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LETTERS

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Breast Cancer and Environmental Research

CHRISTOPHER WILD, DIRECTOR OF THE INTERNATIONAL AGENCY FOR RESEARCH ON CANCER, introduced the concept of the “exposome,” encompassing a person’s environmental exposures across a lifetime, with an image of a fiddler crab, warning against science walking sideways with one powerful “genome” claw and a second, radically smaller body of knowledge about environmental exposure (1). In this regard, the special section on Breast Cancer (28 March, p. 1451) suffers from a grave imbalance. Discoveries of the BRCA gene are important science and interesting history, and additional low-penetrance breast cancer genes are noteworthy, too. However, given that “most cases of breast cancer have no inherited component” (p. 1462), it’s troubling to see a special section on breast cancer that ignores substantial discoveries in environmental breast cancer studies over the same 20 years.

Three compelling themes have emerged from studies of environmental factors. First, breast cancer is now recognized as a developmental disease, with windows of susceptibility across the life course, beginning in the womb, during puberty and the early reproductive years, and up to the 5 years before diagnosis (2). Second, laboratory studies reveal hundreds of common chemicals that activate relevant biological pathways, including genotoxic chemicals that cause mammary gland tumors in rodents (3), hormone disruptors that interact with the estrogen receptor and promote tumor proliferation (4), and developmental toxicants that alter mammary gland development in rodents in ways that later affect lactation and cancer susceptibility (5). Third, the U.S. National Report on Human Exposure to Environmental Chemicals and other exposure studies show that these suspect chemicals are widespread in air and water pollution (6), consumer products (7), house dust and air (8, 9), and human tissues (10).

Three authoritative reports—by the President’s Cancer Panel (6), Institute of Medicine (2), and Interagency Breast Cancer and Environmental Research Coordinating Committee (11)—highlight the importance of such research. Because the exposures are so widespread and breast cancer is so common, addressing environmental factors has the potential to save thousands of women each year, even though the relative risks are vastly smaller than for the BRCA genes.

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Is cancer research walking sideways?

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Copper Limits: Opportunity Costs

IN THE NEWS FOCUS STORY “THE COMING copper peak” (14 February, p. 722), R. A. Kerr describes the public debate over the long-run availability of copper and other mineral commodities. What is troubling is that despite all we have learned since the publication of *Limits to Growth* (1) over four decades ago, we still focus on the fact that Earth contains a fixed stock of copper. Estimates of this stock are always a very tiny fraction of the total copper in Earth, for the logical reason that long before the last copper atoms are mined, costs become prohibitive. The fatal flaw of the fixed stock paradigm is that the amount of copper humans can ultimately produce—what the U.S. Geological Survey (USGS) refers to as resources—

Letters to the Editor

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Chile's copper mines.

changes over time with new technology. For example, USGS in the early 1970s estimated global copper resources at 1.6 billion tons. Its latest figure—5.6 billions tons—has more than tripled (2).

More useful is the opportunity cost paradigm, which assesses long-run availability by what society has to give up for another ton of copper (3, 4). It focuses on real prices, and the race between the cost-increasing effects of depletion and the cost-reducing effects of new technology. Over the past century, new technology has kept depletion at bay (5). Will this continue over the 21st century? Given the erratic course of technological change, no one knows for certain. What we do know is that global population and copper consumption grew very rapidly during the 20th century; both will grow more slowly over the coming century. We also know that a lot of copper remains in marginal porphyry deposits with 0.4 to 0.5% copper equivalent. This

should make it easier than in the past for new technology to keep copper readily available at reasonable costs.

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Copper Limits: Recycling Potential

R. A. KERR'S NEWS FOCUS STORY "THE COMING COPPER PEAK" (14 February, p. 722) draws conclusions based on analyses that equate the exploitation of copper to forecasts for other commodities. The concept of peak copper is not valid because copper is used but not consumed (as is oil). As such, the quantity of copper on Earth remains constant throughout civilization.

The peak copper theory is not valid because of the physical and economic effects of recycling. Were copper to become scarcer, its price would rise, but only to some upper limit because more recycled copper would become available. Because of rising global economic per capita income by the end of this

century (1, 2), the global rate of economic growth will become slower, and with it the use of copper and of other metals. Reduced growth in copper use implies that the availability of secondary recycled copper will increase, and therefore its competition with primary copper will strengthen.

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Copper Limits: Human Agency

THE NEWS FOCUS STORY "THE COMING COPPER PEAK" (R. A. Kerr, 14 February, p. 722) points out that the timing of any production peak depends on a dynamic interplay of geology, economics, and technology. Another crucial factor is human agency. Resource owners and producers are not automatons, but shrewd businesspeople who can usually avoid an abrupt and catastrophic decline in production. For example, at some point in the near future, Chile—the dominant copper producer—might decide that it makes sense not to increase production by more than a factor of 50% by 2030, but to allow prices to increase, thus rationing a scarce commodity. This is one of many reasons to expect that the peak in copper production would not be nearly as disruptive as the News story indicates.

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TECHNICAL COMMENT ABSTRACTS

Comment on "Revealing Nature's Cellulase Diversity: The Digestion Mechanism of *Caldicellulosiruptor bescii* CelA"

Alexander V. Gusakov

Brunecky *et al.* (Reports, 20 December 2013, p. 1513) compared the cellulolytic activity of bacterial multimodular cellulase CelA with fungal Cel7A (cellobiohydrolase I from *Trichoderma reesei*). If more active Cel7A from another fungus were used as a reference enzyme under optimal conditions with β -glucosidase added, the reported difference between bacterial and fungal enzymes would be less dramatic.

Full text at <http://dx.doi.org/10.1126/science.1251248>

Response to Comment on "Revealing Nature's Cellulase Diversity: The Digestion Mechanism of *Caldicellulosiruptor bescii* CelA"

Roman Brunecky, Markus Alahuhta, Qi Xu, Bryon S. Donohoe, Michael F. Crowley, Irina A. Kataeva, Sung-Jae Yang, Michael G. Resch, Michael W. W. Adams, Vladimir V. Lunin, Michael E. Himmel, Yannick J. Bomble

Gusakov critiques our methodology for comparing the cellulolytic activity of the bacterial cellulase CelA with the fungal cellulase Cel7A. We address his concerns by clarifying some misconceptions, carefully referencing the literature, and justifying our approach to point out that the results from our study still stand.

Full text at <http://dx.doi.org/10.1126/science.1251701>

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