Some notes on Saliva

Saliva is produced by the **Salivary Glands**.

There are two types of Salivary Glands: major and minor.

The major glands are situated outside the mouth, and their secretions are conveyed into the mouth by ducts, which open through the oral mucosa. The major glands are paired on each side of the head. There are three pairs (see Figure 1):

The largest pair, the **parotid glands**, lie in the cheek in front of the ear. The duct from parotid gland passes forward, across the surface of the masseter muscle, and then inwards through the cheek to open opposite the upper second molar. Mumps - the child hood illness, is an acute inflammation of the parotid gland caused by a virus. The saliva secreted by the parotid is generally thin and watery (serous).

The **submandibular glands** lie below the posterior portion of the mandible. Saliva is conveyed to the mouth by a duct which opens through the floor of the mouth just on the tongue side of the lower incisors. The saliva is generally a mixture of sticky (mucinous) and watery (serous).

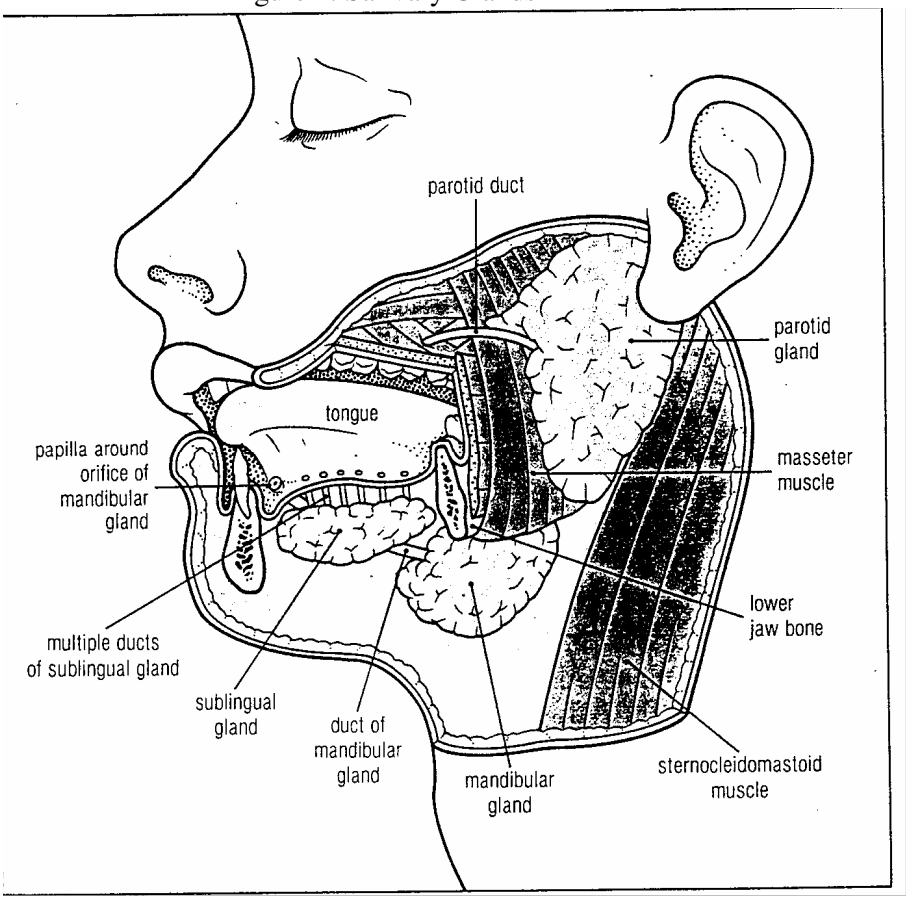
The **sublingual glands** also lie under the floor of the mouth, but forward of the submandibular glands, beneath the tongue. There are several small ducts from each of these glands, opening directly into the floor of the mouth. The major secretion is sticky (mucinous).

The minor glands lie inside the mouth, scattered through the mucous membrane lining the oral cavity, secreting saliva directly onto the mucosal surface. The glands are distributed on the lips, the cheeks, the palate, floor of the mouth and the tongue.

The minor glands are generally responsible for maintaining moisture of the mucous membrane (the lining of the mouth), whereas the major glands listed above produce large amounts of saliva in response to, for example, food intake.

The flow of saliva is controlled automatically by the autonomic nervous system (the part of the nervous system controlling unconscious functions, such as the heart beat, secretion of glands, and the contraction of blood vessels).

Figure 1. Salivary Glands



Note: In this diagram the submandibular gland is termed “mandibular gland”.

The quantity and quality of saliva secreted varies widely both between individuals and by the same person.

However an often-quoted average for an adult is 0.3 ml/min. This is **unstimulated saliva**. The secretion can increase to over 2.0 ml/min when **stimulated**.

Factors affecting unstimulated salivary flow rate:

Important	**Unimportant**
Degree of hydration	Gender
Body position	Body weight
Exposure to light	Gland size
Olfaction (smell)	Psychic effects - thought/sight of food
Smoking	- appetite
Previous stimulation	- mental stress
Circadian rhythms	Functional stimulation
Cirannual rhythms	
Drugs	

Hydration

This is potentially the most important factor. When the body water content is reduced by 8%, the salivary flow decreases to virtually zero.

Body Posture

When standing, an individual secretes more unstimulated saliva than when seated. However when lying down saliva secretion falls to below the rate for both standing and when seated. This of course is the situation with young babies.

Exposure to Light

Unstimulated salivary flow decreases in the dark.

Olfaction (smell)

Unstimulated salivary flow increases with olfaction stimulation.

Biological rhythms

Unstimulated saliva flow is not constant during a 24-hour period. This is demonstrated in Figure 2. Peak flow rate occurs in the late afternoon with the lowest flow rate in the early morning.

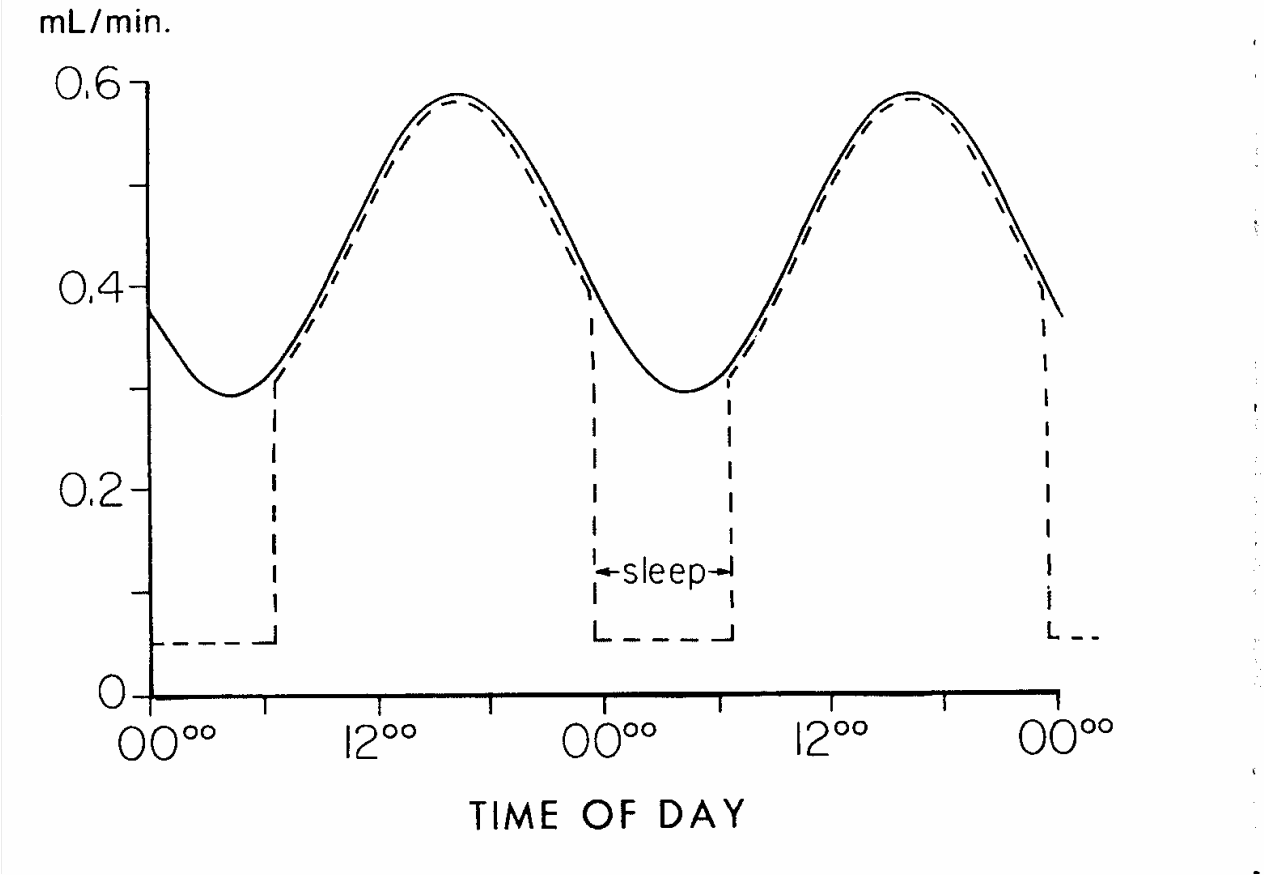


Figure 2. The circadian rhythm in unstimulated salivary flow rate (continuous line) from Daws C., *J Physiol*., 1972, **220**, 529-545, and the idealised effect of sleep (dashed line) from 23:00 to 07:00 h.

The dashed line illustrates the clinically very important finding of Schneyer *et al* (J. Dent Res. 1956, **35**: 109-114) that salivary flow rate is greatly decreased during sleep. Thus sleep would seem to be a period of increased caries susceptibility in those infants consuming fermentable carbohydrates just prior to sleep.

The salivary protein and electrolyte concentrations (that is, the **quality** of the saliva) show similar high amplitude rhythms. (Dawes C., *Int J Chronobiol*, 1974, **2**: 253-279)

It has also been report that there is a Cirannual rhythm in the flow rate of unstimulated parotid saliva, with a peak value in the winter.

Drugs

Many drugs reduce salivary flow rate as a side effect, for example:

Analgesics (pain killing)
Antihistamines
Antinauseants
Decongestants
Sedatives/tranquillisers

Many babies or infants are given at least one of these drugs.

Stimulated Saliva

As mentioned, the flow of saliva can be stimulated to several times the unstimulated rate. Some rates are quoted in the literature:

Type of Saliva	Stimulus	Mean Flow (ml/min)
Whole	Paraffin wax	1.6
Parotid	Lemon juice	1.5
Parotid	Grape candy	1.0
Sub mandibular	1% citric acid	0.8
Whole	Chewing gum	1.7

However flow rates of up to 7 ml/min have been measured.

Factors affecting stimulated salivary flow rate:

Nature (or type) of stimulus
Unilateral stimulation
Gland size
Gag reflex

Mechanical Stimulus

The action of chewing, in the absence of any taste, will itself stimulate salivation. Mastication also serves to mix the contents of the mouth, thus increasing the distribution of saliva

Gustatory (sense of taste) Stimulus

Acid is the most potent of the 4 basic stimuli, the others being salt, bitter and sweet. Research reports indicate that 5% citric acid stimulates the maximum salivary flow rate.

Unilateral Stimulus

If a person habitually chews on one side of the mouth, the glands on that side will produce most of the saliva, unless gustatory stimulation is also present.

Gland Size

Unlike unstimulated saliva, stimulated flow rate is directly related to gland size.

Age

Saliva flow is unrelated to age above 15 years. There seemed to be little research on the unstimulated or stimulated saliva production in infants and young children. This can be attributed to the fact that the quantitative measurement of saliva requires a reasonable amount of cooperation from the subject. Therefore most of the research work has been carried out on 5 year-olds or upward.

In 5 year old children unstimulated salivary flow is about half that of adults.

However, all commentators are agreed that in very young children salivary flow is much lower than this, but without giving precise data.

Food

Surprisingly, comparatively few studies have been carried out with food as the secretory stimulus. However, even the blandest food (boiled rice) elicited 43% of the maximum flow rate produced by 5% citric acid. Rhubarb pie, which is both acidic and sweet, produced 70% maximum flow rate.

Other studies have shown that it was the gustatory (taste) stimulus provided by the food, rather than the mechanical stimulus of chewing, which was responsible for these relatively high flow rates. In comparison with other foods, chewing gum elicits a low flow rate. (See Figure 3)

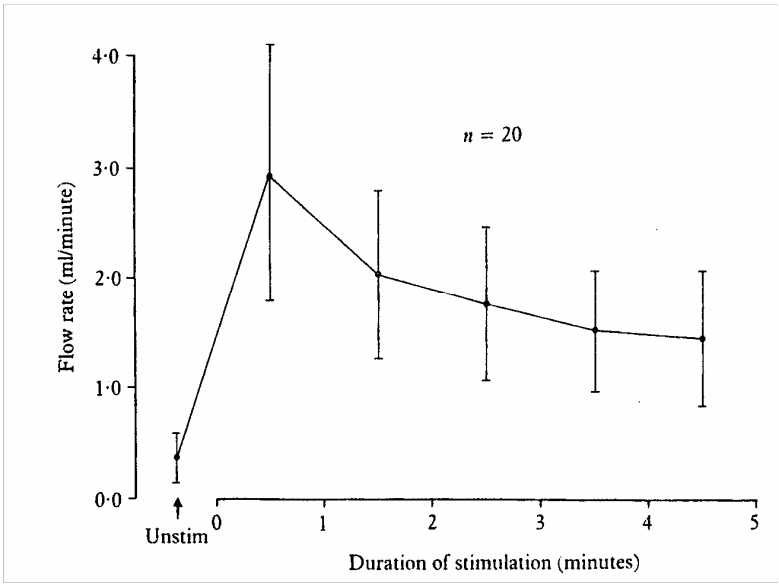


Figure 3. Effect of chewing gum on the flow rate of whole saliva

This is because many chewing gums provide a sweet stimulus, which is generally the least effective of the taste stimuli. Initially the flow rate is raised, but as the flavour sand sweetness leaches out, only the mechanical stimulus remains, and the flow rate falls. However, gum is chewed for a long time and even this stimulus can be beneficial.

This situation may be analogous with the sucking of a soother (see later).

Unstimulated flow rate and oral health

Most review papers suggest that there is little that can be done to influence the unstimulated flow rate on a long-term basis (none of them have apparently researched into non-nutritive sucking). However a study on sugar-free chewing gum given to students over a long period of time produced a small rise in the unstimulated, but not stimulated flow rate. This suggests that stimulation of the glands by this means increases their activity.

Carbohydrate clearance from the oral cavity

One major effect of saliva is the clearance of carbohydrate from the mouth. The more rapid the flow, the faster the carbohydrate is cleared. This is true whether the saliva is unstimulated or stimulated, for example by chewing gum.

Total daily salivary flow

In a healthy adult, it has been estimated that daily saliva production is about 540 ml. This can be divided up as follows: -

Type	Volume of Saliva	No of Hours	Rate per hour
Unstimulated - Awake	300	16	19
Stimulated – chewing etc	215	1	215
Unstimulated - Asleep	50	8	6

The importance of chewing stimulus can be clearly seen, as can the highly significant fall off on saliva production during sleep. The relative position would of course be worse in a young baby/infant who may sleep for at least 15 hours during a 24-hour period.

Factors affecting the composition of saliva

Flow rate	Hormones
Glandular source	Pregnancy
Species	Genetic effects
Duration of stimulation	Exercise
Previous stimulation	Drugs
Nature of stimulation	Various diseases
Plasma composition (diet)	Age

Flow rate

The main factor affecting the composition of saliva is the salivary flow rate: as the flow rate increases., the concentration of some constituents rises, for example, protein, chloride, sodium, bicarbonate, while others fall, for example, phosphate, magnesium. As a generalisation, the "poorest" quality of saliva is produced during sleep.

Contribution of different glands

Gland	% of total unstimulated saliva volume
Parotid	20
Submandibular	65
Sublingual	8
Minor mucous glands	7

At high flow rates, the parotid becomes the dominant gland contributing about 50% to the total salivary secretion. Since the parotid gland secretes calcium at a lower concentration than the submandibular gland, the calcium content of whole saliva is reduced at high flow rates.

Virtually all amylase (an important enzyme that converts starch to simpler carbohydrates) in saliva is produced by the parotid salivary glands.

Duration of stimulus

At a constant flow rate, the composition of saliva will vary depending on whether the gland has been stimulated within the last hour, the time of day, etc.

Nature of Stimulus

Ignoring the effect on rate of flow by different stimuli, it was found that the type of taste stimulus used had virtually no effect on electrolytic composition, but that the taste of salt stimulated much the highest protein content.

Age

The **quality** of saliva is obviously much easier to accurately measure in young children than **quantity**. Therefore some useful work has been done in this area. For example, the level of IgA has been measured. (IgA is an antibody concerned with protection against virus and other infections, especially in the respiratory and digestive systems.)

Secretory IgA is undetected in new-borns, was present in all 2-month-olds tested in both stimulated and unstimulated saliva, and increases progressively reaching adult

values by 6 to 8 years in unstimulated saliva and already by 2 to 4 years old in stimulated saliva.

Some researchers have suggested that the relatively low level of IgA in babies is a contributory factor for SIDS. Importantly, whether stimulated saliva (such as being produced by non-nutritive sucking) produces more protective IgA requires further research work.

Volume of saliva present in the mouth

Obviously the total volume of saliva present in the mouth at any time will vary according to all the conditions and stimuli discussed above. Also, the degree of swallowing will have a major influence on saliva volumes present. However, the literature would indicate volumes before swallowing of 0.5 – 2.1 ml (mean 1.1 ml) and after swallowing of 0.4 – 1.7 ml (mean 0.8 ml). Various estimates have been made of the surface area of the mouth which result in the conclusion that if the saliva was eventually spread, then it would be present as a thin film only 0.1 mm or less in thickness.

This estimated thickness is the same for adults and for five-year-old children.

When flow rate is stimulated, the velocity of the salivary film appears to be relatively low, such as 0.8 mm/min in the upper rear teeth, and 8 mm/min on the rear side of the lower front teeth. Thus unstimulated saliva moves slowly in the mouth and at different rates.

When salivary flow is stimulated, this is estimated to increase the velocity of the salivary film from 2 to 40 times, depending on the location in the mouth.

Mixing of saliva in the mouth

There is very little evidence that unstimulated saliva is well mixed in the mouth. This is important because the compositions of saliva secreted from the parotid, submandibular/sublingual and minor mucous glands are so different in many respects – for example: -

	Parotid	**Submandibular/ sublingual**	**Minor mucous Glands**
% contribution to whole saliva	25	67	8
Viscosity	Very low	Medium	High
Ca (mmol/L)	1.05	1.56	2.29
Inorg. P (mmol/L)	10.8	3.6	0.6
HCO_3 (mmol/L)	1.0	2.2	0.0

Studies have shown that saliva does not easily cross over from one of the mouth to the other.

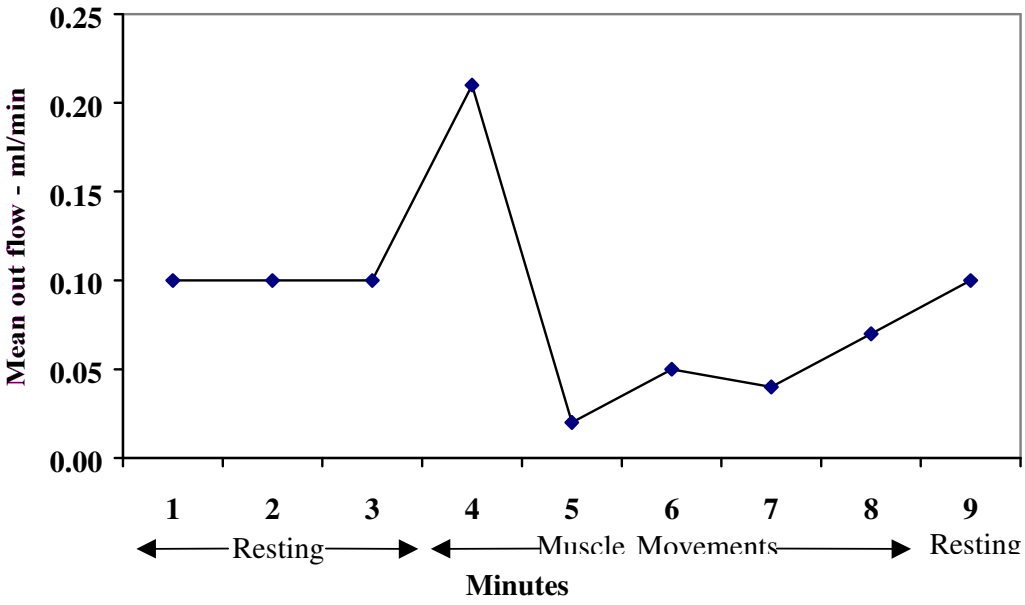
There is also a suggestion that plaque on the cheek side of teeth will mainly be in contact with the minor mucous gland secretions rather than with secretions from the major glands.

Non nutritive sucking and saliva production

There are almost no studies related to the quantity of saliva produced by non-nutritive sucking. However there are some, relatively old research papers which have measured salivary flow on subjects who have merely moved the muscles in and around the mouth. In these cases saliva output rose to twice the unstimulated level.

However, after reaching this peak flow, there was a compensatory pause in flow rate. (See figure 4)

Figure 4. Parotid secretion rate v time



It is significant that the shape of Figure 4 is very similar to that of Figure 3.

It is theorised (but not confirmed) that the jaw movements themselves do not stimulate secretion but that they cause a squeezing out of some of the secretion from the dead space of the gland. This squeezing effect could be either direct by compression of the gland or indirect through reflux stimulation of a contractile mechanism within the gland. The relaxation of the dead space to its normal volume could account for the subsequent compensatory pause in the outflow of secretion.

This initial "burst" in saliva production, followed by a "resting" period has been confirmed by a number of researchers using flavour-free chewing gum.

The following questions still remain unanswered:

- Does sucking on a soother stimulate saliva production?
- If so, for how long?
- What is the net result in saliva flow over a period of time?

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