



Gladiolus sp

Image courtesy of greenhem; image source: Flickr

Smell like Julius Caesar: recreating ancient perfumes in the laboratory

Even everyday scents have the power to take us back in time, awakening half-forgotten memories. With **Gianluca Farusi's** help, you can take your students 2000 years into the past, recreating and testing Julius Caesar's perfume.

Dictator of the Roman Republic until 44 BC, he invaded Britain and was the first Roman general to cross the River Rhine. He was the lover of Queen Cleopatra, and the month of July is named after him. Julius Caesar is famous for many things – but probably not for his choice of perfume.

Perfumes, however, were an important part of life in ancient Rome: in the form of incense for religious

ceremonies; in public areas to mask foul smells – Pliny the Elder (23-79 AD) records rose-scented water being sprinkled in theatres; and for moisturising the skin.

Today, most commercial perfumes are alcohol-based, but Roman perfumes for the skin took the form of *unguents*, or greasy ointments. An unguent consisted of a liquid base and a scented essence, and could also contain preservatives such as salt, and

fixatives such as gums or resins – to stabilise the volatile components of the perfume.

One of the most frequent liquid bases used was omphacium, an oil extracted from green olives or unripe grapes. To obtain scented essences, the Romans used many methods to extract scent from flowers, seeds, leaves, bark and other fragrant plant material. Many of these methods are still used today.



REVIEW

- ✓ Biology
- ✓ Chemistry
- ✓ History
- ✓ Ages 14+

This article provides an opportunity to link history with practical chemistry. Learners will be swept away into Roman times, to learn why our ancestors extracted scents from plant material and turned them in a form that could be applied onto the skin. It is highly beneficial for students to connect their current scientific knowledge to its roots. Following the path of our scientific forefathers helps us to understand the development of the scientific process as well as how organic substances have been developed into useful materials.

The activity could be used in biology (plant histology; physiology of smell), chemistry (organic chemistry; molecular chemistry) and history (the Romans; the his-

tory of chemistry) lessons. It could also be used as the basis for a discussion on the use of natural as opposed to man-made substances in beauty products. How sustainable is the use of natural products for large-scale production?

Information is provided in the article about different methods of extracting scents. As an extension of the project, the students could investigate these methods further – both on the Internet and in the laboratory. Teachers could also extend the activity and bring the scents closer to home by using local plant material to create perfumes: reliving their country's past through plant life. Local universities are usually an excellent source of information on native species. When collecting plant material, attention should be paid to local safety measures, and endangered species should be avoided.

Angela Charles, Malta

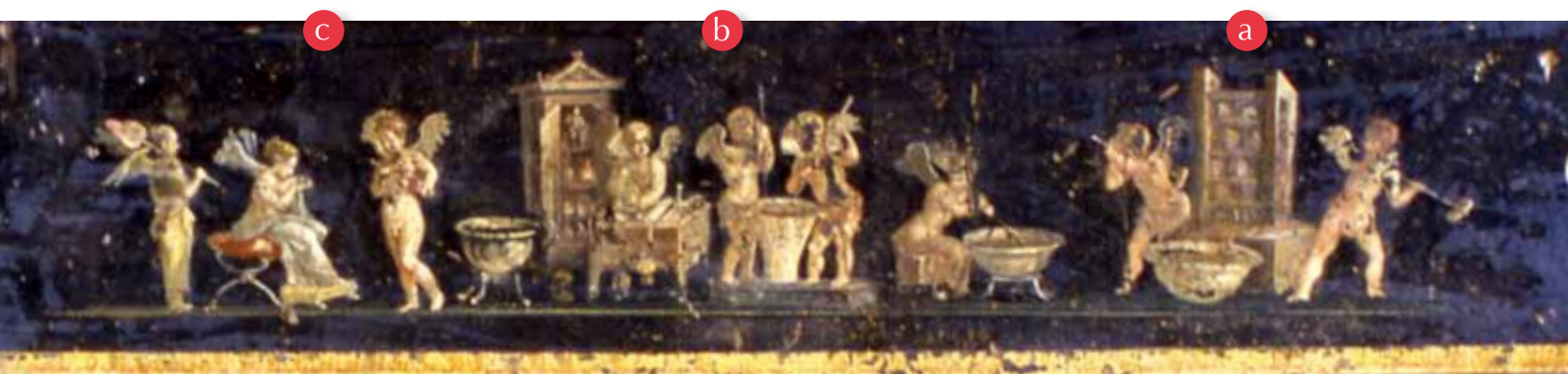


Image courtesy of the Soprintendenza Speciale per i Beni Archeologici di Napoli e Pompei

- **Enfleurage:** petals were placed on suet (the hard fat from around the kidneys) and replaced periodically until the fat was saturated with fragrance.
- **Steeping in oil:** the scented roots or leaves were crushed, placed in a loose-textured linen bag and left to soak in oil at a moderate temperature.
- **Steeping in oil and water:** a method common in warm areas such as Egypt. The scented roots or leaves were placed in earthenware jars and covered in a 50% v/v mixture of rainwater and oil. The jars were then buried up to the neck in the hot sand and left open for

A decoration of the House of the Vetii in Pompeii, Italy, is extraordinary evidence of how Roman perfumes were prepared and sold. From right to left:

- a) Two putti hammer the wedges of a press, to squeeze the oil out of unripe olives. On their left, a psyche stirs a mixture in a cauldron over a fire (probably steeping plants in warm oil).
- b) Two putti stir the contents of a deep vessel, which may have to be added to the olive oil. On their left, another putto holds a phial and has both a papyrus scroll and a pair of scales. Behind the putto is a cupboard containing phials and a statue of a deity.
- c) The story finishes with the sale: the purchaser tests the perfume on her wrist. Behind her is a slave girl and a putto stands in front of her holding a phial and a spatula

one to five days. The essential oils released by the plant material mixed with the oil floating on the water. Once the water had evaporated, the fragrant oil was strained off.

- **Pressing:** to obtain citrus or liquid

base oils, citrus skins or olives, for example, were placed in linen bags and pressed.

- **Boiling and squeezing through cloth:** to extract resins and oily substances from bark.
- An archaeological dig in Pyrgos on

Image courtesy of Gianluca Farusi



The ingredients of the most common and most ancient perfumes, according to Pliny.

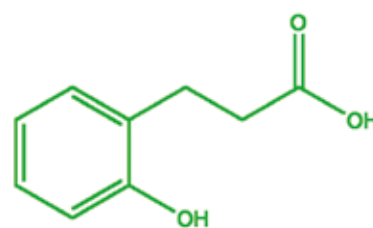
A: Calamus (*Acorus calamus*)

B: Pomegranate (*Punica granatum*)

C: Myrtle (*Myrtus communis*)

D: Mastic (*Pistacia lentiscus*)

E: Cypress (*Cupressus sempervirens*)



3-(2-hydroxyphenyl)propanoic acid

Image courtesy of Gianluca Farusi

fragment of poetry attributed to Caesar ('*Corpusque suavi telino unguimus*', 'We anoint the body with fragrant telinine ointment'), it is thought to be the unguent telinum.

However, finding the recipe is no easy task. For one thing, before the introduction of Linnaean taxonomy, there was no consistent naming convention. Thus, for example, the name 'cyperus' may refer to the many species of sedge (*Cyperus spp*), to gladioli (*Gladiolus spp*), to lemongrass (*Cymbopogon schoenanthus*) or even to privet (*Ligustrum spp*). Moreover, perfume recipes – then as now – were fiercely guarded by their manufacturers, so even though contemporary writers sometimes recorded the ingredients of a perfume, they seldom mentioned the proportions.

In the case of telinum, we were lucky: in his *Naturalis Historia* (*Natural History*), Pliny the Elder records the ingredients (left) and Pedanius Dioscorides (c. 40-90 AD) records somewhat different ingredients but does mention the proportions in his *De Materia Medica* (*On Medical Materials*).

For our recreation of telinum, therefore, we carried out a series of trials

Cyprus even showed that steam distillation was practised in 2000 BC^{w1}.

How do we know so much about Roman perfumery? Partly, of course, from contemporary written records – but science can also help. Modern archaeological analyses of perfume traces in ancient pots can help to identify the perfume, the way it was prepared and even what it was used for. By combining chemical data with information from contemporary authors, we can reproduce some of the perfumes of the ancient world.

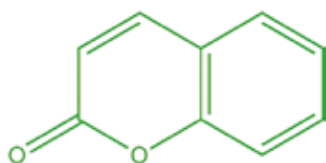
...*Ratio faciendi duplex, succus et corpus: ille olei generibus fere constat, hoc odorum.... E vilissimis quidem hodieque est – ob id creditum et id e vetustissimis esse – quod constat oleo myrteo, calamo, cupresso, cypro, lentisco, mali granati cortice.... Telinum fit ex oleo recenti, cypro, calamo, meliloto, faeno Graeco, melle, maro, amaraco. hoc multo erat celeberrimum Menandri poetae comici aetate.*

Unguent comprise two elements: the juices and the solid parts. The former generally consist of various kinds of oils, the latter of odoriferous substances.... Among the most common unguents today, and for that reason assumed to be the most ancient, is that composed of oil of myrtle, calamus, cypress, cyprus, mastic, and pomegranate rind.... Telinum is made of fresh olive oil, cyperus, calamus, yellow melilot, fenugreek, honey, marum, and sweet marjoram. It was the most fashionable perfume in the time of the comic poet Menander [around 300 BC].

Pliny the Elder, *Naturalis Historia* (*Natural History*), book XIII, chapter 7, paragraph 9

As part of a larger interdisciplinary chemistry project (see box), my students (aged 14-15) and I decided to do just this: recreate the favourite perfume of Julius Caesar. But how did we even know what it was? Thanks to a

Image courtesy of Gianluca Farusi



2H-chromen-2-one

based on these two ancient recipes, to determine the blend we preferred. How should we interpret 'cyperus', though? We prepared two versions: one with lemongrass oil and one with violet oil (*Viola odorata*) – because the roots of both gladioli and *Cyperus* species smell like violets. Finally, because marum (*Teucrium marum*) is thought to be carcinogenic, we decided to replace it with catmint (*Nepeta cataria*), which smells similar. If not entirely historically accurate, our perfume should at least smell like Caesar's.

Materials and proportions

It is not clear from the historical sources whether dried or fresh materials were used. We used dried materials, as they contain more scent per gram and are easily obtainable: try a chemist or herbalist's shop.

- 100 g omphacium – either use

Fresh green olives



Image courtesy of Gianluca Farusi

shop-bought olive oil (choose an odourless one) or if you have access to fresh green olives, pick a carrier bag full of them in August, to prepare your own omphacium (see below).

- 56 g fenugreek seeds (*Trigonella foenum graecum*)
- 11 g calamus roots (*Acorus calamus*)
- 5 g dried yellow melilot flower heads (*Melilotus officinalis*)

Ligustrum sp



Image courtesy of Jyintirel; image source: Flickr

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ACORUS CALAMUS L.



NEPETA CATARIA L.



ORIGANUM MAJORANA L.



MELILOTUS OFFICINALIS L.



TRIGONELLA FOENUM GRAECUM L.

The ingredients of our telinum

Images courtesy of Gianluca Farusi

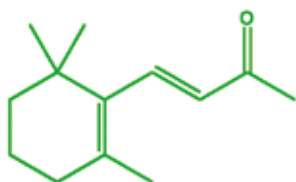


1 Grinding the olives



2 Transferring the ground olives to the tea towel

- 2 g dried catmint leaves (*Nepeta cataria*)
- 3 g dried sweet marjoram leaves (*Origanum majorana*)
- 5-10 drops violet oil or lemongrass oil (depending on the strength of the oil – be careful not to let it dominate the perfume)
- Honey



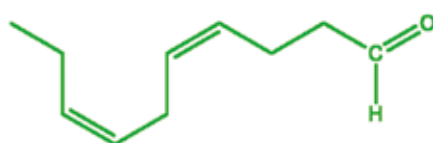
(E)-4-(2,6,6-trimethylcyclohex-1-en-1-yl)but-3-en-2-one

Image courtesy of Gianluca Farusi



Image courtesy of Gianluca Farusi

The herb and oil mixture



(4Z,7Z)-deca-4,7-dienal

Image courtesy of Gianluca Farusi

Preparation

To prepare omphacium for our project, I picked the green olives, ground them in the kitchen mixer, collected the mixture in a tea towel and squeezed the oil into a bowl. I then filtered the oil three times using filter paper, and centrifuged it twice for 5 min each time.

Alternatively, use shop-bought olive oil.

I divided the class into three groups; each group prepared a different historical perfume (instructions for preparing cyprinum and rhodinon can be downloaded from the *Science in School* website^{w2}). At the end of the activity, each student had a small sample of perfume to take home.

1. Chop the herbs and spices, and add them to 100 g omphacium.
2. Place the mixture in the oven at 40 °C, and stir several times per day for three days.
3. Strain the scented oil.
4. Add 10% w/w of honey.
5. Add the violet oil.

The chemistry of scent

Once we had appreciated the perfume of ancient Rome, we returned to the 21st century to investigate which molecules produced the fragrance. Table 1, showing the main aromatic chemicals in our telinum (the structures of some of which illustrate this article) is available for download

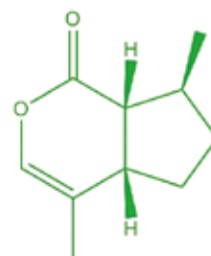


Image courtesy of Gianluca Farusi

(4aS,7S,7aR)-4,7-dimethyl-5,6,7,7a-tetrahydrocyclopenta[c]pyran-1(4aH)-one

from the *Science in School* website^{w2}.

With older students, this activity could be used to investigate organic chemistry in some detail. With my 14- to 15-year-old students, I concentrated on the basics of the chemistry of smell. For example, I asked them:

1. Can you see similarities between the structures of different fragrant chemicals in the perfume?
2. Why is oil effective for extracting these chemicals from plant material?
3. Could we replace oil with something else?
4. Why, once extracted, do the



3 Squeezing the oil through the colander



4 The collected oil



5 Filtering the omphacium

- fragrant molecules leave the oil and enter the air, where you can smell them?
5. Rub a drop of telinum onto the back of your hand and smell it from time to time. What do you expect to happen? Does the fragrance change with time? Can you explain what you observe?

Safety note: check your national or local safety guidelines to see if you are allowed to use lab-prepared materials on the skin.

6. Why did ancient perfumers add honey? (Answer: the polysaccharides it contains help to hold the volatile substances in the perfume.)

By the end of the activity, together with some associated experiments, the students had established that:

1. A substance has to be in the gaseous state to be smelled. At first, many students disagreed because they thought that metals had a distinctive smell. They tested this by wearing gloves to

lift a copper coin, then smelling it without touching it to their nose. They then did the same without gloves (ideally with sweaty fingers) – and realised that the ‘metallic smell’ was a volatile substance formed on their skin.

2. The effusion of a substance is in inverse relation to its molar mass (Graham’s law).
3. Molecules with the same chemical group have a similar smell. Students prepared different esters in the lab – with the same chemical group and similar fruity smells.



Studying chemistry with Pliny the Elder

This activity is part of a larger interdisciplinary project, developed together with my 14- to 15-year old students, to meet the curriculum requirements at that age. We began each session (1-4 two-hour lessons) by discussing a passage from Pliny the Elder’s *Naturalis Historia*, then worked out how to recreate in the laboratory either the event described in the text or something similar. In this way, the students began in the same pre-scientific state as Pliny and, through laboratory work and discussion, gained modern scientific knowledge on each of the topics. The process motivated even the most unenthusiastic students.

Other activities in the project include extracting indigo from woad, preparing glass tesserae with boric acid, simulating the luminescence of the shellfish *Pholas dactylus*, and preparing iron-gall ink (Farusi, 2007).

BACKGROUND

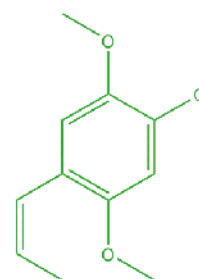


Image courtesy of Gianluca Farusi

(Z)-1,2,4-trimethoxy-5-(prop-1-enyl)benzene

4. The chemical structure is not the only determinant of smell. Students extracted essences of caraway and peppermint using steam distillation and found that they smelled very different. They were amazed when I told them that the structure of the main aromatic molecule is the same. We did not discuss enantiomers at this

Cyperus alternifolius

stage, but the students' curiosity was aroused and they understood that there are several factors that determine scent.

Acknowledgment

The author would like to thank Graziella Zacchini of the Officina Profumo Farmaceutica Santa Maria Novella, who provided plant materials used in the project.

Reference

Farusi G (2007) Monastic ink: linking chemistry and history. *Science in School* **6**: 36-40. www.scienceinschool.org/2007/issue6/galls

Web references

w1 – See the paper 'Cinyra, Cyprus and the notes of music, of wine and perfumes' by Maria Rosaria Belgiorino, which can be downloaded from her website (www.erimiwine.net) or via the direct link: <http://tinyurl.com/65623kd>

w2 – Instructions for preparing cyprium and rhodinon, and Table 1, can be downloaded from the *Science in School* website: www.scienceinschool.org/2011/issue21/caesar#resources

Resources

The following books include information about the techniques and the plants used by the ancients in their perfumes:

Belgiorno MR (ed.) (2007) *I profumi di Afrodite e i segreti dell'olio. Scoperte archeologiche a Cipro. Catalogo della mostra* (catalogue of the exhibition 'The perfumes of Aphrodite and the secret of the oil: archaeological discoveries in Cyprus'). Rome, Italy: Gangemi. ISBN: 978-8849212235

Donato G, Seefried M (1995) *The Fragrant Past: Perfumes of Cleopatra and Julius Caesar* (catalogue of the corresponding exhibition in the Emory Museum of Art and Archaeology, Atlanta, GA, USA). Oxford, UK: Premier Book

Marketing Ltd. ISBN: 978-0963816931

Pennestrì S (1995) *Aromatica. Profumi tra sacro, profano e magico*. Selcom. ISBN: 9788886553001

The following research articles provide helpful background information:

Colombini MP et al. (2009) An Etruscan ointment from Chiusi (Tuscany, Italy): its chemical characterization. *Journal of Archaeological Science* **36**: 1488-1495. doi: 10.1016/j.jas.2009.02.011

Modugno F et al. (2008) Gas chromatographic and mass spectrometric investigations of organic residues from Roman glass unguentaria. *Journal of Chromatography* **1183**: 158-169. doi: 10.1016/j.chroma.2007.12.090

Pérez-Arantegui J (2009) Colorants and oils in Roman make-ups – an eye witness account. *Trends in Analytical Chemistry* **28**: 1019-1028. doi: 10.1016/j.trac.2009.05.006

Ribechini E et al. (2008) An integrated analytical approach for characterizing an organic residue from an archaeological glass bottle recovered in Pompeii (Naples, Italy). *Talanta* **74**: 555-561. doi: 10.1016/j.talanta.2007.06.026

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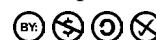
Börsch-Haubold A (2007) Small molecules make scents. *Science in School* **6**: 69-74. www.scienceinschool.org/2007/issue6/scents

Capellas M (2007) Recovering Pompeii. *Science in School* **6**: 14-19. www.scienceinschool.org/2007/issue6/pompeii

Farusi G (2006) Teaching science and humanities: an interdisciplinary approach. *Science in School* **1**: 30-33. www.scienceinschool.org/2006/issue1/francesca

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To learn how to use this code, see page 65.

