

Oral biofilms: The detection and quantification of plaque

This experiment aims to discuss what plaque is, why it is formed and methods used to reduce its formation.

Target audience: KS4

Learning outcomes

- Dental plaque forms on the teeth
- Plaque is an example of a biofilm
- Dental plaque can contribute to gum disease and cavities
- The amount of plaque can be evaluated using the Quigley Hein plaque index
- Plaque can be removed by brushing the teeth

National Curriculum links:

2006 Curriculum for KS4:

This activity covers Sc2 Life processes and living things particularly Organisms and health 'organisms are interdependent and adapted to their environments'.

Prior to 2006: KS4 Single and Double Award

This activity covers Sc2 Life processes and living things particularly

Adaptation and competition 'how the distribution and relative abundance of organisms in habitats can be explained using ideas of interdependence, adaptation, competition and predation' (Single science Sc2 4a, Double science Sc2 5a)

Also Sc1 Scientific enquiry 'Investigative skills' (Sc1 2a f, 2h k, 2m s)

CLEAPSS References

General risk assessments should be carried out prior to this investigation.

Suggested references:

- CLEAPSS Laboratory Handbook section 11.8 Pupils as subjects of investigations. Check in case any medical or dental conditions could affect this investigation, including the fact that children with certain types of orthodontic devices fitted might be restricted in the way they clean their teeth.
- CLEAPSS Laboratory Handbook section 14.13 Hygiene. This includes a reference to dental hygiene studies:

In studies of dental hygiene, where pupils are required to brush their teeth, they should bring in from home their personal toothbrushes; under no circumstances should these be shared between pupils. Care must also be taken with the source of any drinking water used in washing out mouths etc; only use a tap which provides water straight from the mains supply, in case water in the reservoir tank has become contaminated.

- CLEAPSS Laboratory Handbook section 15.12 Sterilisation: note particularly references in section 15.12 for the disinfection of surfaces and used equipment.
- CLEAPSS Guidance leaflet PS6 Institute of Biology: Cheek cell sampling. The guidance can be adapted for this investigation.

Background information

Facts about plaque:

Dental plaque is an example of biofilm; it has a diverse microbial composition. In most ecosystems, there is a direct relationship between the environment and the diversity and abundance of species present. This relationship is dynamic. A change in a key environmental factor can alter the competitiveness of individual species. This can result in the enrichment of a previously minor component of the community or a loss of a dominant organism. This relationship may be fundamental to explaining how plaque related dental diseases arise. For example, mutans streptococci would be favoured by the low pH conditions from eating sugary food. Dental plaque, the presence of various specific microorganisms in the plaque (including mutans streptococci) and the sugar consumption will attack the tooth and cause cavities.

Teeth are normally negatively charged and plaque is positively charged. Opposite charges attract and bond to each other. Plaque, therefore, is attached to the tooth surface by ionic bonding. (see Stowell EC, et al. Ion penetration through the teeth as influenced by an electrostatic field. J Dent Res 1961;40:739-740).

An average daily brushing of approximately 2 minutes duration will remove only half the plaque, leaving the other half to promote rapid re-growth. (see De la Rosa MR, et al. Plaque growth and removal with daily tooth brushing. J Periodontol 1979;50:661-664).

You will need:

- Dental disclosing tablets (1 per student)
- Dental mirrors (1 per student)
- Toothbrushes (1 per student)
- Toothpaste
- Mouthwash
- Water
- Disposable plastic cups
- Battery powered electric toothbrushes (x 4)
- Stopwatches

Note:

It is recommended for Health and Safety reasons that either

1. Students bring in their own toothbrushes from home

Or

2. New equipment is provided and sterilised after use using Milton Sterilising solution (see packaging for details on use)

On NO ACCOUNT must toothbrushes be shared between students.

Mouthwash should be provided as aliquots in disposable cups. Students should not sample the mouthwash from stock.

What to do:

Students should wash hands before and after the activity.

1. Initially give each student one disclosing tablet to chew.
2. In pairs, students should examine and quantify the amount of plaque on each other's teeth using the Quigley Hein plaque index (see below). Specifically look at one upper and one lower incisor and one upper and one lower molar. Time permitting look at both the cheek (buccal) side and the tongue (lingual) side of the teeth. Results should be recorded on the worksheet.
3. Split the class into 4 groups. Each group is allocated one of the following methods:
 1. Toothbrush plus water only
 2. Toothbrush plus toothpaste
 3. Toothbrush plus water only followed by mouthwash
 4. Toothbrush plus toothpaste followed by mouthwash.

Note: One volunteer from each group should use a battery-powered electric toothbrush instead of the conventional toothbrush.

Each student should handle his or her own equipment only.

4. Students should clean teeth **WITHOUT** looking in a mirror and to use their usual brushing technique. Brushing time should be one minute.
5. After brushing, the amount of plaque remaining must be evaluated using the Quigley Hein plaque index (see below). Results should be recorded on the worksheet.
6. Groups should discuss the results by comparing before and after.
7. Class to discuss overall findings. What is the best method of removing plaque according to this investigation? Was an electric brush better than a conventional brush? Did the use of toothpaste make a difference? Did mouthwash make a difference? Are the results meaningful? Are they reliable? What modifications could be made to this investigation?

The outcome of this experiment may be that there are too many variables to make meaningful conclusions or comparisons. However, this investigation will prove that brushing teeth removes plaque. To quantify that statement any further would require a review of the methods used.

It may be useful to consider a similar 'real life' scientific investigation that addresses these questions and illustrates how scientists constantly evaluate and redesign experiments. e.g. Clinical Study on the Control of Dental Plaque Using a Toothbrush Equipped with a TiO₂ Semiconductor <http://www.pitrok.co.uk/soladey/Japanese%20trial.pdf>

The Clinical Effectiveness of a Novel Power Toothbrush and Its Impact on Oral Health <http://www.thejcdp.com/issue010/biesbrock/biesbrock.pdf>

Estimating the amount of plaque

The Quigley Hein plaque index

This index evaluates the plaque revealed on the cheek (buccal) side and the tongue (lingual) side of the teeth on a scale from 0–5 where:

0 = no plaque

1 = isolated flecks of plaque near the gingival (gum) margin

2 = a 1 mm band of plaque at the gingival margin

3 = up to 1/3 of the surface covered with plaque

4 = disclosed plaque from 1/3 to 2/3 of the surface

5 = disclosed plaque on more than 2/3 of the surface

REFERENCES

Quigley, GA and Hein, JW. Comparative cleaning efficacy of manual and power brushing. *J Am Dent Assoc* 1962; 65:26–29.

Addy, M., M.A. Slayne and W.G. Wade, 1993. *Methods for the Study of Dental Plaque Formation and Control*, IN Denyer, S.P., S.P. Gorman and M. Sussman, *Microbial Biofilms: Formation and Control*, Blackwell Scientific Publications, Oxford.

Useful websites

Oral biofilms – suggested lab activity for post GCSE

http://www.rlc.dcccd.edu/mathsci/reynolds/micro/lab_manual/biofilms.html

A Biofilms Bio

<http://www.envirotacklebox.org/modules/m1bio.htm>

Biofilms online – educational resources on biofilms

<http://www.biofilmsonline.com/cgi-bin/biofilmsonline/index.html>

Abstracts from the Society of General Microbiology

<http://www.socgenmicrobiol.org.uk/meetings/pdfabstracts/exeter2000abs.pdf>

A Friendly Guide to Biofilm Basics

http://www.erc.montana.edu/CBEssentials_SW/bf_basics_99/bbasics_01.htm

Society for General Microbiology

<http://www.microbiologyonline.org.uk/>

Plaque Busters!!

Target audience: KS2

National Curriculum links:

This activity supports Sc2 Life and living processes 'Micro organisms' (Sc2 5f) that microorganisms are living organisms that are often too small to be seen and may be beneficial or harmful.

Society for General Microbiology

<http://www.microbiologyonline.org.uk/forms/PB.pdf>

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Date:

Name:

Method:

Brushing time:

| | Upper incisor | Lower incisor | Upper molar | Lower molar |
|-------------------------|---------------|---------------|-------------|-------------|
| Before brushing: | | | | |
| Buccal | | | | |
| Lingual | | | | |
| After brushing: | | | | |
| Buccal | | | | |
| Lingual | | | | |

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