Physics takes the biscuit

Why did a light-hearted experiment attract so much attention from the media? The episode is an interesting lesson for those wanting to explain science to the wider public — equations do not always scare people away.

Len Fisher

Scientists wanting to share their picture of the world with a wider audience have a familiar problem — the knowledge gap. One doesn't need to be a writer to read and understand a novel, or know how to paint before being able to appreciate a picture. Some knowledge of what science is about, though, is a prerequisite for both understanding and appreciation.

Our intended audiences can often be trained on the spot, if we can persuade them to stay around for long enough. One effective approach is to use the 'science of the familiar', exemplified by my recent exercise on the physics of biscuit (or cookie) dunking. The project was a publicity agent's idea, and the results were presented at a press conference in London on "National Biscuit Dunking Day". Local publicity, fuelled initially by the eccentricity of the story, rapidly spread worldwide — I am still receiving requests for radio and TV interviews from countries as far away as Australia and South Africa.

What gave the story such global appeal? Even the Nobel prizes don't receive such coverage. Yet this minor bit of science is on everyone's lips, metaphorically speaking. Its success, I believe, reflects a hunger for accessible science. The lessons from this success, some of them surprising, are important for those who wish to share more serious science with a wide audience.

What is dunking? It is simply dipping your biscuit, cookie, doughnut or pastry into a drink such as tea or coffee, a process shown by chemists at Firmenich (Switzerland) to enhance flavour release by up to ten times. Although scientifically acceptable, dunking is often socially frowned upon, which is probably part of its attraction.

The physics of dunking is straightforward. A biscuit is porous, with interconnecting hollow channels between the crumbs. When the biscuit is dunked, capillary action draws the liquid into these channels: a similar process occurs when a piece of blotting paper is dipped into ink, or when ring stains form from dried liquid drops[1].

The problem for serious dunkers is that the wetted part of the biscuit becomes very soft, especially when the tea or coffee is hot. A biscuit is basically dried-up starch grains glued together with sugar: the hot liquid swells and softens the starch grains and dissolves the sugar. The wetted biscuit eventually becomes so soft that it collapses under its own weight.

The physicist's answer to this problem is to dunk the biscuit so that part of it can remain dry (and mechanically strong) and support the weight of the wet bit. Hence, instead of holding the biscuit vertically when dunking, a physicist grips it at the edge, sliding it into the tea or coffee at a shallow angle, so that the lower surface is wetted but the upper surface remains dry. This explanation is so simple that I was able to talk radio interviewers through it, and have them perform experiments on air. Yet simplicity alone cannot explain the high degree of interest.

I decided to ask the interviewers themselves why they found the story so interesting. An important criterion for most was that the topic is slightly daring, but the scientific gloss added an objectivity that legitimized public discussion. Most interviewers confessed to a strong interest in science, coupled with a fear of looking foolish when asking questions. This fear barrier is much lower when discussing the science of the familiar, as the questioner feels on a more equal footing with the scientist.

These criteria are well known to experienced science popularizers, but there was another attraction that seemed counter-intuitive. Journalists were enthralled to discover that there is an equation to describe biscuit dunking. Newspapers published it; TV programmes showed it. More than one radio interviewer even insisted I describe it on air.

All I had done, in fact, was to write down the Washburn equation, derived[2] in 1921 to describe capillary flow in porous materials:

$$L^2 = \frac{\gamma D t}{4\eta}$$

where t is the time for a liquid of viscosity η and surface tension γ to penetrate a distance L into a fully wettable, porous material whose average pore diameter is D. The equation is strictly true only for capillary flow in a single cylindrical tube in the absence of gravitational effects, but can be extremely accurate for more complex materials, including, as I found experimentally, biscuits. Why this should be so is a very interesting question. In practice, I could use the Washburn equation to predict how long different biscuits could be safely dunked by the physicist's method, the longest dunkers generally giving the best flavour release (to my palate at least).

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Washburn will be turning in his grave to learn that the media have renamed his work the "Fisher equation". The equation was published in almost every major UK newspaper. The journalists who published it took great care to get it right, some telephoning several times to check. Some even did their own experiments, extending my results. Only one journalist published without checking, provoking the following letter: "Dear Sir, I think there is something wrong with your biscuit dunking equation. Please send me some biscuits for noticing this. Chao Quan (aged 12)."

Such excitement over an equation contradicts the normal publisher's advice to authors — that every additional equation halves the sales of a popular-science book. Why was this so? Let me suggest an answer, relevant to the sharing of more serious science. Scientists are seen by many as the inheritors of the ancient priestly power of the keys, the owners and controllers of seemingly forbidden knowledge. Equations are one key to that knowledge. The excitement of journalists in gaining control of a key was surely a major factor in their sympathetic promotion of the story. By making the Washburn equation accessible, I was able to ensure that journalists unfamiliar with science could use the key to unlock Pandora's box. □

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2. Washburn, E. W. *Phys. Rev.* **17,** 374–375 (1921).