A manufacturing renaissance for America?
At an MIT forum, experts examine new ways to pursue a good old idea: making things.

Peter Dizikes, MIT News Office

Over the last few decades, the sector of the U.S. economy devoted to manufacturing has lost ground to the services sector. The number of U.S. manufacturing jobs has declined from nearly 20 million in 1979 to about 12 million today. Yet as the recent global recession suggests, services can propel the economy only so far. There is no substitute for making tangible, useful products.

But what form will new kinds of manufacturing take? At an MIT roundtable discussion on Monday titled “The Future of Manufacturing — Advanced Technologies,” more than a dozen of the Institute’s faculty shared converging ideas about how to reinvigorate America’s goods-producing businesses. The roundtable followed a broader campus forum hosted by MIT President Susan Hockfield on March 1, in which faculty members, some of whom also participated in Monday’s discussion, offered ideas about how to strengthen America innovation and thus its overall economy. These meetings are part of a larger effort by MIT to contribute the Institute’s expertise in emerging technologies and innovation policies to the national effort to revitalize the American economy.

Monday’s discussion cast specific issues of manufacturing in the light of broad economic considerations. “To recover from the current economic downturn, it has been estimated that we need to create on the order of 17 million to 20 million new jobs in the coming decade,” noted Hockfield in her opening remarks at the event, which was co-sponsored by the Council on Competitiveness, an industry group. “And it’s very hard to imagine where those jobs are going to come from unless we seriously get busy reinventing manufacturing.” That question should be of great concern to scientists and engineers — 64 percent of whom, Hockfield noted, are employed in the manufacturing sector.

Hockfield also directly addressed the commonly held notion that the United States cannot compete in manufacturing against low-wage countries, citing the success of Japan and Germany, both of which feature trade surpluses and high wages. “I take this as positive proof that building a strong advanced manufacturing sector is not impossible, but very much worth pursuing,” Hockfield said. In addition to new business practices and continued strength in education, Hockfield added, “A key hope for progress lies in tapping unprecedented new manufacturing technologies.”

Suzanne Berger, a professor of political science and author of How We Compete: What Companies Around the World Are Doing to Make It in Today’s Global Economy, asserted...
that Americans need to be disabused of the notion that manufacturing is “a ‘sunset sector’ that should be allowed to sink over the horizon.” Increased productivity per worker means the United States still produces 22 percent of the world’s goods, Berger noted, a figure that has been roughly constant for 30 years, and which makes the United States the world’s top manufacturer. Yet the country “has failed to exploit new opportunities for exporting U.S. goods,” she said. “The big problem is not that we can’t compete with China on low wages,” Berger added, but that the United States has “not developed enough kinds of manufacturing that could generate both high profits and also good jobs.”

Material benefits

The roundtable discussion was organized into two consecutive panels, the first of which focused on innovation in materials science. Gerbrand Ceder, a professor in MIT’s Department of Materials Science and Engineering (DMSE), outlined how a “Materials Genome Project” can catalogue the properties of known materials and allow designers to better model potential devices, thus accelerating product development. “Clearly there are some things that would be useful to apply in many types of manufacturing,” Ceder noted.

Christine Ortiz, an associate professor also in DMSE, described her research group’s efforts to study the nano-scale properties of “high-strength, lightweight, penetration-resistant” biological materials. Those properties could then be transferred to synthetic materials, expanding the range of products that can be manufactured through methods such as 3-D printing.

Charles Fine, a professor at the MIT Sloan School of Management, and Richard Roth, of the Engineering Systems Division, both discussed lightweight automobiles as an alternative to traditional vehicles and an area where the United State could re-establish a competitive advantage in manufacturing. “If we take on the hard challenges and succeed, it’s not so easy to copy,” Fine said. And as Roth noted, “Batteries are extraordinarily expensive,” so new materials research leading to lighter cars would lower those costs by reducing vehicle battery size. In turn, that could make electric automobiles more affordable for consumers and a more appealing investment for manufacturers.

But the actual techniques of manufacturing are what most need to be reinvented, asserted Martin Culpepper, an associate professor in MIT’s Department of Mechanical Engineering. Over the last 150 years, suggested Culpepper, heavy industry has refined large-scale production techniques effectively, and developed myriad tools suited to its needs. But businesses today must invent equally useful nanotechnology-based manufacturing techniques, he believes, allowing firms to better manipulate matter at the smallest scales in order to produce everything from new industrial materials to cutting-edge medicine.

“We don’t have the tools and technologies right now to do a lot of nano-manufacturing in a really practical way,” said Culpepper. Moreover, he believes, researchers today who want to commercialize lab discoveries underestimate the difficulties of “integrating the science and the [manufacturing] process … this is not a trivial thing.”

Culpepper’s own research group aims to create those kinds of small-scale manufacturing tools. Working with one bioscience research institute, he noted, they have been able to roll back the size boundaries of nano-scale DNA arrays, which could make drug production more efficient.

Still, these advances are also restricted, Culpepper said, by the limited number of people with a thorough knowledge of nano-scale manufacturing. “In my lab, it’s like an apprenticeship,” Culpepper said. “It takes a long time to learn how to do this stuff properly.” Universities and their partners, he stated, need to help rectify this problem: “We would like to have more support for training.”

Production values

The second panel discussion centered on technology advances for transforming production. Rodney Brooks of MIT’s Computer Science and Artificial Intelligence Laboratory suggested it is increasingly hard for industry to find places that provide low-cost labor, meaning that U.S. firms should instead seek low-cost manufacturing technologies. Specifically, manufacturers who use robotics, Brooks said, have gotten
“stuck in what was developed in the 1960s. There’s very little integration of sensors and computation with these robots.” As a result of this adherence to inflexible technology, Brooks added, “the integration cost of using robots in industry is 5 to 10 times the capital cost of the robots, and only makes sense if you do the same thing again and again.”

Bernhardt Trout, a chemical engineering professor and director of the Novartis-MIT Center for Continuous Manufacturing, asserted that the traditional, small-molecule part of the pharmaceuticals industry — firms that make over-the-counter medicines, for instance — invest a “shockingly low” portion of their capital in further product development, instead reaping high profits from existing products, while basic manufacturing technologies have not changed for decades. Trout suggested a streamlined drug-approval process would help motivate industry innovation, but equally claimed the “financialization” of the industry has hurt product development; firms see themselves as “marketing and supply companies.” Advances in academic research, Trout said, are thus especially critical if the industry is to move forward.

The rapid spread of manufacturing know-how has had double-edged effects, observed Sanjay Sarma, an associate professor of mechanical engineering. Profitable industries can now be located around the world, while multinational firms build global supply chains to move products in bulk. “The thing that really hurts manufacturing in the U.S. is the flattening effect that comes from economies of scale,” Sarma said. In response, Sarma suggested domestic manufacturing can become lucrative with the use of “small-lot logistics,” technologies that reduce production and transportation costs and can make many businesses, such as apparel firms, more viable.

However, making new manufacturing environmentally sustainable will be a large challenge, said Timothy Gutowski, also a professor of mechanical engineering. “Here’s the problem: Underpriced ecosystem services provide a competitive advantage,” said Gutowski, meaning that companies who extract natural resources cheaply still have edges in manufacturing. Cooperation between industry and government — and between governments — will be necessary to put new manufacturing on a sound environmental foundation.

Charles Cooney, a professor of chemical engineering moderating the second panel, concluded that three things are important to improving U.S. manufacturing: an understanding of systems thinking, which can help create new, possibly local and regional forms of manufacture and distribution; a recognition that sound public policy will be a necessary part of new development; and a multi-agency approach to science and technology funding, to improve the odds that more forms of research will move from the lab to the factory.