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Music to Enjoy Science Lectures By

The use of songs in the auditorium can make learning more engaging and facts easier to remember – and it ramps up the fun factor for students and teacher alike.

By Roy Goodacre

Music touches all our lives. It can conjure a memory or feeling more strongly than almost anything else. The links between music and memory are visceral and – whether reminding you of your first kiss or your first concert – last a lifetime.

Even as I write, I'm smiling as I remember the songs I listened to before going out on a Saturday night in my student days, which included "She Sells Sanctuary" by The Cult. Later in the evening I could be found dancing to Billy Idol's rendition of "Mony Mony" – I could pogo quite well back then!

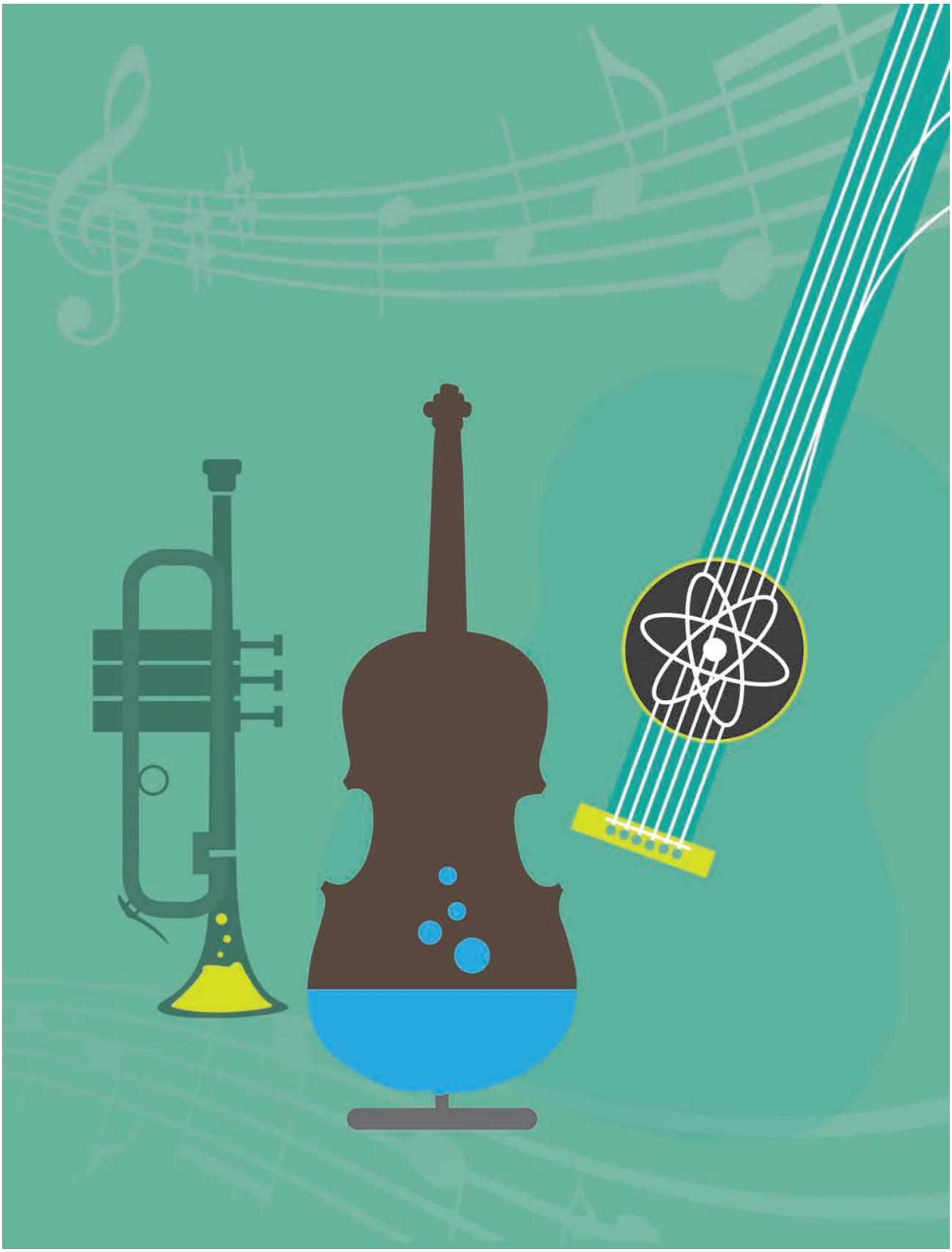
Another very strong song–memory association was formed in 1993, when my wife was pregnant with our daughter. Vanessa Williams' "Save the Best for Last" had been released the year before, and was playing constantly on Atlantic 252, a long-wave radio station we played in the car. Now, whenever I hear that song I am reminded of the birth of my daughter, and of my family becoming complete. The lyrics end with "You went and saved the best for last" – most poignant.

But music isn't just entwined with my personal life – it finds its way into my scientific memories too. One of my most striking musical associations related to science was during a visit to a chicken-processing plant at Sun Valley Foods Ltd 18 years ago. At the time, they processed 935,000 chickens per year, and I was investigating the possibilities of using infrared spectroscopy as a rapid tool to detect food spoilage; a method that we subsequently showed was indeed possible (1). I was told to wear ear defenders: whilst the machinery was below European sound limits, the music was on so loud it broke the legal limit. Now every time I hear "You Get What You Give" by the New Radicals, I see chickens floating above my head. I'm sure readers will have many similar song–memory links.

I first realized the potential for music in education during my high school exams. I used to play music from my favorite bands on my Sony Walkman (younger readers might have to look that up), which helped me cram. I remember thinking that if only the musical lyrics had contained facts, I'd have done much better…

"One of my most striking musical associations related to science was during a visit to a chicken-processing plant."

A couple of years ago, I was reminded of the power of music and memory when I heard my friend and colleague Colin Campbell (School of Chemistry, University of Edinburgh) using music in an after-dinner lecture during the annual Infrared and Raman Discussion Group Christmas meetings (also known as the Infrared and Raman Drinking Group).



Song title	*Artist*	*Science message(s)*
Raman spectroscopy		
Good Vibrations	Beach Boys	Used to remind people that Raman (and infrared) are based on molecular vibrations
The King of Rock 'n' Roll	Prefab Sprout	Summary of bond movements (sort of)
Mr Blue Sky	ELO: Electric Light Orchestra	Associates the fact that Rayleigh light scattering is wavelength dependent
Blue Eyes	Elton John	Highlights that Rayleigh light scattering is the reason that some people have blue eyes
Gold	Spandau Ballet	Highlights gold as a metal used for surface-enhanced Raman scattering (SERS)
Maxwell Silver Hammer	The Beatles	Highlights that silver is used a lot, perhaps dominates, SERS experiments
Silver Machine	Hawkwind	Another song that may be used as an alternative to highlight Ag-based SERS
God Gave Rock and Roll to You	Argent	Perhaps a more obscure one for SERS performed with silver nanoparticles.
Fluorescent Adolescent	Artic Monkeys	For biological systems the Raman signal can be affected by fluorescence
Ring of Fire	Johnny Cash	UV resonance Raman spectroscopy at 244 nm (i.e., in the deep UV) may burn and damage the sample during analysis
Applications of Raman and Infrared Spectroscopy		
Littlest Things	Lily Allen	Raman can be used to analyze individual bacterial cells – these prokaryotes really are small with dimensions in the order of 1 µm and weight about 1 pg
Do They Know it's Christmas	Band Aid	Infrared and Raman are used in food security – especially in terms of assessing food spoilage and food waste
Harvest For The World	The Christians	An alternative for the above; if the audience is (ahem) older
Art for Art's Sake or Money	10cc or Pink Floyd	Raman is used to assess the authenticity or otherwise of artwork. Here I like to highlight that a Marc Chagall painting bought in 1992 for £100,000 was tested with Raman spectroscopy and shown to be fake and thus destroyed.

Table 1. Songs I've used in undergraduate lectures, with the learning points.

"Music acts as a brain 'reset.' Most lectures are 50 minutes long, and I think lecturers sometimes forget that 50 minutes is a long time."

Within a memorable talk on surface-enhanced Raman scattering, which he was developing for the measurement of the redox potential in situ within cells (2), Colin captivated the audience by using musical quizzes. I borrowed (perhaps "stole" would be more accurate) his idea for use in undergraduate teaching, with three main reasons in mind.

The first reason is to punctuate scientific points. For example, when discussing Rayleigh light scattering I play "Mr Blue Sky" by the Electric Light Orchestra. This happy song associates the fact that light scattering is wavelength dependent. According to Lord Rayleigh, the intensity (I) of light scattering approximates to be inversely proportional to the wavelength of light to the power of 4 (i.e., $I = 1/\lambda 4$) and thus light scattering is ca. five times more effective for 400 nm (blue light) than 600 nm (red light). This can then be followed with a discussion on why certain people have blue eyes – also due

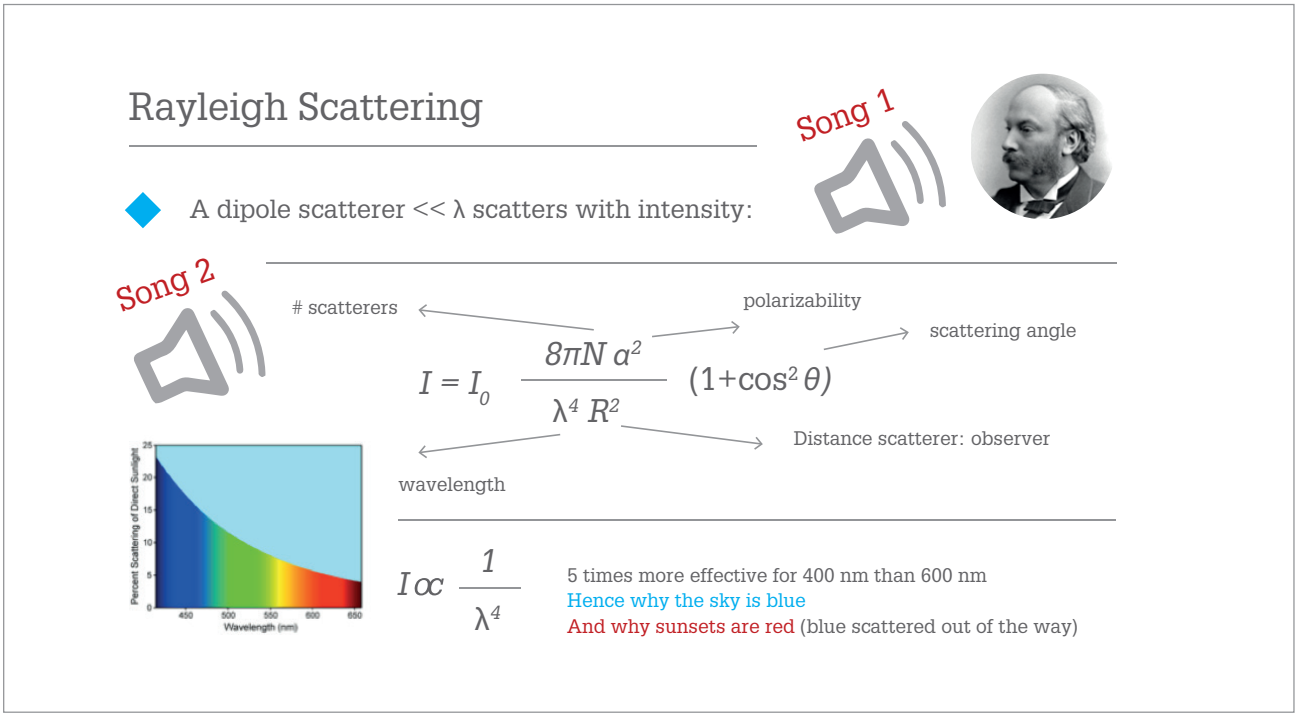
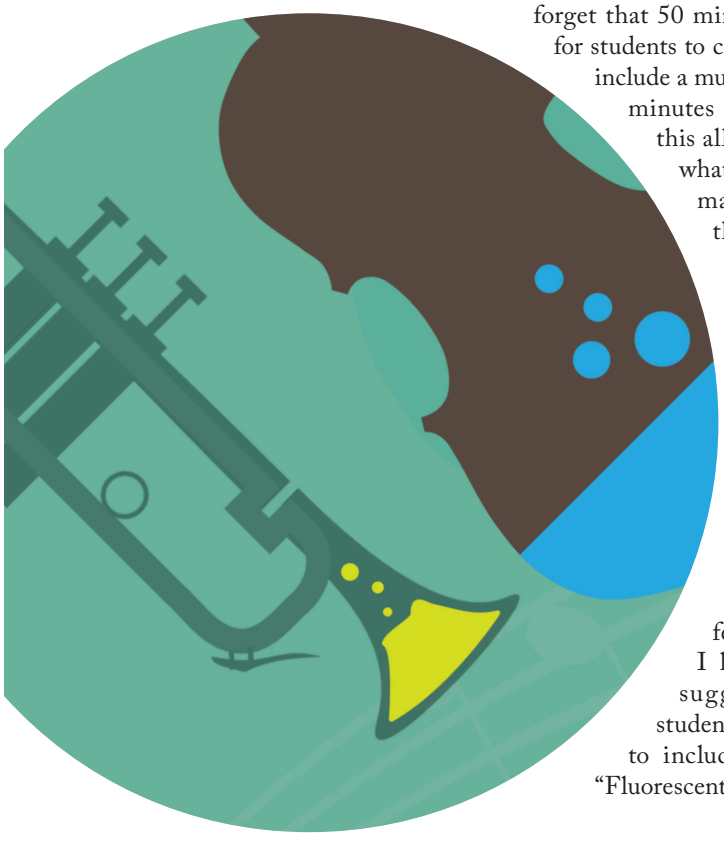


Figure 1. Slide introducing Rayleigh scattering. This highlights the Rayleigh equation and its approximation, along with explanation as to why the sky is blue, and two songs to help reinforce learning. Song 1 is "Mr Blue Sky" by the Electric Light Orchestra and Song 2 is "Blue Eyes" by Elton John. The significance of these songs is highlighted in Table 1.

Q: What aspect of the lecturer's approach to teaching best helped your learning?
Good explanations of content. The music was good as a quick break from thinking about the material and was entertaining.
The random musical snippets gave a nice break from solid lecturing while still being (albeit from my perspective, tangentially) relevant to the topic of discussion.
Engaging delivery, I liked the music :)
The musical challenges were very good! I liked learning about a technique that is used so extensively, and Roy's delivery of the content was enjoyable and funny.
He tried to make it interesting, included relevant topics to make it relatable and included random music to try and keep spirits up.
The use of music made what could have been a very dry unit entertaining.

Table 2. Highlights from feedback received after using music in undergraduate lectures.



to Rayleigh light scattering by proteins in the eye (which I accompany with "Blue Eyes" by Elton John). Table 1 highlights some songs, artists, and the science associations that I have used in lectures on Raman spectroscopy. Also included are a few songs that I have used to help people remember areas that Raman (and infrared) spectroscopy is applied within.

The second reason is that it's fun and increases student interaction. It allows the class to play name that tune, with prizes given to the first person to get the song title correct, and another for naming the right artist. (I recommend spherical chocolates – maximum accuracy when throwing to a worthy recipient!)

The third reason? Music acts as a brain "reset." Most lectures are 50 minutes long, and I think lecturers sometimes forget that 50 minutes is a long time for students to concentrate. I tend to include a music quiz about 20-25 minutes into a lecture, and this allows one to break up what may be quite dense material, lengthening the attention span of the students.

The feedback from my students has been very positive, with one saying "The use of music made what could have been a very dry unit entertaining." Table 2 contains other anonymous feedback I received. I have also received suggestions from the students of potential songs to include – which is why "Fluorescent Adolescent" by the Arctic Monkeys now features in lectures (science message: for biological systems, the Raman signal can be affected by fluorescence).

The use of music for scientific learning is not new. In 1982, Harold Baum published a delightful book entitled "The Biochemists' Songbook" (3). Music also features in research projects; there have been some relatively recent developments of turning protein sequences into Protein Music (4). And Howard Shapiro often used lyrics in talks when reporting his studies on flow cytometry – my favorite being "There's No Business Like Flow Business" (5).

Music and science are both relevant and ubiquitous. I hope that some of you may consider incorporating music into teaching and research. It's not only fun and memorable for the audience – it's also highly enjoyable to develop a scientifically inspired playlist.

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2. *J Jiang et al., "Quantitative measurement of redox potential in hypoxic cells using SERS nanosensors", Nanoscale 20, 12104-12110 (2014).*
3. *http://bit.ly/2C50Vtu*
4. *http://bit.ly/2C4dPaV*
5. *http://bit.ly/2C3KhtX*