space and computer servers for saving data and the journal's website.

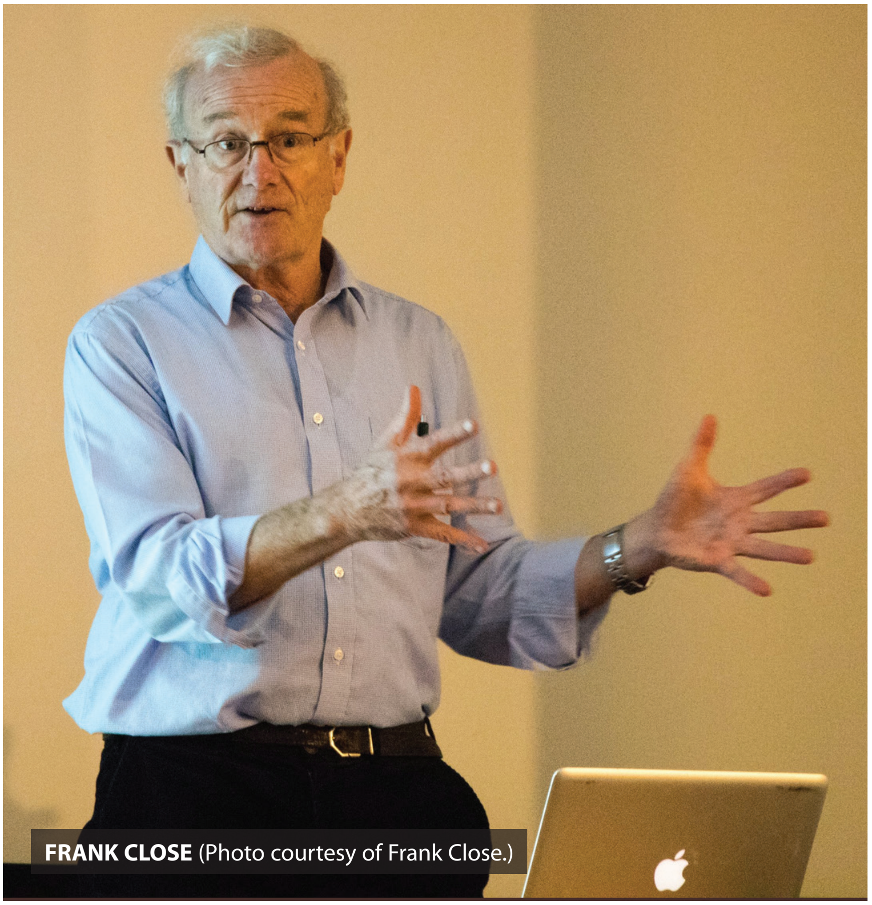
Six months after the invasion, *FNT* resumed publishing from its Kharkiv headquarters. The bombings and raids continue, and the editorial team is still scattered—in Ukraine, Poland, Switzerland, and beyond. As of press time, *FNT* had published 477 articles in the three years since the invasion. Authors hail from around the globe, but after the invasion, the journal stopped accepting submissions from Russia and Belarus, the *FNT* physicists wrote.

Over the half century of its existence, *FNT* has published some 10 000 articles in areas including quantum liquids, disordered systems, biophysics, and methods in low-temperature experiments. It has featured many special issues, including ones celebrating the centenary of the production of liquid helium (2008), the 30th anniversary of the discovery of high-temperature superconductivity (2016), and advances in quantum materials (2023).

Toni Feder

Q&A: Frank Close probes quarks and popularizes science

He has written books on quarks, protons, spies, nuclear threats, and more.



FRANK CLOSE (Photo courtesy of Frank Close.)

Writing about science for a broad audience and researching in the rarefied area of quarks bear some resemblance, according to Frank Close. He should know.

For much of his career as a theoretical physicist, Close was also writing articles and books for the public, and he has continued writing since retiring from research in 2010. His books—21 and counting—include a coffee table collection of images from particle physics; a profile of Peter Higgs and the boson named for him; the cold fusion controversy; and dives into Klaus Fuchs and Bruno Pontecorvo, physicists who both worked on the Manhattan Project and were, respectively, confirmed and suspected spies.

His 22nd book, *Destroyer of Worlds: The Deep History of the Nuclear Age*, is due out in June. He wrote it over the course of 27 weeks in 2023 while undergoing chemotherapy and radiation for non-Hodgkin's lymphoma. The irony, he says, is that he was writing about how nuclear physics led to bad things while he was benefiting from some of its good things—PET scans, radiology, and the like.

Researching for a book is "like a classical scientific research project," Close says. Much research in science is not greatly different from being a detective in the police force or what have you, he adds. "It's trying to find out, How much do we know? What are the known unknowns?"

For his scientific research, Close focused on quantum chromodynamics (QCD), quarks, and gluonic hadrons. After earning his PhD at Oxford University in 1970, he did postdocs at SLAC and CERN, and then he spent most of his research career at Rutherford Appleton Laboratory in Oxfordshire, UK.

PT: Why did you go into physics?

CLOSE: My high school chemistry teacher told us that everything was made of atoms and that atoms of one element and another element differed only by the number of electrons whirling around the central nucleus. That was a mind-blowing revelation.

I thought, "If I can understand how that works, I can derive all the other stuff from it." Six decades later, I haven't managed to do that, but that was how I suddenly understood that physics underlies everything.

PT: Describe your career path.

CLOSE: I happened to be starting my PhD research in 1967 in Oxford, one of the few places in the world that took quarks even semiseriously at the time. Luckily for me, I got in on the ground floor.

In the summer of 1968, I was talking to my supervisor, Dick Dalitz. I was depressed that I was doing a thesis on something that I had no evidence for at all. He told me to talk to Don Perkins, a professor who worked on neutrinos.

Perkins had just returned from a conference in Vienna at which [Wolfgang] Panofsky from Stanford [University] had announced the first experiments on deep inelastic scattering, which today we know were the first evidence for the reality of quarks. When I told Perkins what I was doing and why I was depressed by it, he went to a drawer in his office and pulled out a sheet of paper with a graph on it and said, "If that's not a quark, I don't know what is."

When I eventually finished my thesis, I went to Stanford, where the experiments that produced evidence for the existence of quarks had been done. For two years, I felt I was at the center of the universe. It was perhaps the most exciting time of my life.

PT: What came next?

CLOSE: For the next 40-odd years, I worked either on the constituent quark picture of hadrons or on applying QCD to the deep structure of hadrons.

PT: How did you get into popularizing science?

CLOSE: In 1976, I attended the International Conference on High Energy Physics in Tbilisi, Georgia. For some random reason, I got a communication from *Nature* asking me to write about the conference for their News & Views section.

Because I suddenly had a reason to be there, it meant I had to concentrate. The headline was "Iliopoulos wins his bet"—a reference to John Iliopoulos's having said two years earlier that he was prepared to wager a whole case of wine that the next conference in the series would be dominated by discussion of the charm quark.

That's how I got started. For about 20 years, until the mid 1990s, I continued to write for News & Views. I covered a really exciting period, including the discoveries of charm and the W and Z bosons. (See, for example, PHYSICS TODAY, November 1983, page 17.)

I also wrote for the *Guardian* newspaper. That's where I got the best education in writing—from Tim Radford, the science editor. I would compare line by line what I had sent him with what was finally published. From that, I started learning to say things more concisely.

Over the years, I have also been a guest on the BBC radio show *In Our Time*. We've had a program on the electron, the proton, the neutron, the photon. We've had programs on antimatter, neutrinos, Paul Dirac, the Pauli exclusion principle. I do it roughly once a year. It's great fun.

PT: How did you go from writing short pieces to books?

CLOSE: The 1980s were a messy time in the UK for particle physics. Other areas of science were beginning to question why so much money was going into CERN and particle physics. Was Britain better off out of it all? Money could be used for other things. I thought about writing a book about this.

Popularization of physics was not yet a big deal. Steven Weinberg's *The First Three Minutes* changed all that when it came out in 1977 (see PHYSICS TODAY, June 1978, page 53). It was about the first three minutes of the universe. I thought I could write something complementary about particle physics. That became *The Cosmic Onion*, which was published in 1983. Members of the committee that was investigating whether Britain should stay in CERN read my book. Thankfully, in the end, we stayed in CERN—not because of my book, but the book was in the background.

PT: How do you choose book topics?

CLOSE: In 2006, I wrote Ray Davis's obituary for the *Guardian*. He had spent 40 years chasing neutrinos from the Sun. The obituary won a prize for best science writing in a nonscientific context. I developed that into a book.

In the course of researching that book, Bruno Pontecorvo's name kept coming up, which led me to research him. That eventually led to my book *Half-Life: The Divided Life of Bruno Pontecorvo, Physicist or Spy*. One thing leads to another.

PT: How did you come to write about Klaus Fuchs, who worked on the Manhattan Project and spied for the Soviet Union?

CLOSE: When I was getting to the end of my book on Pontecorvo, I decided to see what the National Archives had on Fuchs. It turned out there were 25 volumes. For both Pontecorvo and Fuchs, there was also a personal connection: They had lived in Abingdon, not far from where I live. And I knew Rudi Peierls, who knew them both and was like a father to Fuchs.

I opened the first file and saw a photostat sheet of Fuchs's travel expenses. I discovered something: He had gone to a meeting at Cambridge, and his travel expenses said he'd done 220 miles. He'd gone a couple of other times, and it was 180 miles. And the longer trip was on the same date that he later admitted he met his Russian contact in London. The date caught my eye because it was the same as a family birthday.

"If only someone back then had noticed that the trip took another 40 miles," I thought. "I bet nobody has seen this before." That's what started me on Fuchs.

PT: Did you uncover anything interesting about him?

CLOSE: The really scandalous thing I discovered was that when he moved over to the US from the UK, the British decided not to alert the Americans about suspicions they had about his proclivities for communism. I found an astonishing letter in the files. It said that Fuchs was unlikely to meet any fellow travelers over there. How wrong could you be?

If General [Leslie] Groves, who [oversaw the Manhattan Project and] was always suspicious of the whole British involvement in it, had been aware of that letter back in 1943, the Brits would have been hung out to dry.

But Fuchs was a very successful spy. He spied for nine years and didn't make a single mistake. It was the Russians who failed him. His information was sent by cable to Moscow after encryption using a one-time pad. Use the pad once only and it is uncrackable. But for some reason, the Russians used a one-time pad twice. That mistake ultimately led to his being uncovered.

PT: What about cold fusion? How did you get on to that topic?

CLOSE: When the news was announced in 1989, everyone was asking, "What's going on? What does it mean?" I started off thinking this is a great thing to be on top of because if it's indeed correct, it's the greatest discovery since who knows what, and it will be fascinating to describe how the new revolution happened and how science developed from this thing to the great golden future.

But if it turns out not to be true—and very quickly we suspected that was the case—how will science establish that? I thought it was an opportunity to describe how science works in real time, on a story that everybody is interested in and has heard about. I had great hopes that I was going to chronicle a great moment in human culture. I never anticipated that my investigation would result in a headline, above the fold of the *New York Times*, "Cold fusion claim is faulted on ethics as well as science."

PT: What are you working on now?

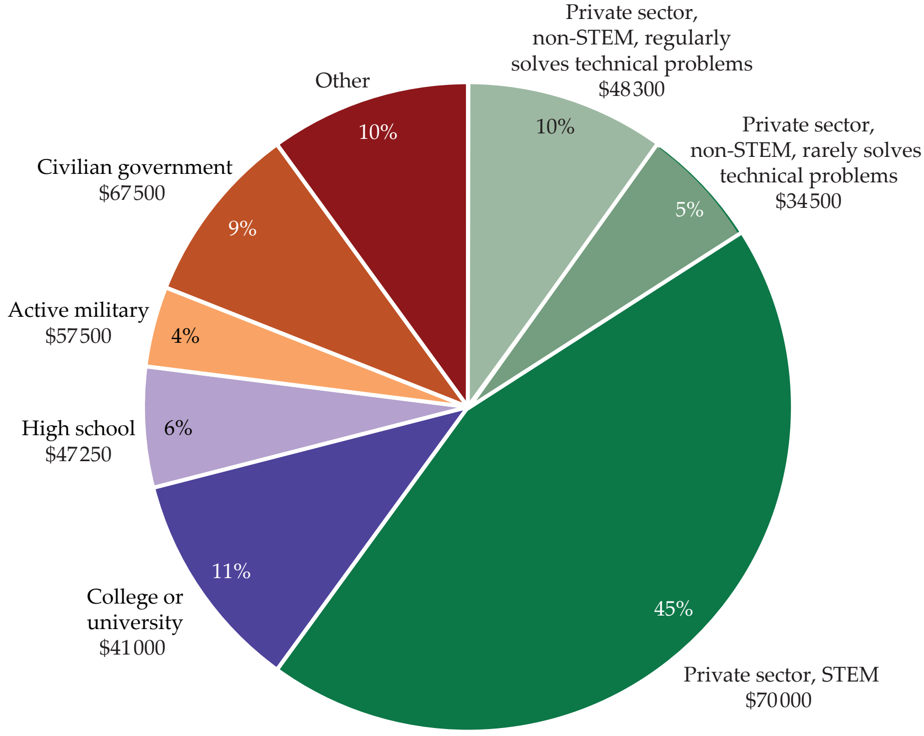
CLOSE: I just sent in a proposal about Abdus Salam and John Ward. Their work on unifying the weak force and quantum electrodynamics is well known. How Ward missed a share of Salam's Nobel Prize is a question to be resolved. But how their covert lives—Ward's as the father of the hydrogen bomb in the UK and Salam's to be revealed in the book—got entangled is all in there. I am gathering the material and waiting for the protagonists, who both died more than 20 years ago, to tell me in my subliminal slumbers what their story will be. One of the great adventures is never quite knowing where a narrative is going to lead you.

Toni Feder

Physics bachelor's holders find jobs in many sectors

Just shy of half of US physics bachelor's degree recipients from the 2021–22 academic year entered the workforce within a year of earning their degree. The other half were enrolled in graduate studies in physics or astronomy (30%), were enrolled in another field (17%), or were seeking employment (4%). The percentage of physics bachelor's degree earners who enter the workforce immediately after graduating has been trending upward since 2009. Those and related data are available in a report published in January by the statistical research team of the American Institute of Physics (publisher of Physics Today.)

Initial employment sectors and median salaries for new physics bachelor's recipients in 2021 and 2022



(Figure adapted from J. Pold, P. J. Mulvey, *Physics Bachelor's Initial Employment: Academic Years 2020–21 and 2021–22*, AIP Research, 2025.)

In the combined graduating classes of 2021 and 2022, 60% of physics bachelor's holders were in the private sector; 11%, in colleges and universities; 9%, in civilian government (including national laboratories); 6%, in high schools; 4%, in the military; and 10%, in other areas (see the chart).

In those employment sectors, new degree recipients worked in engineering (27%), computer software (16%), physics or astronomy (11%), and other fields. Starting salaries vary significantly both between and within sectors. The median salary for new physics bachelor's earners working in the private sector in STEM fields was $70 000; some individuals reported a starting salary of more than $120 000. The median starting salaries for those who work in civilian government was $67 500 and in colleges and universities, $41 000.

The full report, which includes details on salary ranges, job satisfaction, and skills used, can be found at https://ww2.aip.org/statistics/physics-bachelors-initial-employment-booklet-academic-years-2020-21-and-2021-22.

Tonya Gary