Teacher Notes

The Hole in the Tooth

Student Worksheet 1

The importance of brushing teeth.

Objective of experiment

Students

- participate in hands-on activities that lead them to good-health conclusions.
- explain how each experiment illustrates the importance of brushing their teeth every day.

Materials Needed

- hard-boiled eggs
- soft drink, such as cola or root beer
- dried chicken bones
- vinegar
- water and sugar solutions
- water and salt solutions
- fluoride (from a local dentist, or a dental supply store or pharmacy)

Experiment 1

1. For this simple experiment, fill one container with water and another with a brown soft drink -- cola or root beer, for example.
2. Place a hard-boiled egg into each container.
3. Leave the eggs in the containers overnight.
4. Pour out the liquid the next day and examine the eggs.
5. Compare the eggs left in the soda to the egg left in the water.

Experiment 2

1. Each group of students obtains 2 or more dry chicken bones.
2. Place one of the bones in a plastic cup; then pour vinegar in the cup to cover the bone.
3. Leave the other bone exposed to the air. Let the bones sit for several days, and then compare the two bones. What has happened? Why?

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Additional Experiments

Lesson Objective

To illustrate the way fluoride strengthens tooth enamel against acid

Materials Needed

- 2 boiled eggs
- Large Pickle Jar
- Vinegar
- Plastic Food Storage Bag
- Fluoride Gel

Experiment

1. Take one egg and put it in a plastic bag containing the fluoride gel. (make sure the fluoride completely covers the entire egg shell). Leave the other egg as is.
2. Leave the egg in the fluoride for 24 hours.
3. Take both eggs and put them in separate jars containing vinegar.
4. Observe the immediate difference in bubbling or reactivity of the two different eggs.
5. Leave overnight
6. Take both eggs out of the jar and examine.

Example of an Experimental Study on the Effectiveness of Different Ingredients in Toothpaste on Stained Teeth

Purpose

The purpose of this experiment was to determine which tooth cleaner most effectively removes stains from teeth.

Hypothesis

The fluoridated toothpaste will be the best cleaner to remove stains from teeth.

Experimental design

The variables controlled in this study were - the sugars (soda pop) and acid (lemon juice); kind of teeth; kind of cleaner; tooth brush; amount of time brushed.

The manipulated variable was the substance used to clean the teeth.

The responding variable was the whiteness of the teeth.

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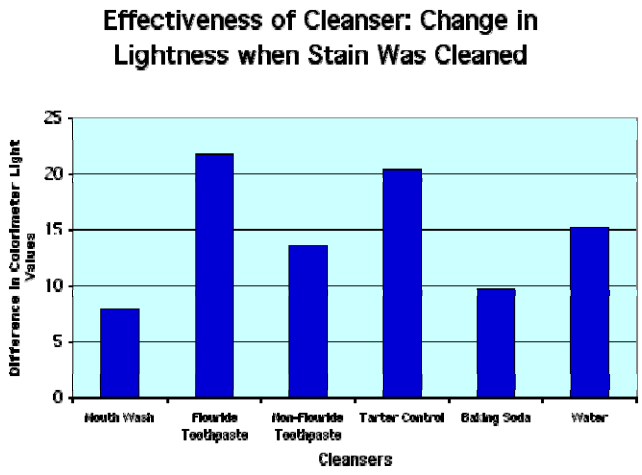
A colorimeter was used to observe the responding variable (whiteness and discolouring of the teeth).

Procedure

1. Make labels for the petri dishes according to the type of stain and cleaner solution that will be used for that tooth.
2. Put gloves on to handle teeth.
3. Pour glycerine out of jar making sure that the teeth remain in the jar.
4. Place teeth in container of water and boil for ten minutes. Remove the teeth from the boiling water and dry them thoroughly.
5. Place each tooth into correct ziplock bag according to label.
6. Put tooth in colorimeter and record reading. Repeat for each tooth.
7. Fill six empty petri dishes three-fourths full with only soda pop .
8. Fill six empty petri dishes three-fourths full with only lemon juice.
9. Arrange petri dishes in the order in which they appear on the recording chart.
10. Keep them in this order to avoid recording information incorrectly.
11. Soak each tooth in its solution for 2 weeks.
12. At the end of this period of time put on rubber gloves.
14. Remove tooth from petri dish.
15. Put stained tooth in colorimeter.
16. Brush tooth with correct cleaner. 3 min. Clean all surfaces equally.
17. Put tooth in colorimeter and record data.
18. Dispose of teeth and gloves at Tree Top Lab .



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Results

The original purpose of this experiment was to determine which tooth cleaner most effectively removes stains from teeth.

The results from my experiment indicated that tooth five had the largest amount of discoloration removed during the brushing process. The reading of the stained color was 119.44. The cleaned color was 63.40. The difference between the stained and cleaned color was 56.04.

Conclusion

My hypothesis was that the fluoridated toothpaste would be the best cleaner to remove stains from teeth.

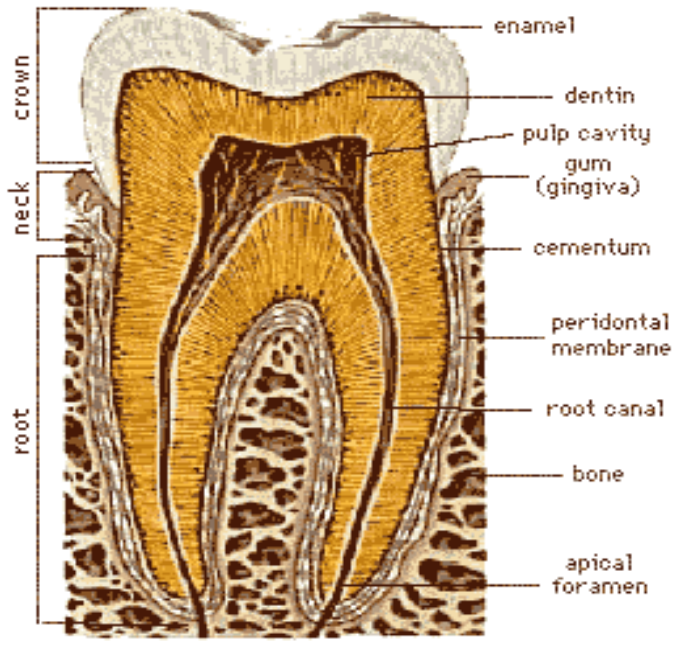
The results indicate that this hypothesis should be rejected because the greatest amount of discoloration was removed by the non-fluoridated toothpaste.

Because of the results of this experiment I wonder if the same results would occur with other kinds of stains, longer staining time, and other cleaning agents.

If I were to conduct this project again I would use cow teeth instead of teeth from humans, possibly use different stains, and conduct it for a longer period of time.

Notes on Teeth and Toothpastes

1. Structure of Teeth



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2 Tooth enamel

About Tooth Enamel

Tooth enamel is the hardest and most highly mineralized substance of the body. Together with dentin, cementum, and dental pulp is one of the four major tissues which make up the tooth.

It is the normally visible dental tissue of a tooth and must be supported by underlying dentin. Ninety-six percent of enamel consists of mineral, with water and organic material composing the rest. The normal color of enamel varies from light yellow to grayish white. At the edges of teeth where there is no dentin underlying the enamel, the color sometimes has a slightly blue tone.

Since enamel is semi-translucent, the color of dentin and any restorative dental material underneath the enamel strongly affects the appearance of a tooth. Enamel varies in thickness over the surface of the tooth and is often thickest at the cusp, up to 2.5mm, and thinnest at its border, which is seen clinically as the cemento-enamel junction (CEJ).

Enamel's primary mineral is hydroxyapatite, which is a crystalline calcium phosphate. The large amount of minerals in enamel accounts not only for its strength but also for its brittleness. Tooth enamel is the hardest substance in the human body, ranking a 5 on Mohs hardness scale.

The discoloration of teeth over time can result from exposure to substances such as tobacco, coffee, and tea. This is partly due to material building up in the enamel, but is also an effect of the underlying dentin becoming sclerotic. As a result, tooth color gradually darkens with age. Additionally, enamel becomes less permeable to fluids, less soluble to acid, and contains less water.

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Destruction of teeth

Destruction of enamel by cervical decay from dental caries.

The extent to which tooth decay is likely, known as cariogenicity, depends on factors such as how long the sugar remains in the mouth. Contrary to common belief, it is not the amount of sugar ingested but the frequency of sugar ingestion that is the most important factor in the causation of tooth decay. When the pH in the mouth initially decreases from the ingestion of sugars, the enamel is demineralized and left vulnerable for about 30 minutes. Eating a greater quantity of sugar in one sitting does not increase the time of demineralization. Similarly, eating a lesser quantity of sugar in one sitting does not decrease the time of demineralization. Thus, eating a great quantity of sugar at one time in the day is less detrimental than is a very small quantity ingested in many intervals throughout the day. For example, in terms of oral health, it is better to eat a single dessert at dinner time than to snack on a bag of candy throughout the day.

In addition to bacterial invasion, enamel is also susceptible to other destructive forces. Bruxism, also known as clenching of or grinding on teeth, destroys enamel very quickly. The wear rate of enamel, called attrition, is 8 micrometers a year from normal factors. A common misconception is that enamel wears away mostly from chewing, but actually teeth rarely touch during chewing. Furthermore, normal tooth contact is compensated physiologically by the periodontal ligaments (pdl) and the arrangement of dental occlusion. The truly destructive forces are the para-functional movements, as found in bruxism, which can cause irreversible damage to the enamel.

Other nonbacterial processes of enamel destruction include abrasion (involving foreign elements, such as toothbrushes), erosion (involving chemical processes, such as lemon juice), and possibly abfraction (involving compressive and tensile forces).

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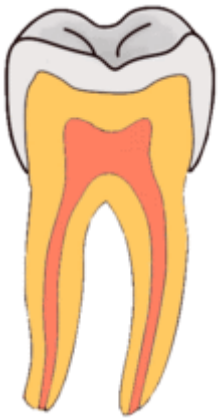
Dentin

Dentin, less mineralized and less brittle, 3-4 in hardness, compensates for enamel and is necessary as a support. Unlike dentin and bone, enamel does not contain collagen. Instead, it has two unique classes of proteins called amelogenins and enamelins. While the role of these proteins is not fully understood, it is believed that they aid in the development of enamel by serving as a framework support, among other functions.

Unlike enamel, the dentin reacts to the progression of dental caries. After tooth formation, the ameloblasts, which produce enamel, are destroyed once enamel formation is complete and thus cannot later regenerate enamel after its destruction. On the other hand, dentin is produced continuously throughout life by odontoblasts, which reside at the border between the pulp and dentin. Since odontoblasts are present, a stimulus, such as caries, can trigger a biologic response. These defense mechanisms include the formation of sclerotic and tertiary dentin.

In dentin from the deepest layer to the enamel, the distinct areas affected by caries are the translucent zone, the zone of bacterial penetration, and the zone of destruction. The translucent zone represents the advancing front of the carious process and is where the initial demineralization begins. The zones of bacterial penetration and destruction are the locations of invading bacteria and ultimately the decomposition of dentin.



The faster spread of caries through dentin creates this triangular appearance in smooth surface caries.

Fluorisis

Many groups of people have spoken out against fluoridated drinking water. One example used by these advocates is the damage fluoride can do as fluorosis. Fluorosis is a condition resulting from the overexposure to fluoride, especially between the ages of 6 months to 5 years, and appears as mottled enamel. Consequently, the teeth look unsightly and, indeed, the incidence of dental decay in those teeth is very small. However, it is important to note that most substances, even beneficial ones, are detrimental when taken in extreme doses. Where fluoride is found naturally in high concentrations, filters are often used to decrease the amount of fluoride in water. For this reason, codes have been developed by dental professionals to limit the amount of fluoride a person should take.

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The acute toxic dose of fluoride is ~5 mg/kg of body weight. Furthermore, whereas topical fluoride, found in toothpaste and mouthwashes, does not cause fluorosis, its effects are also less pervasive and not as long-lasting as those of systemic fluoride, such as when drinking fluorinated water. For instance, all of a tooth's enamel gains the benefits of fluoride when it is ingested systemically, through fluoridated water or salt fluoridation (a common alternative in Europe). Only some of the outer surfaces of enamel can be reached by topical fluoride. Thus, despite fluoridation's detractors, most dental health care professionals and organizations agree that the inclusion of fluoride in public water has been one of the most effective methods of decreasing the prevalence of tooth decay.

Tooth whitening

Tooth whitening or tooth bleaching are procedures that attempt to lighten a tooth's color in either of two ways: by chemical or mechanical action.

Working chemically, a bleaching agent is used to carry out an oxidation reaction in the enamel and dentin. The agents most commonly used to intrinsically change the color of teeth are hydrogen peroxide and carbamide peroxide. A tooth whitening product with an overall low pH can put enamel at risk for decay or destruction by demineralization. Consequently, care should be taken and risk evaluated when choosing a product which is very acidic.

Tooth whiteners in toothpastes work through a mechanical action. They have mild abrasives which aid in the removal of stains on enamel. Although this can be an effective method, it does not alter the intrinsic color of teeth.

Micro-abrasion techniques employ both methods. An acid is used first to weaken the outer 22–27 micrometers of enamel in order to weaken it enough for the subsequent abrasive force. This allows for removal of superficial stains in the enamel. If the discoloration is deeper or in the dentin, this method of tooth whitening will not be successful.

Tooth decay

The second most common of all health disorders is tooth decay. It is second to the common cold. Tooth decay usually occurs in young children but it can affect any person. Tooth decay is the leading cause of tooth loss in young people. It has been shown that eighty four percent of all cavities are located on molars which are in the back of the mouth. Molars contain many pits and grooves. It is harder to reach these areas with a toothbrush. When these grooved areas are not properly cleaned bacteria settle on the tooth surface and use the food particles left in the mouth to create acid. It is this acid that creates cavities.

Tooth decay is caused by certain types of acid-producing bacteria which cause damage in the presence of fermentable carbohydrates such as sucrose, fructose, and glucose. The resulting acidic levels in the mouth affect teeth because a tooth's special mineral content causes it to be sensitive to low pH. Specifically, a tooth (which is primarily mineral in content) is in a constant state of back-and-forth demineralization and remineralization

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between the tooth and surrounding saliva. When the pH at the surface of the tooth drops below 5.5, demineralization proceeds faster than remineralization (i.e. there is a net loss of mineral structure on the tooth's surface). This results in the ensuing decay.

Location of caries

Generally, there are two types of caries when separated by location:

- caries found in pits and fissures.
- caries found on smooth surfaces and

The pits and fissures of teeth provide a location for caries formation.

Pit and fissure caries

Pits and fissures are anatomic landmarks on a tooth where tooth enamel infolds creating such an appearance. Fissures are formed during the development of grooves, and have not fully fused (unlike grooves), thus possessing a unique linear-like small depression in enamel's surface structure, which would be a great place for dental caries to develop and flourish. Fissures are mostly located on the occlusal (chewing) surfaces of posterior teeth and lingual surfaces of maxillary anterior teeth. Pits are small, pinpoint depressions that are found at the ends or cross-sections of grooves. In particular, buccal pits are found on the facial surface of molars. For all types of pits and fissures, the deep infolding of enamel makes oral hygiene along these surfaces difficult, allowing dental caries to be common in these areas.

The occlusal surfaces of teeth represent 12.5% of all tooth surfaces but are the location of over 50% of all dental caries. Among children, pit and fissure caries represent 90% of all dental caries. Pit and fissure caries can sometimes be difficult to detect. As the decay progresses, caries in enamel nearest the surface of the tooth spreads gradually deeper. Once the caries reaches the dentin at the dentino-enamel junction, the decay quickly spreads laterally. Within the dentin, the decay follows a triangle pattern that points to the tooth's pulp. This

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pattern of decay is typically described as two triangles (one triangle in enamel, and another in dentin) with their bases conjoined to each other at the dentino-enamel junction (DEJ). This base-to-base pattern is typical of pit and fissure caries, unlike smooth-surface caries (where base and apex of the two triangles join).

Smooth-surface caries

There are three types of smooth-surface caries. Proximal caries, also called inter-proximal caries, form on the smooth surfaces between adjacent teeth. Root caries form on the root surfaces of teeth. The third type of smooth-surface caries occur on any other smooth tooth surface.

In this radiograph, the dark spots in the adjacent teeth show proximal caries.

Proximal caries are the most difficult type to detect. Frequently, this type of caries cannot be detected visually or manually with a dental explorer. Proximal caries form cervically (toward the roots of a tooth) just under the contact between two teeth. As a result, radiographs are needed for early discovery of proximal caries.
Root caries, which are sometimes described as a category of smooth-surfaces caries, are the third most common type of caries and usually occur when the root surfaces have been exposed due to gingival recession. When the gingiva is healthy, root caries is unlikely to develop because the root surfaces are not as accessible to bacterial plaque. The root surface is more vulnerable to the demineralization process than enamel because cementum begins to demineralize at 6.7 pH, which is higher than enamel's critical pH. Regardless, it is easier to arrest the progression of root caries than enamel caries because roots have a greater reuptake of fluoride than enamel.
Root caries are most likely to be found on facial surfaces, then interproximal surfaces, then lingual surfaces. Mandibular molars are the most common location to find root caries, followed by mandibular premolars, maxillary anteriors, maxillary posteriors, and mandibular anteriors.
Lesions on other smooth surfaces of teeth are also possible. Since these occur in all smooth surface areas of enamel except for interproximal areas, these types of caries are easily detected and are associated with high levels of plaque and diets promoting caries formation.

Signs and symptoms of caries

Until caries progresses, a person may not be aware of it. The earliest sign of a new carious lesion, referred as incipient decay, is the appearance of a chalky white spot on the surface of the tooth, indicating an area of demineralization of enamel. As the lesion continues to demineralize, it can turn brown but will eventually turn into a cavitation, a "cavity". The process before this point is reversible, but once a cavitation forms, the lost tooth structure cannot be regenerated. A lesion which appears brown and shiny suggests dental caries was once

present but the demineralization process has stopped, leaving a stain. A brown spot which is dull in appearance is probably a sign of active caries.

As the enamel and dentin are destroyed further, the cavitation becomes more noticeable. The affected areas of the tooth change color and become soft to the touch. Once the decay passes through enamel, the dentinal tubules, which have passages to the nerve of the tooth, become exposed and cause the tooth to hurt. The pain can be worsened by heat, cold, or sweet foods and drinks. Dental caries can also cause bad breath and foul tastes. In highly progressed cases, infection can spread from the tooth to the surrounding soft tissues which may become life-threatening, as in the case with Ludwig's angina.

Causes of caries formation

There are four main criteria required for caries formation: a tooth surface (enamel or dentin); cariogenic (or potentially caries-causing) bacteria; fermentable carbohydrates (such as sucrose); and time. The caries process does not have an inevitable outcome, and different individuals will be susceptible to different degrees depending on the shape of their teeth, oral hygiene habits, and the buffering capacity of their saliva. Dental caries can occur on any surface of a tooth that is exposed to the oral cavity, but not the structures which are retained within the bone.

The minerals in tooth enamel, especially hydroxyapatite, will become soluble when exposed to acidic environments. Enamel begins to demineralize at a pH of 5.5. Dentin and cementum are more susceptible to caries than enamel because they have lower mineral content. Thus, when root surfaces of teeth are exposed from gingival recession or periodontal disease, caries can develop more readily. Even in a healthy oral environment, the tooth is susceptible to dental caries.

The anatomy of teeth may affect the likelihood of caries formation. In cases where the deep grooves of teeth are more numerous and exaggerated, pit and fissure caries are more likely to develop. Also, caries are more likely to develop when food is trapped between teeth.

Bacteria and dental caries

Bacteria which are tiny colonies of living organisms are constantly found in the human mouth. It is normal for millions of bacteria to be in your mouth. The mouth contains a wide variety of bacteria, but only a few specific species of bacteria are believed to cause dental caries: *Streptococcus mutans* and *Lactobacilli* among them. Particularly for root caries, the most closely associated bacteria frequently identified are *Lactobacillus acidophilus*, *Actinomyces viscosus*, *Nocardia spp.*, and *Streptococcus mutans*. Mutans streptococci are able to grab any sugar that enters the mouth. Bacteria in a person's mouth convert sugars (glucose and fructose, and most commonly sucrose - or table sugar) into acids such as lactic acid through a glycolytic process called fermentation. This changes the pH in the mouth and forms acid on the teeth. It is this acid that causes teeth to decay. The lactobacilli are more able to survive in an acid environment. Bacteria changes all foods into acid. Sugars and starches are favourites of bacteria. Plaque is formed by bacteria, acid, food debris, and saliva.

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Plaque is a sticky substance that sticks to the teeth. Plaque is easily detected on the grooved chewing surfaces of the back molars, just above the gum line, and at the edges around fillings. When plaque is not removed from the teeth it becomes tartar.

There is acid in the plaque. It is this acid that dissolves the enamel surface of the tooth and creates holes in the tooth. Most of the bacterial activity occurs within twenty minutes after eating. This is when the acid is most active. The bacteria multiply faster and the plaque grows in size and thickness. This makes it harder to wash the bacteria away with saliva. Bacteria will use the sugars found in candy and other sweet foods as well as the natural sugars found in fruits and milk. They also use the carbohydrates found in potato chips, pasta, and bread.

Our teeth are able to repair the damage done to the enamel by the acid in a process called remineralization. The minerals found in the saliva try to repair the damaged areas of the tooth surface. But, the rate of destruction of the tooth enamel by acid is much faster than the natural remineralization that occurs.

If left in contact with the tooth, these acids may cause demineralization, which is the dissolution of its mineral content. The process is dynamic, however, as remineralization can also occur if the acid is neutralized; suitable minerals are available in the mouth from saliva and also from preventative aids such as fluoride toothpaste, dental varnish or mouthwash. Caries advance may be arrested at this stage.

Prevention of caries

Oral hygiene

Personal hygiene care consists of proper brushing and flossing daily. The purpose of oral hygiene is to minimize any etiologic agents of disease in the mouth. The primary focus of brushing and flossing is to remove and prevent the formation of plaque. Plaque consists mostly of bacteria. As the amount of bacterial plaque increases, the tooth is more vulnerable to dental caries. A toothbrush can be used to remove plaque on most surfaces of the teeth except for areas between teeth. When used correctly, dental floss removes plaque from areas which could otherwise develop proximal caries. Other adjunct hygiene aids include inter-dental brushes, water picks, and mouthwashes.

Professional hygiene care consists of regular dental examinations and cleanings. Sometimes, complete plaque removal is difficult, and a dentist or dental hygienist may be needed. Along with oral hygiene, radiographs may be taken at dental visits to detect possible dental caries development in high risk areas of the mouth.

Dietary modification

For dental health, the frequency of sugar intake is more important than the amount of sugar consumed. In the presence of sugar and other carbohydrates, bacteria in the mouth produce acids which can demineralize enamel, dentin, and cementum. The more frequently teeth are exposed to this environment, the more likely dental caries are to occur. Therefore, minimizing snacking is recommended, since snacking creates a continual supply of nutrition for acid-creating bacteria in the mouth. Also, chewy and sticky foods (such as dried fruit or candy)

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tend to adhere to teeth longer, and consequently are best eaten as part of a meal. Brushing the teeth after meals is recommended.

It has been found that milk and certain kinds of cheese like cheddar can help counter tooth decay if eaten soon after the consumption of foods potentially harmful to teeth. Also, chewing gum containing xylitol (wood sugar) is widely used to protect teeth in some countries, being especially popular in the Finnish candy industry. Xylitol's effect on reducing plaque is probably due to bacteria's inability to utilize it like other sugars. Chewing and stimulation of flavour receptors on the tongue are also known to increase the production and release of saliva, which contains natural buffers to prevent the lowering of pH in the mouth to the point where enamel may become demineralised.

Fluoride therapy is often recommended to protect against dental caries. It has been demonstrated that water fluoridation and fluoride supplements decrease the incidence of dental caries. Fluoride helps prevent decay of a tooth by binding to the hydroxyapatite crystals in enamel. The incorporated fluoride makes enamel more resistant to demineralization and, thus, resistant to decay. Topical fluoride is also recommended to protect the surface of the teeth. This may include a fluoride toothpaste or mouthwash. Many dentists include application of topical fluoride solutions as part of routine visits.

Furthermore, recent research shows that low intensity laser radiation of argon ion lasers may prevent the susceptibility for enamel caries and white spot lesions. Also, as bacteria are a major factor contributing to poor oral health, there is currently research to find a vaccine for dental caries. As of 2004, such a vaccine has been successfully tested on non-human animals, and is in clinical trials for humans of May 2006.

Tooth decay prevention

There are several things that can be done to prevent tooth decay. The timing of your snacks is critical to preventing cavities. After snacking the acid that is produced is neutralized by the saliva and is cleared from the mouth. After the acid is removed the minerals present in saliva crystallize on the enamel and begin to repair the areas that were damaged by the acid. The longer the interval between meals and snacks provides more opportunity for the acid to be neutralized and more time for the damage to be repaired. When frequent snacking takes place there is a constant attack on the tooth surface by the acid. There is also less time for tooth repair to take place.

Fluoride has been called a wonder of modern dentistry. It incorporates itself into the enamel of the tooth and strengthens it and makes it more resistant to attacks by acid. Fluoride works with the saliva in the mouth to restore, or remineralise the decayed spot on the tooth. The pH level in the mouth is lower after eating. It is during this time that fluoride is able to reduce the activity of the mutans streptococci. Fluoride is found in many tooth cleaners as well as being applied to the teeth by the dentist at regular visits.

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There are many toothpastes that promise better results in cleaning tooth surfaces as well as helping to control plaque growth and tartar control. The cleaning power of a toothpaste depends on its ability to remove stains from the surface of the tooth. Toothpastes contain gentle abrasives to help clean tooth surfaces. Most toothpastes contain fluoride. Some use stannous fluoride while others use sodium fluoride or sodium monofluoroshosphate. Tartar control toothpastes contain pyrophosphates to slow the build-up of tartar above the gumline. The most important factors to reduce the build-up of plaque on tooth surfaces is regular brushing, twice a day and flossing to remove debris that is between the teeth.

Measures of Hardness

There are many different aspects of materials which could be considered as a measure of hardness. Hardness can mean resistance to scratching, indentation, bending, breaking, abrasion, cleavage, or fracture. It is easy to confuse durability or toughness with hardness. A very simple example is to consider a glass ball and a rubber ball. Glass is harder than rubber, but rubber is more durable. Try bouncing both on a hard floor, the glass ball will shatter, whereas the rubber ball will bounce. The aspect of hardness which is measured by Moh's test is the scratchability of a mineral.

Moh's Hardness Scale

Moh	Mineral	
10	Diamond	Hardest of all minerals
9	Corundum	It scratches Topaz
8	Topaz	Harder than any common mineral
7	Quartz	Hardest common mineral It scratches steel and glass easily
6	Feldspar	Steel knife does not scratch it easily scratches glass
5	Apatite	Steel knife scratches it
4	Fluorspar	Steel knife scratches it easily
3	Calcite	Copper penny scratches it
2	Gypsum	Fingernail scratches it
1	Talc	Fingernail scratches it easily

Tooth enamel rates 5 on the Moh scale.

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In 1822, Friedrich Moh, a German mineralogist devised a crude but practical method of comparing hardness or scratch resistance of minerals. It has become universally known as Moh's scale.
It should more accurately be called a table, because it is not to scale, that is the numbers allocated to different minerals are not proportional to their actual scratch resistance, so that the scale is really an ordered list.
Moh took ten well known, easily available minerals, and arranged them in order of their "scratch hardness". If a specimen to be tested can be scratched by a known mineral from the list, it is softer than that mineral. If it in turn will scratch another known mineral, it is harder than that mineral. This gives a very quick and easy field test for hardness. As such is it very useful for mineralogists. It is too destructive to be commonly used in gemmology, but is available, and can be valuable on rough gemstones.

Toothpaste

Ingredients

A modern toothpaste has much more ingredients than those some years ago. New toothpaste ingredients have been introduced in order to provide effective protection against various dental conditions.
The most common active ingredients in toothpastes are :

1. Fluoride

This is the most popular active ingredient in toothpaste due to its proved ability to prevent cavities. Fluoride incorporates itself into tooth enamel making your teeth more resistant to acids produced by plaque bacteria, as well as acids found in fruit juices, soda (both regular and diet) and certain foods.
Most toothpaste brands use ***Sodium fluoride*** (NaF); some brands use ***Sodium Monofluorophosphate*** - *SMFP* (Na_2PO_3F). The concentration of fluoride in a toothpaste for adults is 1000 to 1450 ppm max.

2. Antimicrobial agents

These fight the bacteria of dental plaque. There are two kinds of antibacterial agents used as ingredients of toothpastes :

- *bactericidal* agents as ***Triclosan*** that kill bacteria. Triclosan induces damage and lesions to the cell wall of bacteria resulting in bacteriolysis (death of the cell).
- *bacteriostatic* agents as ***Zinc*** (Zinc chloride or Zinc citrate) that stop the growth of dental plaque bacteria by inhibiting their metabolism.

The combination of a bacteriostatic with a bactericidal agent as toothpaste ingredients is the most effective one to fight dental plaque and gum disease.

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3. Surfactants (detergents) and Foaming agents

These help to carry away debris from the mouth and between the teeth. Foam keeps the toothpaste in our mouths, preventing it from dribbling out as we brush. Common foaming ingredients in toothpastes are *Sodium Lauryl Sulfate (SLS) and ammonium lauryl sulfate*. Unfortunately, SLS and other detergents have been linked to the promotion of canker sores (mouth ulcers) in susceptible individuals. The presence of bad-tasting detergents requires the use of strong flavorings to mask the bad taste.

4. Anti-tartar agents as *Tetrasodium Pyrophosphate* (TSPP).

Pyrophosphates are water-softening agents that remove calcium and magnesium from the saliva, so they can't deposit on teeth creating tartar (calcified plaque). Pyrophosphate does not remove tartar, it merely helps prevent its formation.

5. De-sensitising agents to relieve tooth sensitivity.

Strontium chloride works by blocking the tiny crevices (microtubules) that enable cold and heat sensations to reach the tooth's nerve. *Potassium citrate* and *Potassium nitrate* work in a different way by blocking the mechanism of pain transmission between nerve cells.

6. Abrasives

Abrasives give toothpaste its cleaning power. They remove stains and plaque, as well as polish teeth. Toothpaste should be abrasive enough to remove plaque and stains, but not abrasive enough to damage tooth enamel. Unfortunately, some toothpastes are too abrasive, and do damage tooth enamel. This leads to tooth sensitivity. Damaged tooth enamel also causes yellowing as the thinned enamel reveals the yellowish dentin layer below. Calcium phosphate (chalk) and alumina were used as the abrasive base of tooth pastes but they had the disadvantage of reacting with other chemical ingredients. Today the common abrasives are *Silicon Dioxide* (silica) and *Titanium Dioxide*. Hydrated silica is a transparent abrasive used not only in white opaque tooth pastes, but in gel toothpastes as well.

Baking Soda (Sodium bicarbonate) is a mild abrasive. It has a mild whitening action and helps to keep an alkaline environment (not friendly for dental plaque bacteria) in the mouth.

7. Teeth Whitening agents

The whitening toothpastes, except of the mechanical whitening action of toothpaste abrasives, use extra whitening ingredients as the *Hydrogen Peroxide* or Sodium carbonate peroxide that breaks down into sodium carbonate (washing soda) and hydrogen peroxide.

8. Flavouring.

Toothpastes come in a variety of flavours, most often being some variation on mint. These are added to improve the taste of toothpaste. You may have noticed that toothpastes often have very strong flavouring. This is necessary to cover up the horrid taste of most detergents, especially SLS.

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9. Humectants

Humectants give toothpaste its texture as well as retain moisture so that your toothpaste does not dry out. Glycerin, sorbitol, and water are common humectants. Xylitol is an uncommon, but superior humectant, which also boosts fluoride's cavity-fighting power.

10. Thickeners

Thickeners also help to create the texture of toothpaste and determine how 'thick' your toothpaste is. Carrageenan, cellulose gum, and xanthan gum are common thickening agents.

11. Preservatives

Preservatives prevent the growth of micro-organisms in toothpaste. This eliminates the need to refrigerate toothpaste. Common preservatives include sodium benzoate, methyl paraben, and ethyl paraben.

12. Sweetener

Sweeteners also improve the taste of toothpaste. Most toothpaste sweeteners are artificial and contribute very little to cavity formation. Saccharin is a common toothpaste sweetener.

13. Colouring Agents

Some toothpastes would look down right disgusting if it were not for colouring agents. Colouring agents provide toothpaste with pleasing colours. Artificial dyes are used to make red, green, and blue toothpastes. Titanium dioxide is used to make some toothpastes white.

14. Additional ingredients

Enzymes, vitamins, herbs, calcium, mouthwash are often included in the formulas. Other non active ingredients in toothpaste are water softeners .

Potentially harmful ingredients in toothpaste

Sodium Fluoride: The main ingredient in toothpaste and rat poison

Many people are probably aware that most toothpaste and many mouth rinses contain fluoride because that's what dentists have recommended for years to prevent cavities. But did you know that most popular toothpastes contain enough fluoride to kill a small child within 2 to 4 hours?

In children and youth, minimal ingestion of sodium fluoride causes salivation, nausea, vomiting, epigastric pain, and diarrhoea. Large doses of the carcinogen may cause paralysis, muscular weakness and clonic convulsions, followed by respiratory and cardiac failure.

It’s no wonder that fluoride can cause death in humans! In addition to being one of the main ingredients in toothpaste as well as rat and cockroach poisons, sodium fluoride is also a key component in anaesthetic, hypnotic, and psychiatric drugs and SARIN NERVE GAS!

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Fluorides have been used throughout history to alter the behaviour and mood of human beings. It is a little known fact that fluoride compounds were added to the drinking water of prisoners to keep them quiet and to hamper non-compliance with authority, both in Nazi prison camps during World War II and in the Soviet gulags in Siberia.
Surprisingly, fluoride has NEVER been approved by the Food and Drug Administration (FDA) in the USA. Additionally, a 1990 study stated that fluoride has been shown to NOT reduce cavities and scientists are now linking fluoride to dental deformity, arthritis, allergic reactions and about 10,000 unnecessary deaths each year

Are you eating crude oil for breakfast?

There are artificial dyes/colourings often found in familiar toothpaste brands and a wide variety of other products. Recent studies indicate that FD & C Blue Dyes 1 & 2 can trigger a wide number of behavioural, learning, and health problems. FD&C colour dyes may also cause potentially severe allergic reactions, asthma attacks, headaches, nausea, fatigue, nervousness, lack of concentration, and cancer. Using FD & C Blue Dyes 1 & 2 is just like ingesting crude oil as it too, is synthesized from petroleum. These dyes were originally made from coal tar oil, which is a black, sticky tar by-product of steel making and petroleum distillation, and is a source of numerous complex chemicals. Through repeated human exposure, some of these isolated coal tar components were classified as active carcinogens, ultimately leading to US government regulations and restrictions. Nowadays, coal tar dyes are synthetically engineered rather than extracted from actual coal tar, thereby greatly reducing the possibility of being contaminated with carcinogenic residuals from the coal itself. However, the dyes still contain carcinogenic properties. Over several decades of use, some of these synthetic dyes have come under greater scientific and government scrutiny due to their carcinogenic and mutagenic activity. Because of this, they are still referred to in the industry as - coal tar dyes - according to the US FDA. Even if toothpaste is never swallowed, these dyes can be absorbed within seconds through the skin on the lips, or through the mucous membrane in the mouth. According to the Physician's Desk Reference, the mucosal lining inside of the mouth has an absorption efficiency of over 90 percent. Because of this, these carcinogens get into your blood, your brain, and your cells in no time at all – especially when you consider most people use dental care products 2 to 3 times a day.

Sodium Lauryl Sulfate (SLS): The most dangerous ingredient

Perhaps the most dangerous ingredient in personal-care products is Sodium Lauryl Sulfate (SLS). Because SLS has a foaming property, it is added to toothpastes in order to generate foam and give the impression that the toothpaste is working. However, SLS has been found to be quite corrosive and harmful to skin tissue says a report by the American College of Toxicity.
In the cleaning industry, SLS is used in products such as garage floor cleaners, engine degreasers and car wash soaps. Elsewhere, SLS is used for clinical testing as a primary skin irritant. Laboratories use it to irritate skin on

test animals and humans so that they may then test healing agents to see how effective they are on the irritated skin.

The journal of the American College of Toxicology reports that SLS can penetrate and be retained in the eye, brain, heart, and liver with potentially harmful long-term effects. Also found in most shampoos including "no tears" baby shampoos, SLS can keep children's eyes from developing properly, can cause cataracts in adults, can retard healing, and can impair hair growth.

Triclosan: A pesticide found in many types of toothpaste

Triclosan, a chemical used for its antibacterial properties, is an ingredient found in many detergents and toothpastes. However, the formulation and structure of this ingredient are similar to some of the most toxic chemicals on earth. While the companies that manufacture products containing triclosan claim that it is safe, the United States Environmental Protection Agency (EPA) has registered it as a dangerous pesticide. The EPA gives triclosan high scores both as a human health risk and as an environmental risk.

Triclosan is a chlorophenol, which is a class of chemicals that is suspected of causing cancer in humans. Externally, phenol can cause a variety of skin irritations, but since it can temporarily deactivate sensory nerve endings, contact with it may cause little or no pain. Taken internally, even in small amounts, phenol can lead to cold sweats, circulatory collapse, convulsions, coma, and death. Additionally, chlorinated hydrocarbon pesticides can be stored in body fat, sometimes accumulating to toxic levels. Long term exposure to repeated use of many pesticide products can damage the liver, kidneys, heart and lungs, suppress the immune system, and cause hormonal disruption, paralysis, sterility and brain haemorrhages.

Hydrated Silica: A whitener that damages tooth enamel

Hydrated silica, which is primarily used as an abrasive in toothpaste, is made from a crystallized compound found in quartz, sand, and flint. Tooth enamel re-mineralizes daily from the supply of ionic calcium and phosphorus in the saliva. Scratching the surface of the tooth with an abrasive such as hydrated silica harms the enamel and prevents re-mineralization, much like using sand to clean glass. Severe wear could eventually occur. Products containing the ingredients silica and cellulose, in particular, should be avoided when gum disease, tooth decay, sensitivity and receding gums are present. While these ingredients can remove tartar and make teeth whiter in appearance, they also may do harm to dental health by altering the acidic balance of the mouth, gums and tongue.

Other Problems With Toothpaste

Teeth become sensitive when tooth enamel is worn away, exposing the underlying permeable tooth layer, known as dentin. Many toothpastes are too abrasive and actually strip away tooth enamel which never grows back. In fact, the first thing dentists will do for patients suffering from sensitive teeth is to have them switch to a

less abrasive toothpaste. A toothpaste's abrasiveness is measured by its Relative Dentin Abrasivity (RDA). The table above shows the RDA of some common toothpastes.

Toothpaste	Relative Dentin Abrasivity
Colgate	68
Mentadent	103
Crest	106
Colaget Platinum	106
Aquafesh Whiteninig	113
AIM	185
Close-Up	218

Whitening Toothpastes

Contrary to what many people think, whitening toothpastes do not increase the whiteness of the underlying tooth. What they do is remove stains so that the underlying whiteness of the tooth becomes more apparent. Think of these toothpastes as "carwashes" for your teeth. In the same way that a good car washing removes the dirt and grime on your car making it sparkle, whitening toothpastes remove stains and plaque from your teeth, making your smile shine.

It is important to note that while effective in removing stains, some brands of whitening toothpastes can destroy tooth enamel in the process. Due to their harsh abrasives, these toothpastes, over time, may strip tooth enamel, making teeth appear yellow and causing teeth to become sensitive to cold or hot foods and liquids, sweets, baking soda, and highly salted foods.

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