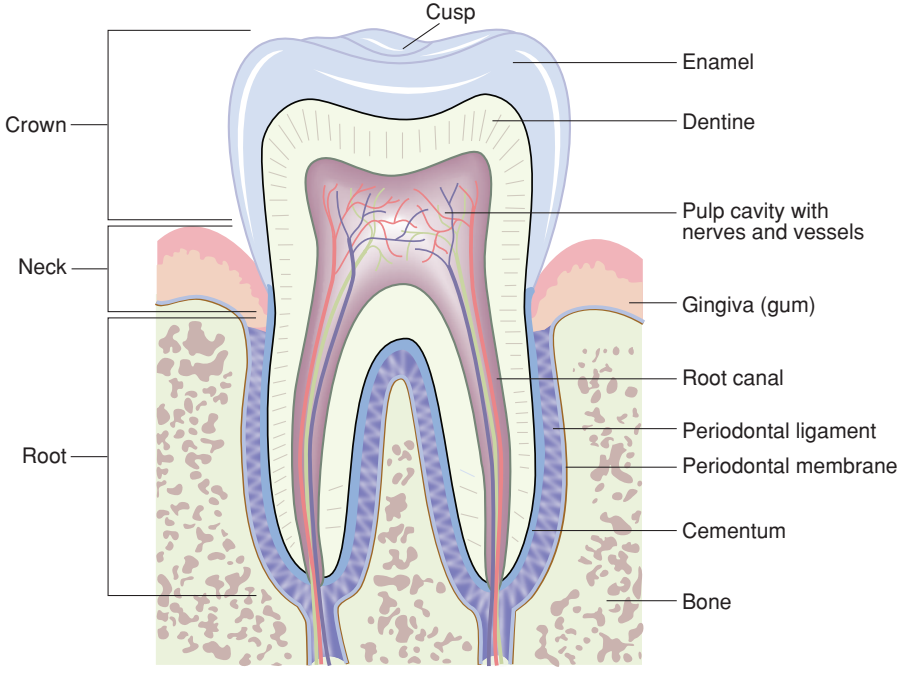

Figure 1.9 Structure of the tooth (© Elsevier 2002. Reproduced with permission from Reference 1)

Enamel is also subject to four types of wear and tear (see Chapter 6). The educator needs to be aware of these and able to differentiate between them:

1. *Erosion* – usually seen on *palatal* and *lingual* (next to palate and tongue) surfaces.
2. *Abrasion* – usually seen on *cervical* (outer neck of tooth) surfaces.
3. *Attrition* – natural wear often seen on *occlusal* (biting) surfaces.
4. *Abfraction – notching* of the enamel close to, or beneath the *gingival margin* (gum line).

Dentine

Dentine constitutes the main bulk of the tooth (Figure 1.9) and consists of millions of microscopic tubules (fine tubes), running in a curved pattern from the pulp to the enamel on the crown and the cementum on the root.

Properties of dentine

Dentine is:

- Softer than enamel, but harder than cementum and bone.
- Light yellow in colour.
- Sensitive to stimuli (e.g. hot, cold and sweet substances). Reasons for this sensitivity are not fully understood, but it usually lessens with age.

Dentine also changes throughout life. After a tooth is fully developed, more dentine is laid down and is known as *secondary dentine*.

Cementum

Cementum covers the surface of the root (Figure 1.9) and provides an attachment for the *periodontal ligament*. The fibres of the ligament are fixed in the cementum and in the *alveolar bone* (see supporting structures of the tooth).

Properties of cementum

Cementum is of similar hardness to bone and thickens throughout life to counteract wear and tear caused by chewing and movement.

Pulp

Pulp is a soft living tissue within the pulp chamber and root canal of the tooth (Figure 1.9). It consists of blood vessels, nerves, fibres and cells.

Properties of pulp

The pulp chamber shrinks with age as more secondary dentine is laid down, so that the tooth becomes less vulnerable to damage.

Supporting structures of the tooth

The *periodontium* (Figure 1.10) is the collective name for the supporting structures of the tooth.

It comprises:

- Periodontal ligament.
- Cementum (part of the tooth and supporting structure).
- Alveolar bone. This develops as the tooth erupts forming the alveolus of the mandible and maxilla.
- Gingivae (gums).

The periodontal ligament

The periodontal ligament is a connective tissue that holds the tooth in place in the alveolar bone (assisted by cementum). The ligament is between 0.1 and 0.3 mm wide and contains blood vessels, nerves, cells and *collagen fibres* [5].

The collagen fibres attach the tooth to the alveolar bone and run in different directions, which provide strength and flexibility and act as a *shock absorber* for the tooth; teeth need to move slightly in their sockets in order to withstand

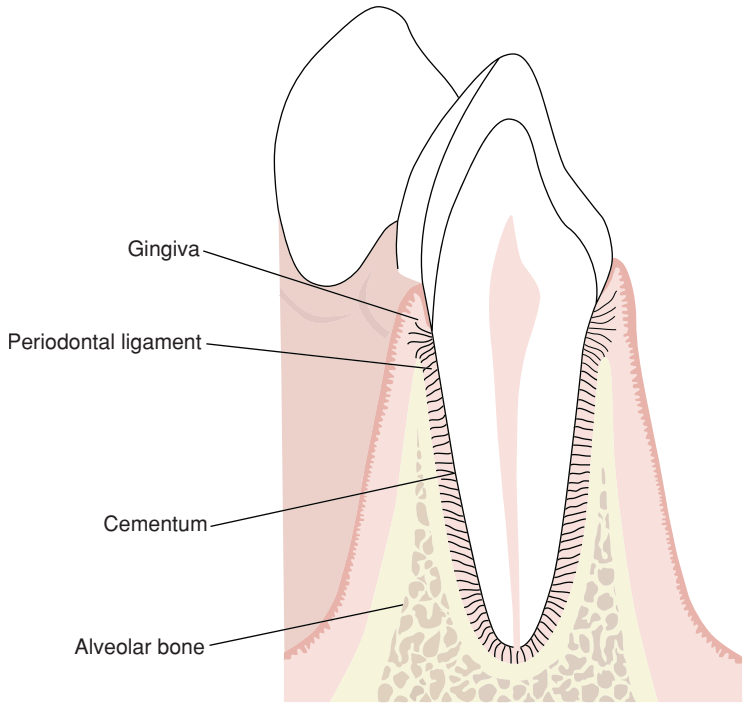

Figure 1.10 The periodontium (© John Wiley & Sons, Ltd 2003. Reproduced with permission from Reference 4)

the pressures of *mastication* (chewing). Imagine what it would feel like to bite hard with teeth rigidly cemented into bone.

Cementum

See 'Structure of the tooth'.

Alveolar bone (also known as the alveolar ridge)

Alveolar bones are *horseshoe-shaped* projections of the *maxilla* (upper jaw) and *mandible* (lower jaw). They provide an attachment for the fibres of the periodontal ligament, sockets for the teeth and support the teeth by absorbing and distributing occlusal forces.

Gingivae

The *gingivae* (gums) consist of mucous membranes and underlying fibrous tissue, covering the alveolar bone.

Gingivae are divided into four sections (Figure 1.11):

1. *Attached gingiva* – a firm, pale pink, stippled gum tightly attached to the underlying alveolar bone. It is *keratinised* (*hard and firm-like horn*) to withstand the friction of chewing. Its orange-peel appearance (known as *stippling*) comes from tightly packed bundles of collagen fibres that attach it to the bone. Loss of stippling is one of the signs of gingivitis (see Chapter 3).

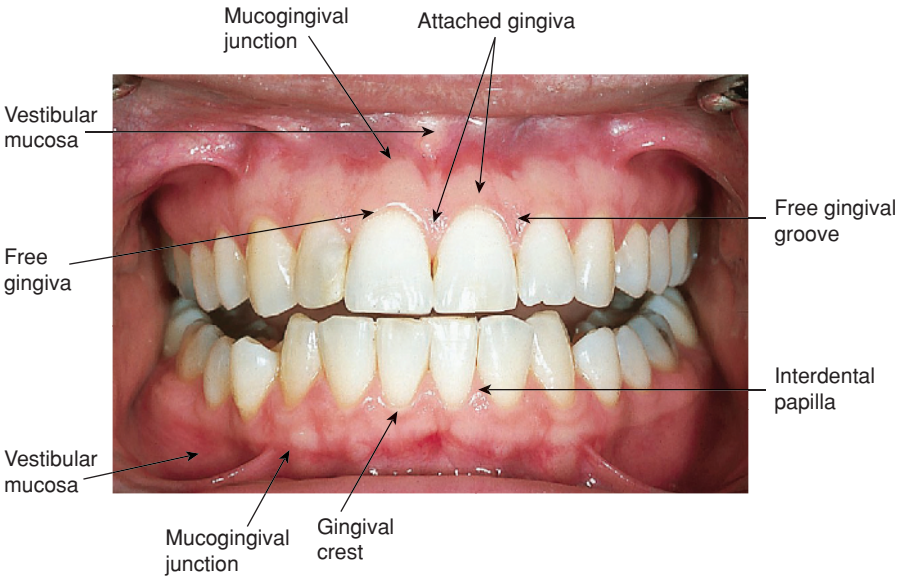

Figure 1.11 Gingivae (© John Wiley & Sons, Ltd 2003. Reproduced with permission from Reference 2)

2. *Free gingiva* – where the gum meets the tooth. It is less tightly attached and not stippled. It is also keratinised and contoured to form little points of gum between teeth – the *interdental papillae*. The indentation between attached and free gingiva is called the free gingival groove.
3. *Gingival crest* – the edge of the gum and interdental papillae bordering the tooth. Behind the crest is the *gingival sulcus* (or crevice), which is not more than 2 mm in depth [5]. This base of the crevice is lined with a layer of cells called the *junctional epithelium*, which attaches the gum to the tooth. When this epithelium breaks down, in disease, periodontal ligament fibres are exposed to bacterial enzymes and toxins. As these fibres break down, a *periodontal pocket* is formed.
4. *Mucogingival junction* – the meeting point of the keratinised attached gingiva and the non-keratinised *vestibular mucosa* (soft, dark red tissue, which lines the inside of lips, cheeks and the floor of the mouth).

THE TONGUE AND THE FLOOR OF THE MOUTH

The tongue is a muscular, mobile organ which lies in the floor of the mouth, and comprises four surfaces:

1. *Dorsal* (upper) surface – covered by a thick, keratinised epithelium to withstand chewing and a large number of projections called *papillae*. These papillae contain taste buds. The dorsal surface is divided into two sections:
   – *Anterior* (front) two-thirds (against the palate).
   – *Posterior* (back) third (towards the pharynx).
2. *Ventral* (under) surface – covered by a thin mucous membrane. In the middle of the front section, the mucosa is divided by a sharp fold, which joins the tip of the tongue to the floor of the mouth (the *lingual fraenum*).
3. *Tip* – the pointed front, which can be protruded or moved around the mouth by muscular action. For a baby, the tip of the tongue is an important sensory organ, which explores and identifies objects. It also acts as a great natural cleanser, removing food debris.
4. *Root* – the deep attachment of the tongue, which forms the anterior surface of the pharynx.

Muscles of the tongue

There are two groups of tongue muscles:

1. *Intrinsic* (inside) – which can alter its shape.
2. *Extrinsic* (outside) – which move the tongue and help alter its shape.

Functions of the tongue

The main functions of the tongue are:

- Taste.
- *Mastication* (chewing).
- *Deglutition* (swallowing).
- Speech.
- Cleansing.
- Protection.

Taste

The tongue (and other parts of the oral cavity) is covered with taste buds that allow us to distinguish between sweet, sour, salt, bitter and umami (savoury) tastes. An adult has approximately 9000 taste buds [5], which are mainly situated on the upper surface of the tongue (there are also some on the palate and even on the throat).

Mastication

The tongue helps pass a soft mass of chewed food (*bolus*) along its dorsal surface and presses it against the hard palate.

Deglutition

The tongue helps pass the bolus towards the entrance of the oesophagus.

Speech

Tongue movement plays a major part in the production of different sounds.

Natural cleansing

Tongue muscles allow for tremendous movement, and the tongue can help remove food particles from all areas of the mouth (mainly using the tip).

Protection

The tongue moves saliva (which has an antibacterial property) around the oral cavity.

Conditions affecting the tongue

The following conditions affect the tongue (see also Chapter 8):

- *Glossitis* (inflammation of the tongue) – a symptom of conditions such as dry mouth, infections, injury from a burn, irritants, vitamin B12 deficiency, skin conditions (e.g. lichen planus) or an allergic reaction. The underlying cause needs to be treated.
- Soreness of the tongue, which may be due to a variety of reasons, including anaemia, vitamin B deficiency and hormonal imbalance.

Figure 1.12 Geographic tongue (source: Alison Chapman)

- *Black hairy tongue* – due to overgrowth of tongue papillae, stained by *chromogenic* bacteria, medication (e.g. chlorhexidine) or smoking. Looks alarming, but is not serious.
- *Geographic tongue* (Figure 1.12) – also known as *migratory glossitis* – smooth 'map-like' irregular areas on the dorsal surface, which come and go. Harmless, but sometimes sore and often runs in families [5].

Piercing of the tongue can also cause problems and the educator should be able to advise patients on this matter (see Chapter 6). Tongue cleansing is also back in vogue, due to an increased awareness of halitosis, and tongue cleansers (e.g. TePe®) can help with this condition.

The floor of the mouth

The educator must know that the floor of the mouth consists of a muscle called the *mylohyoid* and associated structures.

SALIVA

Incredible stuff, saliva! It is often taken for granted, and patients only realise how vital it is to the well-being of the oral cavity and the whole body, when its flow is diminished.

Saliva is secreted by three major and numerous minor salivary glands. The minor glands are found in the lining of the oral cavity; on the inside of the lips, the cheeks, the palate and even the pharynx.

Major salivary glands

The three major salivary glands (Figure 1.13) are as follows:

1. *Parotid gland* – situated in front of the ear. It is the largest salivary gland and produces 25% of the total volume of saliva [5]. It produces *serous* (watery) saliva, which is transported into the oral cavity by the parotid duct, which opens above the upper molars. The parotid gland swells during mumps (*parotitis*).
2. *Submandibular gland* – situated beneath the *mylohyoid* muscle towards the base of the mandible. It is the middle of the three glands, in both size and position, and produces a mixture of serous and mucous saliva. It accounts for around 70% of total saliva and opens via the submandibular duct on the floor of the mouth [5].

   When dental nurses assist the dentist, they may *occasionally* notice a small 'fountain' as the saliva appears from this duct (which can also happen when yawning).

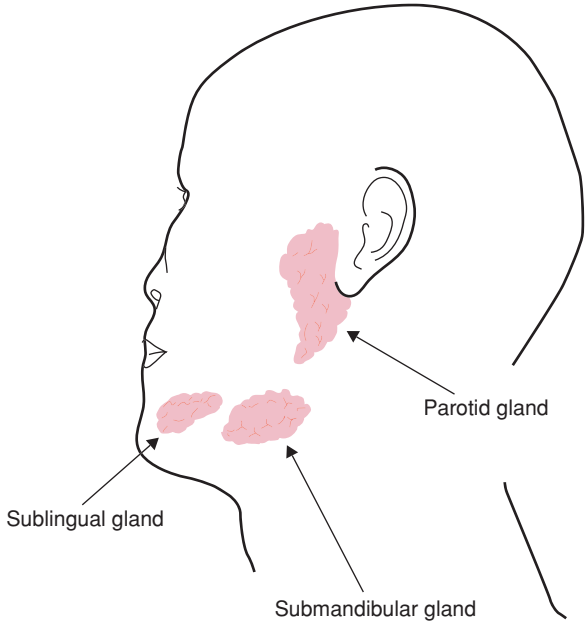

Figure 1.13 Major salivary glands (© John Wiley & Sons, Ltd. Reproduced with permission from Reference 6)

3. *Sublingual gland* – is also situated beneath the anterior floor of the mouth under the front of the tongue. It produces 5% of total saliva [5], mainly in the form of mucous which drains through numerous small ducts on the ridge of the *sublingual fold* (the section of fraenum beneath the anterior of tongue).

Composition of saliva

Saliva is made up of 99.5% water and 0.5% dissolved substances, although the composition varies between individuals [5].

Dissolved substances include:

- Mucins – these are *glycoproteins* that give saliva its viscosity (stickiness), lubricate the oral tissues, and are the origin of the *salivary pellicle* (the sticky film which forms on teeth within minutes of cleaning).
- Enzymes – there are many, but the OHE needs to remember only the main ones: *salivary amylase* (*ptyalin*), which converts starch into maltose and *lysozyme*; the latter attacks the cell walls of bacteria protecting the oral cavity from invading pathogens.
- *Serum proteins* – *albumin* and *globulin* (saliva is formed from *serum*, the watery basis of blood).
- Waste products – urea and uric acid.
- Gases – oxygen, nitrogen and carbon dioxide in solution. The latter vaporises when it enters the mouth and is given off as a gas.
- Inorganic ions – including sodium, sulphate, potassium, calcium, phosphate and chloride. The important ones to remember are calcium and phosphate ions, which are concerned with *remineralisation* of the teeth after an acid attack and the development of calculus.
- Saliva also contains large numbers of microorganisms and remnants of food substances.

Functions of saliva

There are eight main functions of saliva:

1. Aids mastication and deglutition – mucous helps form the food bolus.
2. Oral hygiene – washing and antibacterial action helps control disease of the oral cavity. Lysozyme controls bacterial growth. This is why saliva is said to have antibacterial properties and why animals instinctively lick their wounds.
3. Speech – a lubricant. For example, nervousness = production of adrenaline = reduction in saliva = dry mouth.
4. Taste – saliva dissolves substances and allows the taste buds to recognise taste.
5. Helps maintain water balance (of body) – when water balance is low, saliva is reduced, producing thirst.

6. Excretion – trace amounts of urea and uric acid (a minor role in total body excretion).
7. Digestion – salivary amylase begins the breakdown of cooked starch (a relatively minor role in the whole digestive process, but important in relation to sucrose intake and oral disease).
8. Buffering action – helps maintain the neutral pH of the mouth. The bicarbonate ion is vital to the health of the mouth as it is concerned with the buffering action of saliva. The resting pH of the mouth (when no food has just been consumed) is around 6.8. This is neutral, neither acid nor alkaline. (pH is a symbol used to indicate measurement of acidity or alkalinity of substances or liquids, and stands for the German term *potenz Hydrogen*.)

Facts about saliva

Here are some general points of interest about saliva:

- More is secreted when required (reflex action).
- Composition varies according to what is being eaten (e.g. more mucous with meat).
- Average amount produced daily by adults is 0.5–1 L. Certain medical conditions and disabilities cause the overproduction of saliva, resulting in dribbling (e.g. patients with Down's syndrome and Parkinson's disease, and fungal infections such as *angular cheilitis* – see Chapter 8).
- Flow almost ceases during sleep.
- Saliva is sterile until it enters the mouth.
- Saliva tests can be used to solve crimes, since saliva contains *deoxyribonucleic acid* (DNA) which can be used to help identify individuals. Dental companies sell saliva test kits, which can be used by OHEs to demonstrate saliva pH to patients.

Other additives within the mouth

Although saliva entering the mouth is sterile, it soon loses this property as it collects organic materials that are already present, including:

- Microorganisms: bacteria (mainly *streptococci*), viruses (e.g. *herpes simplex*), and fungi (e.g. *Candida albicans*).
- *Leucocytes* (white blood cells) which fight infection. Not present in *edentulous* (toothless) babies or in saliva collected from the duct, so presumed to come from gingival crevice after teeth erupt.
- Dietary substances (meal remains).

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