century for stylistic reasons, and we were quite pleased to find that Zinner and his informants reached the same conclusions.

It's likely that the painting is not even a painting of Kepler but, as Zinner suggested in 1930, a 19th-century forgery based loosely on a portrait of Kepler's teacher and mentor Michael Mästlin (top right). That image depicts Mästlin in the ruffled collar and academic gown typically worn by professors of that period. The alleged Kepler portrait held by the Kremsmünster monastery shows Kepler in a similar academic outfit, but that does not accord with what Kepler wears in other portraits that incontrovertibly depict him: a commemorative medallion from his wedding in 1597 and an official portrait from 1620 (bottom left). In those, Kepler wears a lace collar, which is more appropriate as he was neither an academic at the time nor a nobleman. Moreover, the Latin inscription in the alleged portrait could have been added by anyone knowing Kepler's birth date.

The bottom right painting is another presumed portrait of Kepler, from around 1610, that since 1973 has been attributed to Hans von Aachen, one of the favorite painters of Holy Roman Emperor Rudolf II and a contemporary of Kepler in Prague.[4,5] The top left and bottom right portraits cannot be simultaneous representations of the same person. Although the identifications are still disputed, at least in the case of the von Aachen the artist is known and the painting is original. Finally, another painting identified as Kepler, known as the Linz portrait, is dated to 1620. The artist is unknown, but it does bear resemblance to the depiction on the frontispiece of Kepler's *Rudolphine Tables* (1627).[6]

So how did the fake Kepler portrait spread? Except for Wolf's and Günther's mentions, we cannot find any examples of the portrait attributed as being Kepler before 2005. That's the year the portrait first appeared on Wikipedia, and thereafter it became ubiquitous. For example, it appears in a European Space Agency press release from 2011 (explicitly citing Wikipedia), the European Southern Observatory attached it to an article from 2016, and NASA used it in its Solar System Exploration educational materials in 2017. This past April the image appeared on the cover of *Giornale di Fisica*, an Italian magazine for secondary-school physics teachers.

Although this matter may just seem like a trivial byway, images fix in the mind. Kepler deserves better.

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Hydrogen as an aviation fuel

Powering airplanes by hydrogen, as reported on by David Kramer in the December 2020 issue of PHYSICS TODAY (page 27), is a nice theoretical idea that brings little practical benefit.

Apart from the difficulties of handling hydrogen as a cryogenic liquid or a gas at very high pressure, the most serious problem with hydrogen as an aviation fuel isn't the weight of the tanks containing it but rather its low density, even as a liquid. Consider the Toyota Mirai, an electric car powered by a hydrogen fuel cell: The hydrogen is stored as a gas in polycarbonate tanks at 700 bar, twice the pressure proposed for the hydrogen-powered aircraft. The 2021 Mirai can hold 5.6 kg of hydrogen, but that's just 6% of the combined mass of the fuel and the fuel tanks. For tanks of conventional aviation fuel—kerosene or aviation gasoline (avgas)—the mass is mostly fuel, not tank structure.

The energy per unit volume of liquid hydrogen is 24% that of avgas or kerosene; that of hydrogen at 350 bar, only about 8%. Light aircraft use only a small part of the wing to store fuel. The combination of fuel cell and electric motor has approximately twice the efficiency of an internal combustion engine, though, so only half as much energy needs to be stored.

The situation is very different for long-range, turbine-powered aircraft used for intercontinental travel. The whole wing serves as a fuel tank, and fuel can account for 45% of a plane's allowed maximum takeoff mass. Even for the high-bypass-ratio turbofans found on a commercial aircraft, a substantial part of the high-altitude cruise thrust comes from the turbine core, not the fan, so driving the fan with a fuel-cell-powered electric motor effectively makes the aircraft more like a slower turboprop. The low density of hydrogen, even as a liquid, means that the aircraft doesn't have the space for the fuel needed for an intercontinental journey.

A flight of 500 nautical miles (900 km) takes about 1.25 hours. If the aim is to minimize carbon dioxide emissions from travel, then for flights of less than that distance—for which hydrogen is viable, though not necessarily practical—it would be better to just take the train!

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Correction

July 2021, page 24—Steel Made via Emissions-Less Technologies (SMELT) was incorrectly identified as a program of the Advanced Research Projects Agency–Energy. SMELT is in fact a "request for information," seeking public input that could potentially lead to a future program. PT