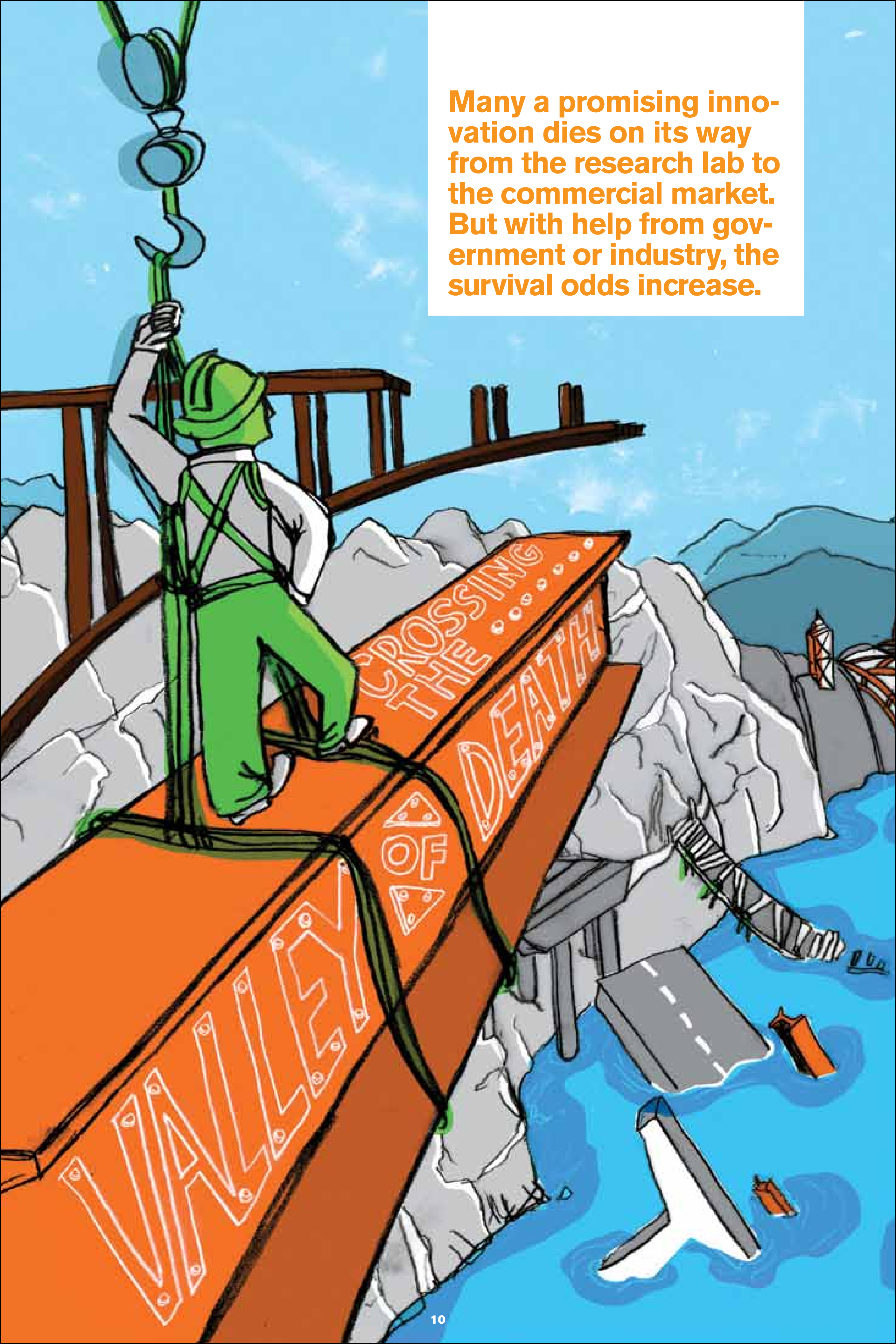
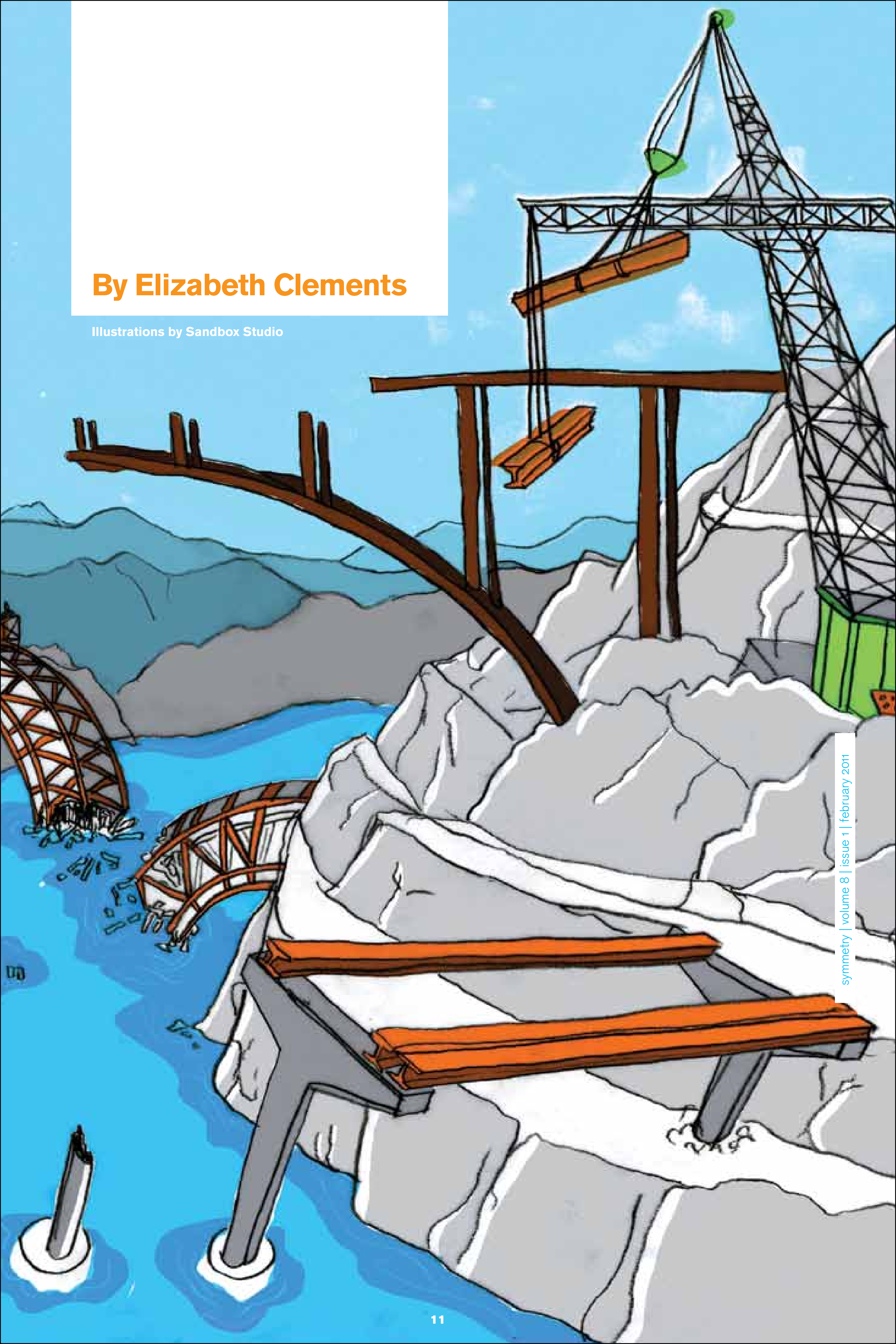
Many a promising innovation dies on its way from the research lab to the commercial market. But with help from government or industry, the survival odds increase.



By Elizabeth Clements

Illustrations by Sandbox Studio



It's a classic boy-meets-girl, they-start-up-a-high-tech-company, spend-decades-getting-it-off-the-ground, nearly-lose-it-all but ultimately-live-happily-ever-after accelerator-physics story.

Bob and Marianne Hamm met and married in graduate school. Together they pursued PhDs in physics, got jobs at a national research laboratory, left that laboratory to start an accelerator technology company, and successfully crossed the "Valley of Death" not once but twice, eventually generating $57 million in sales during their 22 years in business.

The Valley of Death. It's a phrase familiar to anyone who owns a small high-tech business, Marianne Hamm says. It all starts with an innovative idea and a small business loan. The company builds a prototype and proves that the technology works. Maybe a seed grant comes along. Then, somewhere between the laboratory bench and the commercial market, the loans expire and the seed money is gone. The business runs out of cash and out of steam and dies a painful death in a landscape littered with the carcasses of companies that came before.

Lost opportunities

The US Department of Energy's Office of Science has launched an initiative to encourage breakthroughs in accelerator science and their translation into applications for energy and the environment, medicine, industry, national security and discovery science. A report, *Accelerators for America's Future*, published by the Office of Science, cites the Valley of Death as a critical challenge that results in countless lost opportunities.

As the report describes it, innovative accelerator concepts arise on one side of the valley, and the industries that could transform those ideas into products for the marketplace operate on the other. Difficult obstacles block the bridge between the two: complex funding mechanisms for research and development; a lack of national facilities and demonstration projects; an aversion to risk; and policies that make coordination among government entities and between government and industry extremely challenging.

"There are no mechanisms for industry and national laboratories to explore newer things," says Walter Henning, a physicist at Argonne National Laboratory who, with Charles Shank, the former director of Lawrence Berkeley National Laboratory, chaired a 2009 national symposium on accelerator applications.

From diagnosing and treating disease to inspecting cargo in shipping ports, the practical applications of particle accelerators are everywhere. More than 30,000 particle accelerators are at work today in industry, health care and basic and applied research. The total annual value of the products that they treat, inspect or process is more than $500 billion. As technology advances, opportunities increase for an ever-growing list of applications. But they will never see the commercial light of day if they can't get across the Valley of Death.

Joint ventures

Henning points to the example of heavy-ion therapy for cancer treatment. The majority of cancer patients who undergo radiation therapy receive treatment with beams of high-energy X-rays. Heavy ions—protons or carbon ions generated by particle accelerators—often offer a more precise and powerful form of therapy to eradicate cancer cells without damaging the organs that surround a tumor. But only a few dozen particle beam cancer centers exist around the world, fewer than 10 of them in the United States.

"It's an area that requires further research and development, and no company or hospital is going to build the $100 million facility to do this," Henning says.

A partnership between a hospital and government might be a solution, he says, citing the Heidelberg Ion-Beam Radiotherapy Center in Germany as one working model.

Funded jointly by the Heidelberg University Hospital and the German federal government, the roughly $155 million facility opened in December 2009 and will treat approximately 1300 patients a year when it reaches full capacity in 2011. Besides treating patients, it serves as a facility for medical physicists and physicians to collaborate on further research, Henning says.

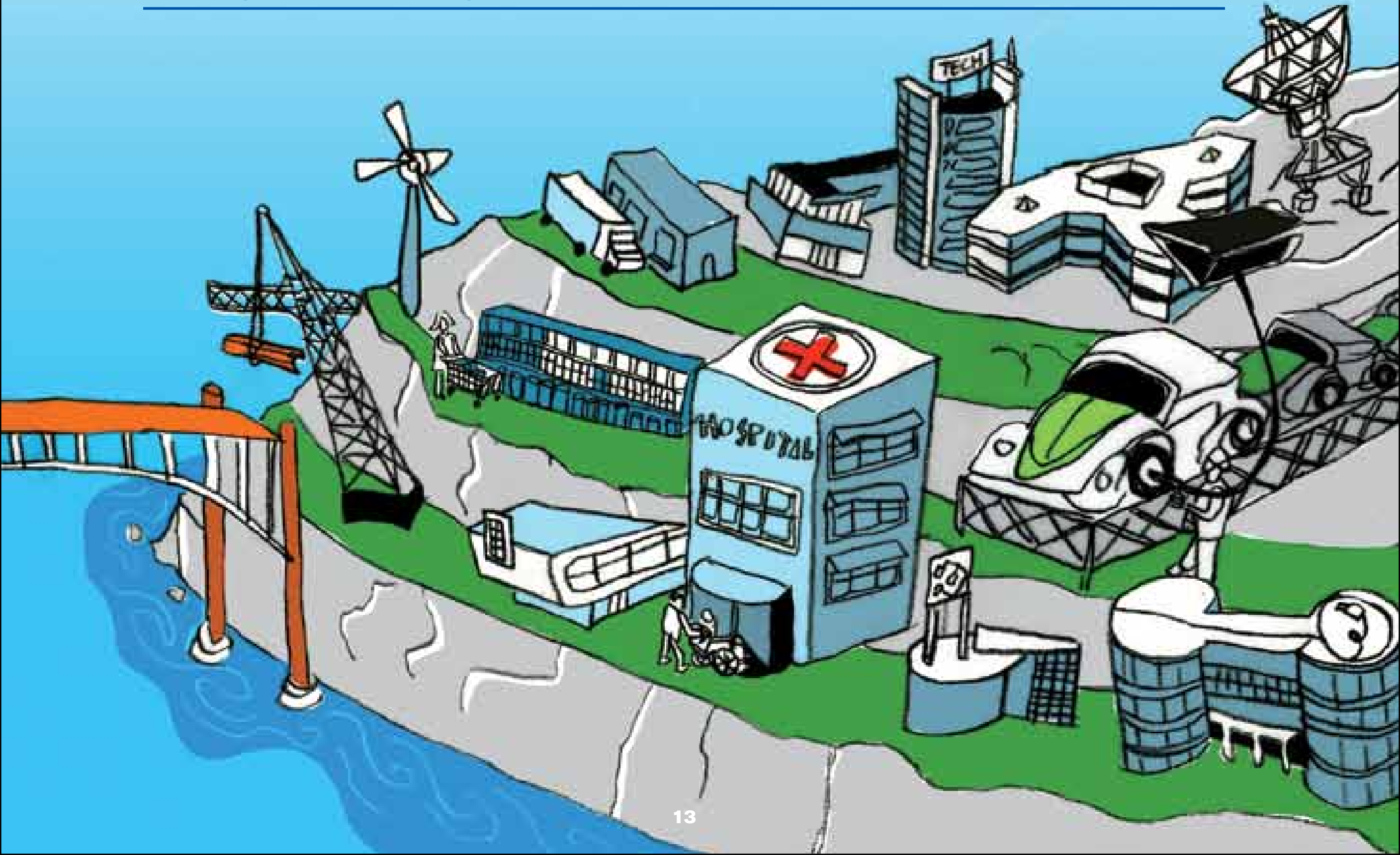
The electron beam wastewater treatment plant in Daegu, Korea offers another working example of partnership between government and, in this case, industry.

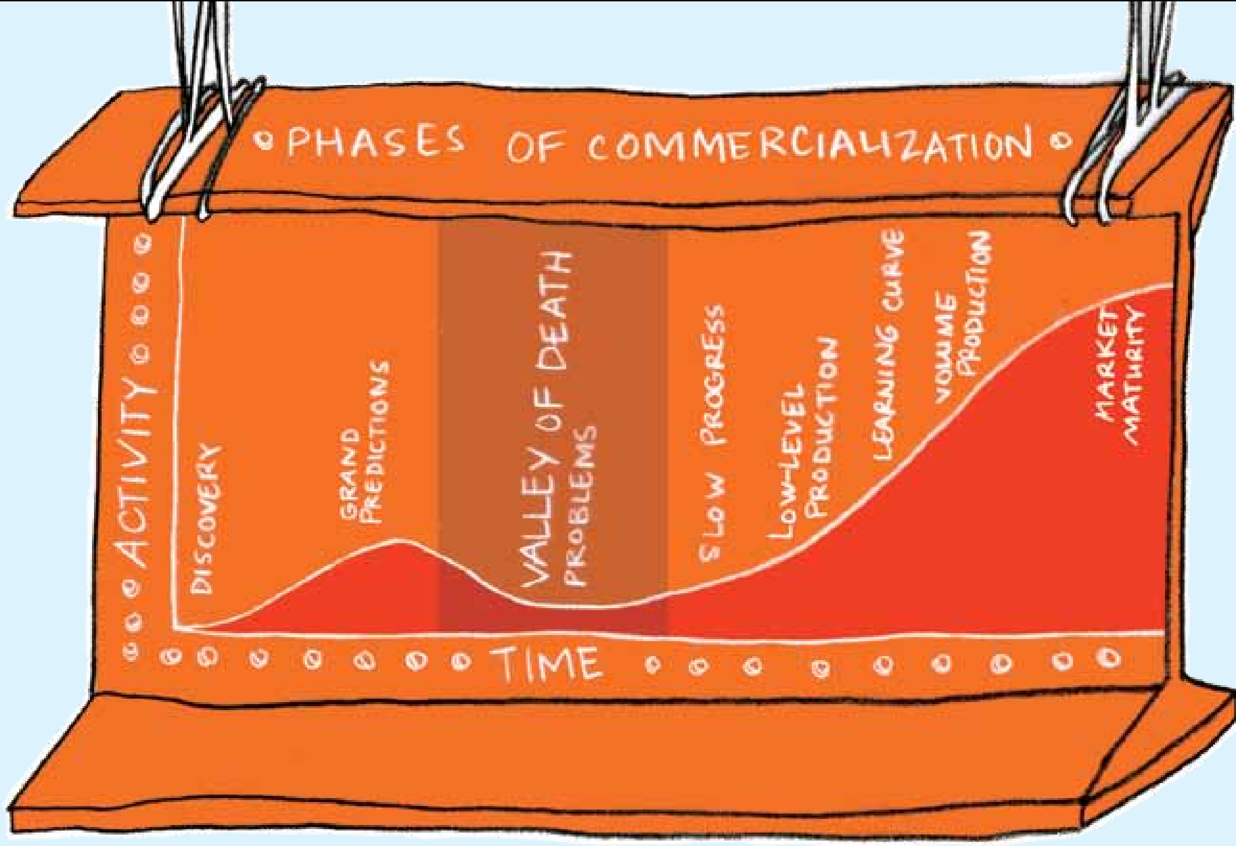
Pilot studies have shown that blasts of electrons from a particle accelerator safely and effectively remove harmful pollutants from drinking water. Traditional treatment plants disinfect wastewater with chlorine, which can leave a residue behind and requires multiple cycles to break down pollutants such as cancer-causing benzene. An electron beam removes all of the pollutants with one residue-free blast.

The Daegu Dyeing Industrial Complex has used an electron beam to treat wastewater since 1998. The Korean government and the International Atomic Energy Agency collaborated with the textile company to fund the pilot plant, which removes dye from 10,000 cubic meters of wastewater a day. Countries including Bulgaria, China, and Saudi Arabia are turning to electron beams for environmental applications, but the US lags behind, with no plans to develop pilot or demonstration facilities.

"The electron beam accelerator is an industrially proven machine that makes money," says Bill Cooper, an environmental chemist and director of the Urban Water Research Center at the University of California, Irvine. But while the cost of operating and managing a plant that treats wastewater with electron beams is low, he says, the higher initial cost is a barrier. Cooper adds that the US market for environmental cleanup technologies tends to be very risk averse.

Below: Innovative accelerator concepts arise on one side of the valley. The industries that could transform those ideas into products for the marketplace exist on the other.





Above: For a small high-tech business, the Valley of Death comes right after the R&D phase, as the company needs to start marketing its products and find its customers–an endeavor that requires large amounts of capital.
Source: R&M Technical Enterprises, Inc. by Roger Little of Spire Corporation

Demonstration facilities

The high cost and high risk of accelerator science are the two major obstacles that leave many potential developments stranded in the Valley of Death, according to Henning. But both Cooper and Henning believe that demonstration facilities where accelerator researchers and industry can work side by side would help.

"Industry and research laboratories working together is a natural thing," Henning says. "A test facility that is open to industry will allow them to decide if they like a new technology and if they think it will make money."

One proposed mechanism for building a demonstration facility could involve a third-party, not-for-profit entity to fund and manage the project.

"The validation process needs to be flexible, unbiased and economical," Cooper says. "It all comes down to money, and an independent validation is important."

Full-service campuses

Britain has found another way to smooth the path between the research laboratory and the marketplace: Science & Innovation Campuses.

Operated by the UK's Science & Technology Facilities Council, a funding agency for research in physics and astronomy, the campuses represent a government initiative to encourage business-science collaborations for the nation's economic growth. They give both new and established businesses access to state-of-the-art facilities and scientific expertise to help develop their products and services.

"The UK has large research groups, but they don't work together," says Colin Whitehouse, STFC deputy chief executive and head of the Daresbury Laboratory and Daresbury Science and Innovation Campus. "We needed a new mechanism to co-locate large science research groups with ultra-high technology."

In 2005, STFC opened the Daresbury Science and Innovation Campus on the site of the Daresbury Laboratory, near Manchester in northern England. The Harwell Science and Innovation Campus near the Rutherford Appleton Laboratory in Oxfordshire followed in 2006. More than 200 small-to-medium-sized companies rent space on the campuses. Some established companies only need access to high-tech equipment that they couldn't afford on their own. Others are start-ups that come with ideas but need scientific and business expertise to turn them into commercially viable products.

"There are often holes in the technology, and we can help to short-cut the development phase," says Paul Vernon, head of new business opportunities for STFC Innovations Ltd, the technology transfer office that handles intellectual property rights on the campuses. "We are trying to bring products to market quicker."

Vernon recalls one entrepreneur who came to STFC with an idea that involved accelerator mass spectrometry, a precision technology with applications that range from geology to art authentication.

The entrepreneur had what Vernon describes as a pipe dream to produce disposable mass spectrometers for medical diagnostics. Vernon teamed him up with an STFC scientist, and within two hours they had produced an outline to develop the product. Today they have a functioning prototype, and STFC is exploring ways to market it.

"It's difficult to get people to take on startup companies," he says. "We understand business and science and can spot an opportunity. We take it on, shape it up and help secure funding."

If a company does its own research using the STFC facilities, the company owns all of the rights to the resulting product. If a company collaborates with STFC on the research and business development, intellectual property rights agreements ensure that both parties benefit.

According to Marianne Hamm, such government-funded facilities that offer assistance through the commercialization phase could benefit small high-tech companies. The R&D phase is not necessarily where the major problems exist, she says.

"The Valley of Death comes after the R&D, when the early markets have run out," Marianne says. "It's before you have penetrated whatever market you're going after and found your customers. That's where you need sufficient capital to do the marketing to get through and that takes a lot of money."

Know when to hold 'em (and know when to fold 'em)

Marianne Hamm should know. She still remembers sitting on the couch with her husband the second time they were on the brink of the Valley of Death in the late 1990s. Nothing was working, she recalls, and even Bob, ever the optimist, was ready to throw in the towel.

"Sometimes you have to admit failure," Marianne says.

But Marianne Hamm wasn't quite ready.

Bob and Marianne Hamm had joined Los Alamos National Laboratory in the mid-1970s. Bob worked on particle accelerators, and Marianne did nuclear and particle physics research. In the late 1970s, Bob's research turned to compact accelerators, and he immediately recognized many potential applications for these devices.

In 1981, at a Los Alamos technology-transfer meeting with industry, Bob got an idea for a compact linear accelerator for medical diagnostics. After some deliberation, Bob and Marianne decided to leave the laboratory to move to California and take the plunge into their own business. They wrote a business plan at one of their son's swim meets. They obtained a small-business grant from the National Cancer Institute, a component of the National Institutes of Health, and made a technology-transfer agreement with Los Alamos in 1984. AccSys Technology, Inc. was born in 1985 as a design and manufacturing company to develop and produce compact linear ion accelerators for medical, industrial, and research applications.

In their early "flying high" years, the Hamms found a strong demand for their company's technical expertise, generating a healthy cash flow. They thought that they had really made it when they landed a contract to build accelerator components for the Superconducting Super Collider, under construction in Waxahatchie, Texas.

"We doubled in size and expanded to 45 employees and two facilities," she says. "Two-thirds of the way through, Congress cancelled the project. It just about nearly killed the company."

Within a single day the Hamms laid off a third of the staff, and the cash flow came to a halt. They spent the next two years negotiating the terms of the contract settlement with the government and came within a hair of declaring bankruptcy. The lawyer had the bankruptcy papers ready for signature when the government finally released the funds the company needed to pay its subcontractors.

After the cancellation of the SSC in 1993, AccSys dusted off its feathers and partnered with a Japanese company to build proton accelerators for short-lived radioisotopes for medical diagnosis. But, with the Japanese economy collapsing, the company defaulted on the agreement with AccSys, leaving the Hamms with $1 million in equipment—and once again no cash flow.

"That was our second encounter with the Valley of Death, so we shrank back again and started looking for the right partner," Marianne says. "Then Hitachi came along."

Hitachi Ltd. had been an AccSys customer for proton accelerators, and in 2002 they agreed to become an 80 percent stockholder. The Hamms stayed on for five more years, selling the remaining 20 percent to Hitachi in 2008. "To my knowledge, the company is still going strong," Marianne says.

Today Marianne and Bob Hamm are about to publish a book on the industrial applications of particle accelerators. Marianne gives lectures on high-tech entrepreneurship.

Her basic Valley-of-Death survival kit contains cash, a detailed map with an exit strategy, more cash, business sense, a skilled labor pool, good legal and financial advice, friends with cash they're willing to loan, and a fire in the belly.

"You need to say 'I know I can do this,' but also keep an open mind," Marianne says. And while they aren't necessarily essential, she says that mass quantities of antacids and a good therapist can't hurt.