From hard-boiled eggs to bog bodies
An investigation into the effects of tannin and mild acid

When an animal or plant dies and its remains fall into a peat bog, it is usually remarkably well preserved, being naturally mummified. In peat bogs and marshes, bodies (and part of bodies) up to 6,000 years old have been found in varying states of preservation. Animals have been found with preserved skin, organs, and hair. Preservation of internal organs may depend on the prevailing temperatures at the time the body fell into the bog. Tollund Man, *photo below*, is one of the best preserved examples. Even pollen, spores and macro- and microscopic remains of fungi and algae have been preserved.

4th century BCE Tollund Man
preserved in a peat bog in Denmark.
Tollundmanden_i_Silkeborgmuseet.JPG Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation license

Why is preservation so good?
Peat bog water contains humic acid and tannin which is produced from rotting vegetation. Humic acid is weak and is not a single acid but a mix of varying components depending on vegetation types. Tannin is the chemical which is released by plants, for example the tea plant, and it colours stream water brown. Tannin is also the agent in tea which gives it its brown colour and refreshingly astringent flavour. People have used tannin for staining and for tanning leather since ancient times. Bog water is also cold and low in oxygen and this restricts bacterial decomposition. While the skin is well-preserved, the bones are generally not, due to the dissolution of the calcium phosphate of bone by the peat's acidity. This is why animals are not preserved in peat bogs as fossils, i.e. older than 10,000 years, because shells and bone are not preserved and the soft tissue eventually decays. However, scientists claim that the brain of a 133 million year-old dinosaur similar to *Iguanadon*, has been preserved by mineralisation in bog conditions.

This activity takes three days before the results are known. Tell the pupils they are going to see the results of tanning an egg and then to observe what happens to the egg when it is placed in mild acid.

Day 1
- Use three white-shelled eggs (A, B and C) which are at room temperature, (light brown eggs can be used but the colour change is less obvious).
- Boil egg A for seven minutes, allow it to cool and put it in the fridge. This will be your 'control' egg which will be used as a reference for any changes that occur to the others.
- Create a really strong brew of tea by boiling leaves or tea bags for ten minutes. Sieve out the leaves or remove the tea bags and allow the liquid to cool. This is tannin-rich water.
- Place the two remaining white eggs (B and C) in the tannin solution and raise to boiling. Boil for seven minutes and allow them to cool.
- Compare eggs B and C to your control egg A and record any changes caused by the tannin.
  The white egg shells have been stained brown.
- Vinegar contains mild acid and this will be used as an alternative to humic acid in the real world. (Vinegar is used as a preservative for pickling.)
- Place one of the tannin-coloured eggs (C) into the vinegar and leave for two days.

Fig 1: Tanned egg C in vinegar Day 1

Fig 2: Effervescence appeared in the jar, Day 2

Day 2: Observe egg C in the vinegar. Record your observations.
As Figure 2 above shows, a reaction occurred between the calcium carbonate of the egg shell and the acid of the vinegar (acetic acid CH_3COOH and water)

Day 3: Remove egg C from the vinegar. Now compare egg C, first to the control egg A, and secondly to the tannin-coloured egg B. What is the same and what is different?

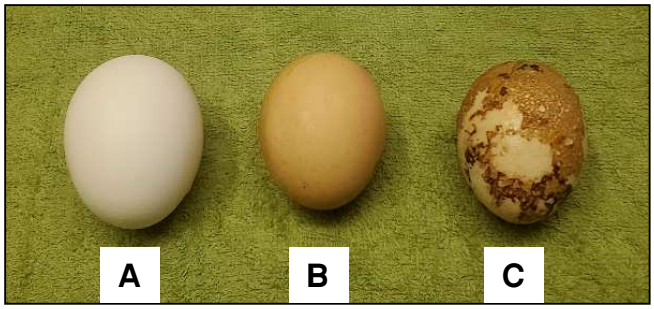

Figure 3: The three eggs
A control, B tanned, C immersed in vinegar

The three eggs were now quite different., (Figure 3) Egg B showed the result of being boiled in a tannin solution which stained the shell brown.
When the brown residue was removed, the shell from egg C was seen to have been completely dissolved by the vinegar. However, it was noted that the membrane between the shell and the white of the egg remained intact (Figure 4). This membrane had a rubbery texture.

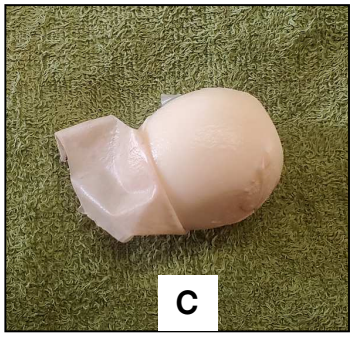

Fig 4: membrane partially removed

Why do the bodies in the bogs have well preserved skin and internal organs but their bones are damaged?
The bodies have well-preserved skin and internal organs, because the bog water is cold and low in oxygen and this restricts bacterial decomposition. The bones are damaged or destroyed because the calcium phosphate of bone is dissolved by the peat's acidity.

The back up

Title: From hard-boiled eggs to bog bodies

Subtitle: An investigation into the effects of tannin and mild acid

Topic: This activity simulates the effects of preservation in a peat bog

Age range of pupils: 9 - 14 years

Time needed to complete activity: About 20 minutes on day 1 and then a further 10 minutes for analysis on day 3

Pupil learning outcomes: Pupils can:
- describe the conditions that exist in a peat bog;
- state how those conditions can lead to exceptional preservation of animals and plants;
- follow a plan for an activity using white-shelled eggs to demonstrate the action of tannin and of a weak acid;
- use one hard-boiled egg as a 'control' for comparison later;
- make a solution rich in tannin;
- observe the results of boiling two eggs in the strong tannin solution;
- realise that vinegar is a weak acid and can be used as a substitute for the humic acid of peat bogs;
- observe the results of leaving one of the tanned eggs in vinegar for three days;
- compare and contrast their three eggs at the end of the activity;
- relate their results to real examples of preservation of animals in peat bogs.

Context:
Exceptional preservation of animals and plants takes place when they have fallen into peat bogs within the last 10,000 years. This activity allows pupils to investigate the effects of tannin and a mild acid in this process.

Following up the activity:
Using the internet, research examples of other methods of exceptional preservation, e.g. being frozen in ice, trapped in amber . . .

Underlying principles:
- In a peat bog, acidic water, low temperatures, and a lack of oxygen can preserve animals or plants which fall into it. While skin is well-preserved, bones are generally not, due to the dissolution of the calcium phosphate of bone by the peat's acidity. The acidic conditions of these bogs allow for the preservation of materials such as skin, hair, nails, wool and leather which all contain the protein keratin.
- Animals are not preserved in peat bogs as fossils, i.e. older than 10,000 years, because shells and bone are not preserved and the soft tissue eventually decays.
- Scientists claim that some soft tissue may be preserved by mineralisation in bog conditions.
- Tannins are astringent, polyphenolic biomolecules that bind to and precipitate proteins and various other organic compounds including amino acids and alkaloids.

- Tannin compounds are widely distributed in many species of plants (e.g. tea), where they play a role in protection from predation (acting as pesticides) and might help in regulating plant growth.

Thinking skill development:
Construction is involved in planning and carrying out the activity. Discussion of the outcomes involves metacognition. Cognitive conflict may occur when the results of the mild acid are recorded. Relating the effects of tannin and mild acid on hard-boiled eggs to the real process of preservation in peat bogs involves bridging.

Resource list:
- access to a fridge
- three white-shelled eggs
- access to a hot plate or cooker
- tea leaves or tea bags
- vinegar
- containers (beakers or jars)

Useful links:
How could I become fossilised?
https://www.earthlearningidea.com/PDF/50_How_could_I_be_fossilised.pdf
Tollund Man
https://www.museumsilkeborg.dk/?AreaID=18

Source:
Developed with permission by Elizabeth Devon of the ELI Team from an idea from 'The Australian Earth Science Education' https://ausearthed.com.au/wa/