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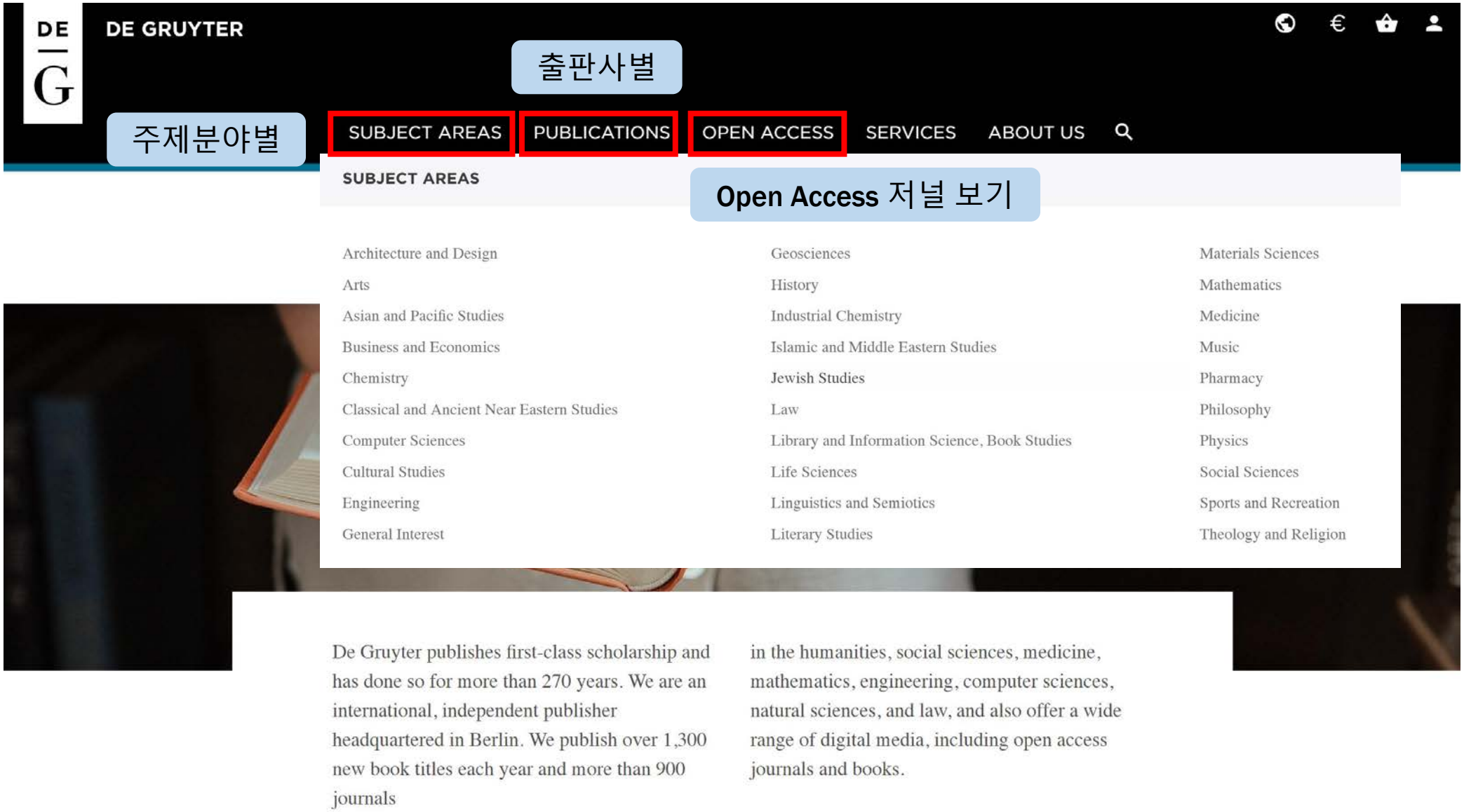

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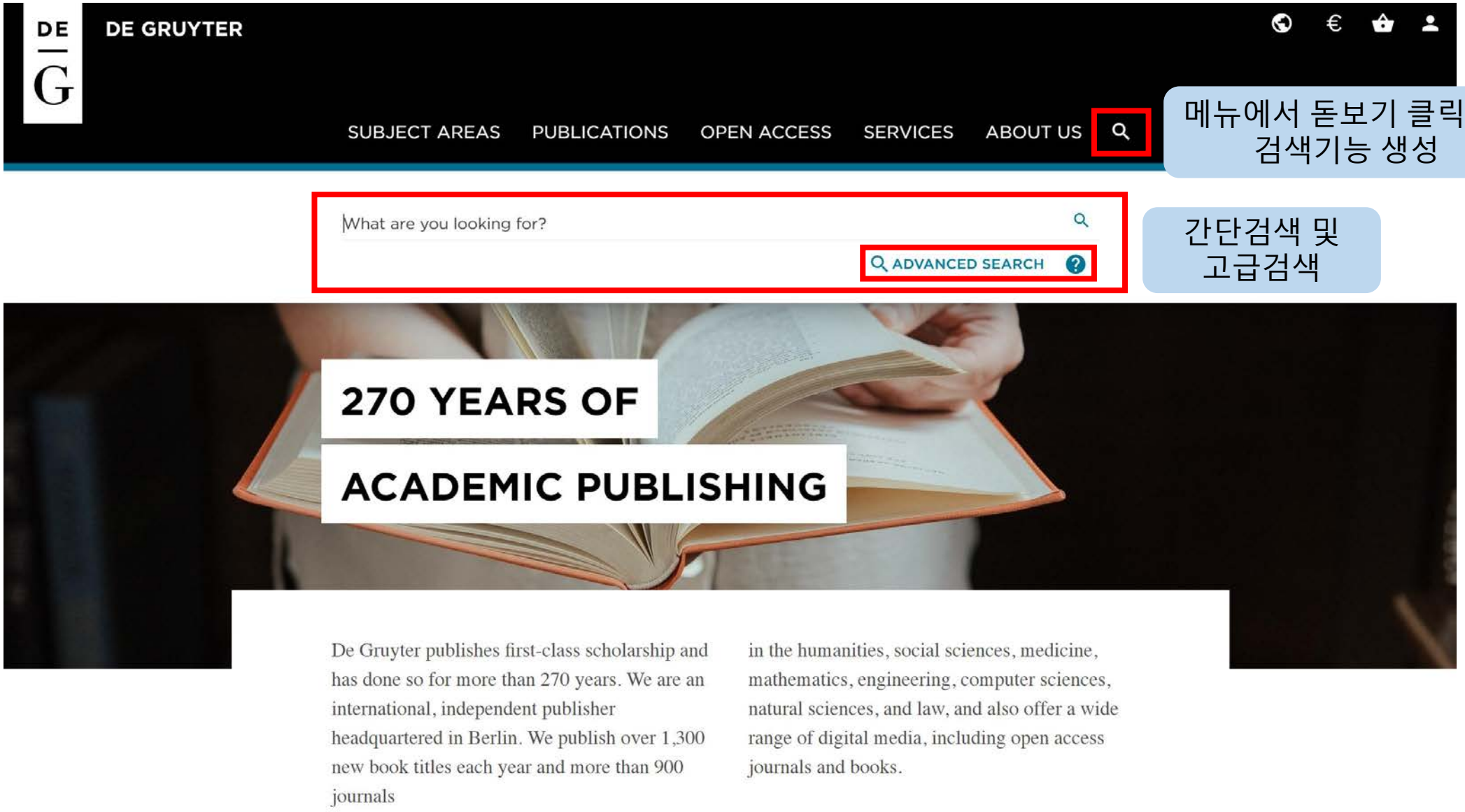

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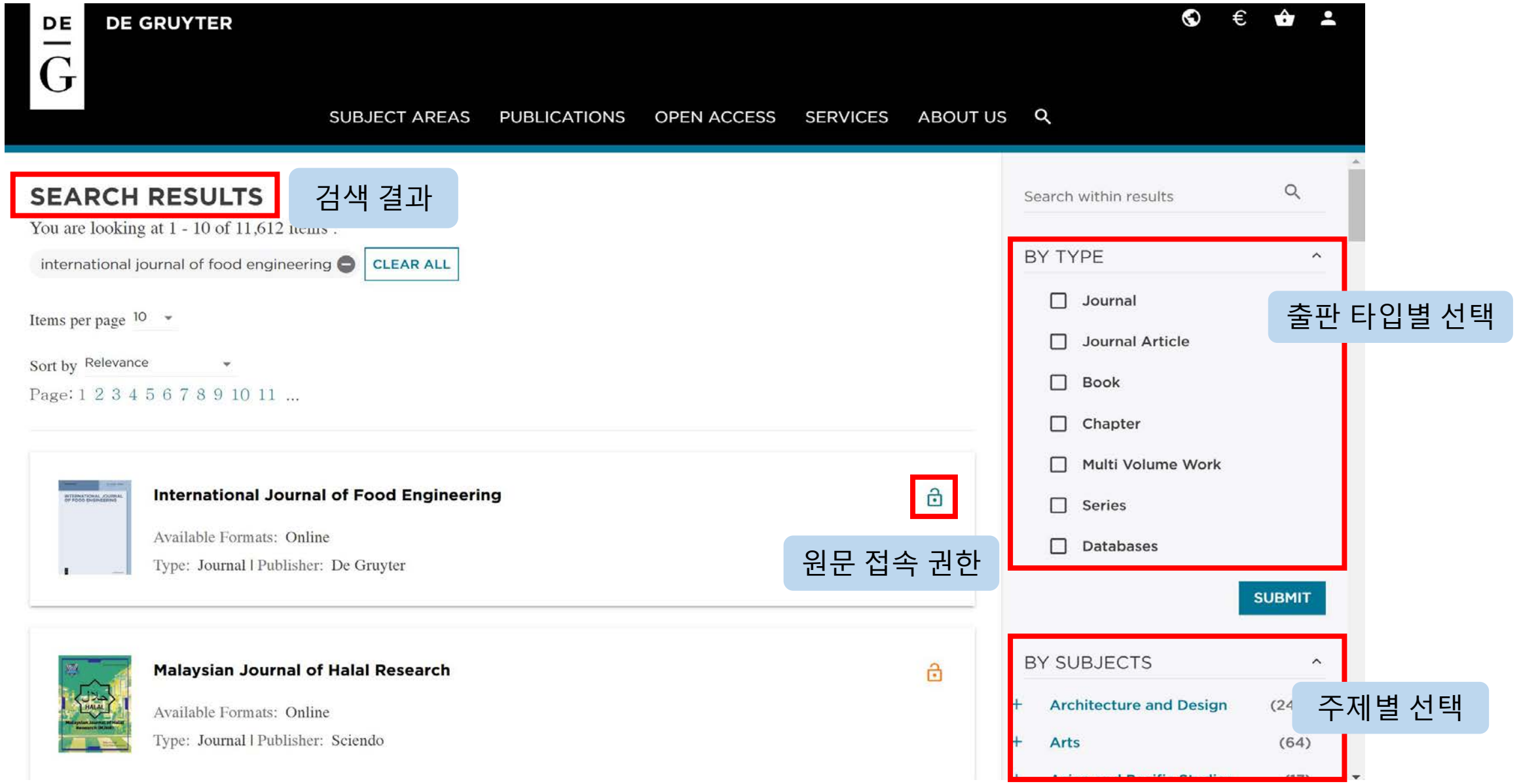

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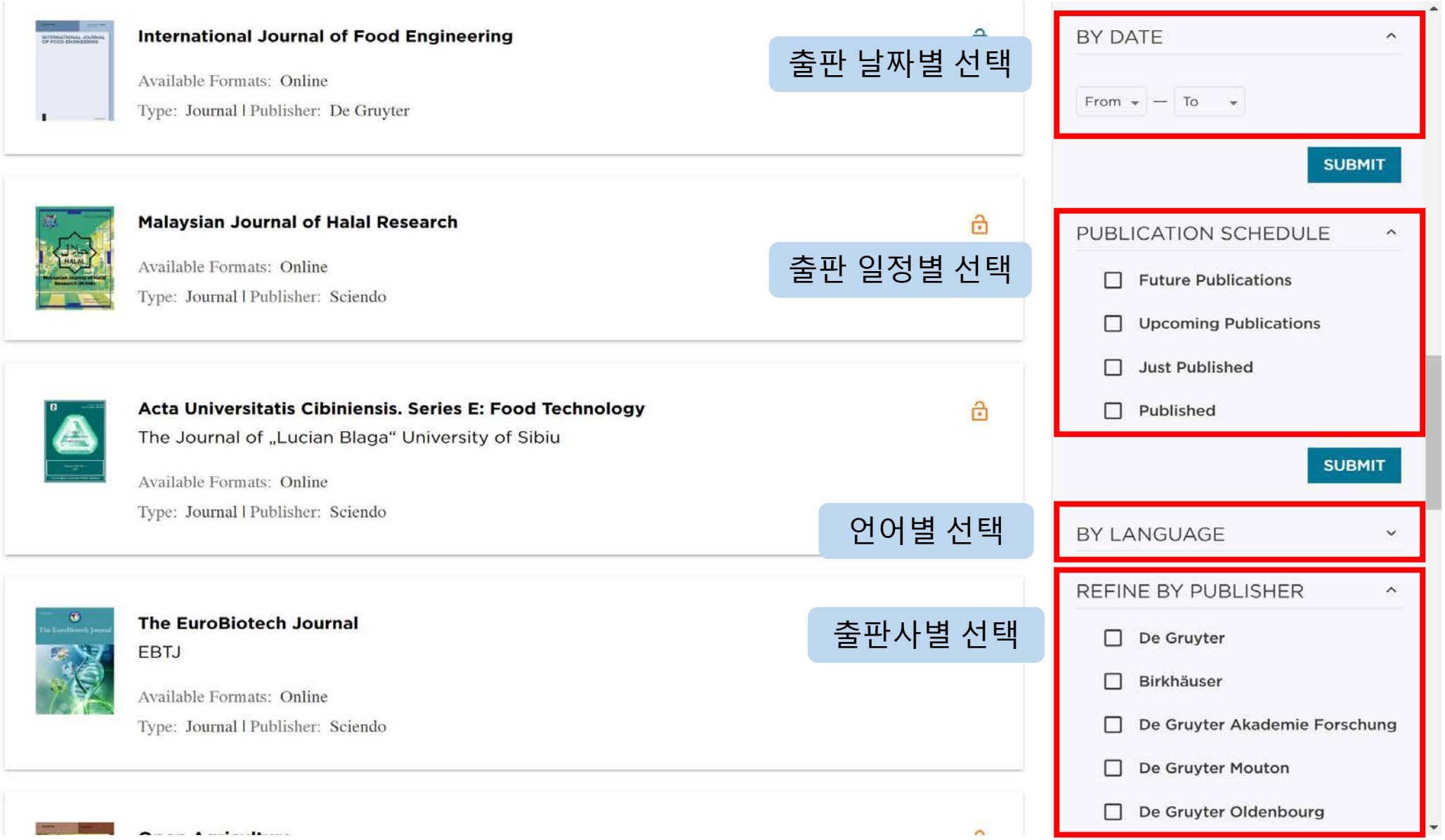

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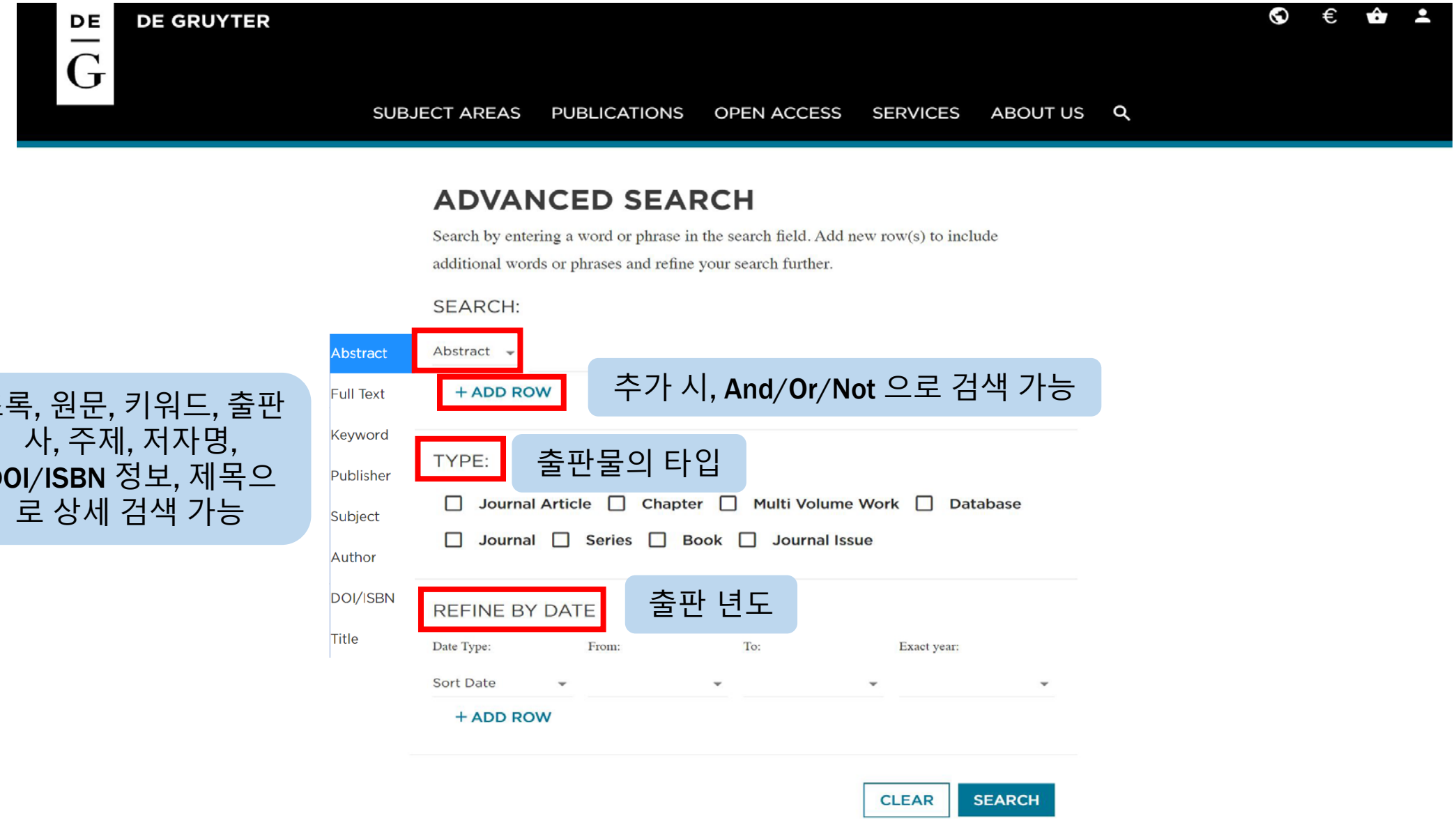

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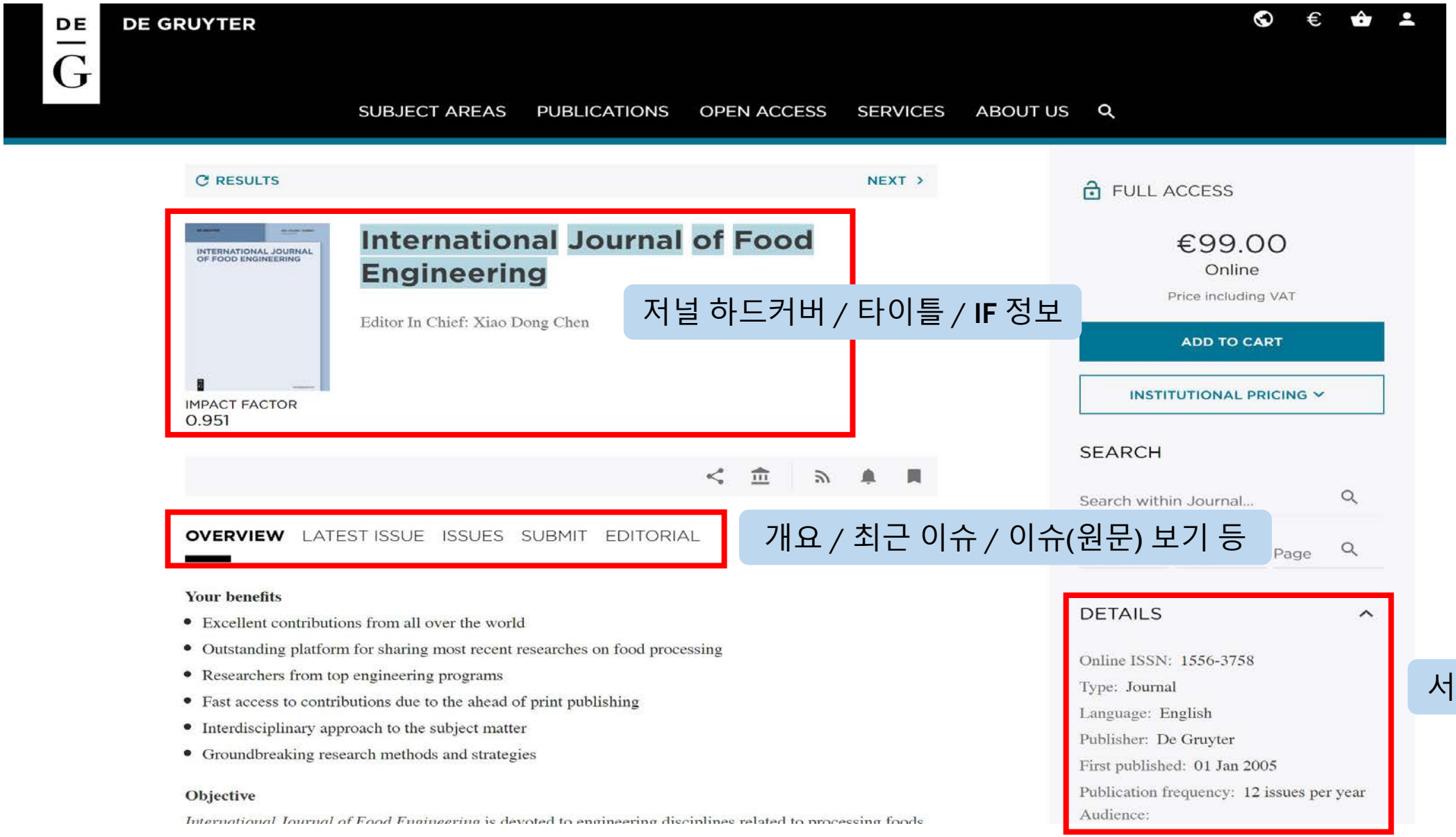

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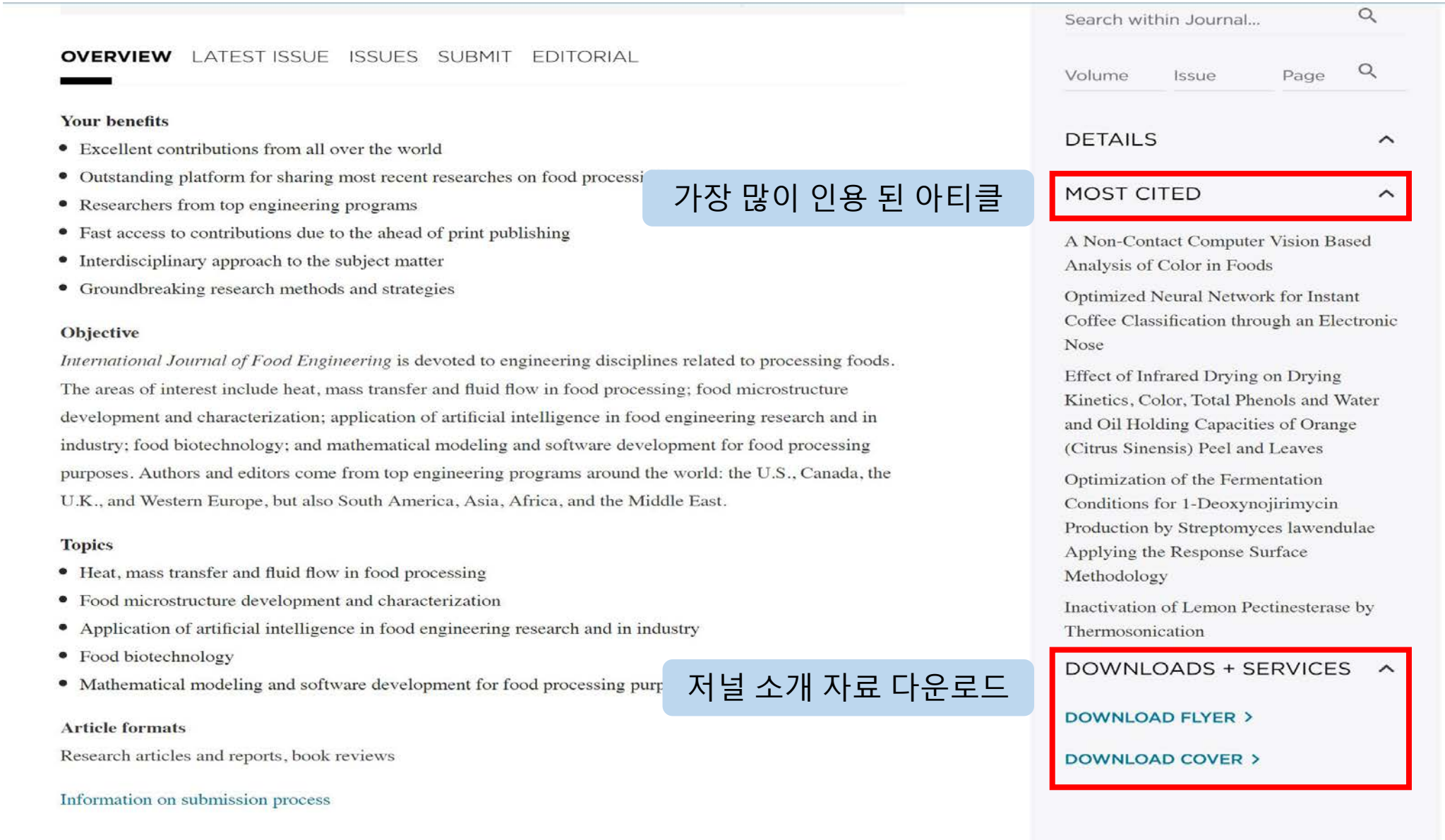

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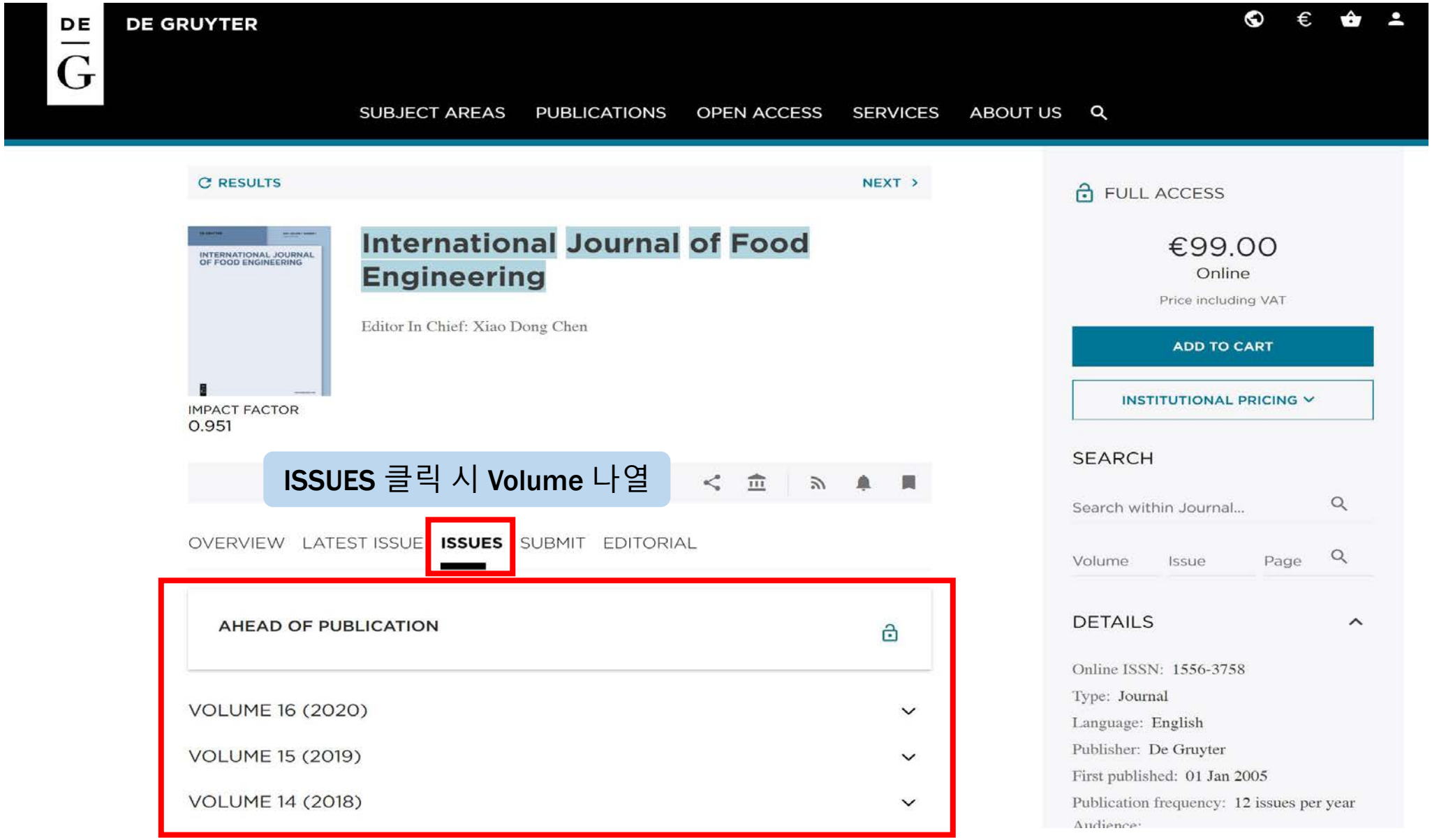

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CRITICAL REVIEW

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Safe and Complete Extraction of Astaxanthin from *Haematococcus pluvialis* by Efficient Mechanical Disruption of Cyst Cell Wall

Muhammad Irshad, Min Eui Hong, Aye Aye Myint, Jaehoon Kim and Sang Jun Sim

Article Number: 20190128 | Published online: 03 Oct 2019

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Haematococcus pluvialis (*H. pluvialis*) can naturally accumulate high amounts of astaxanthin – a powerful antioxidant. However, complete rec

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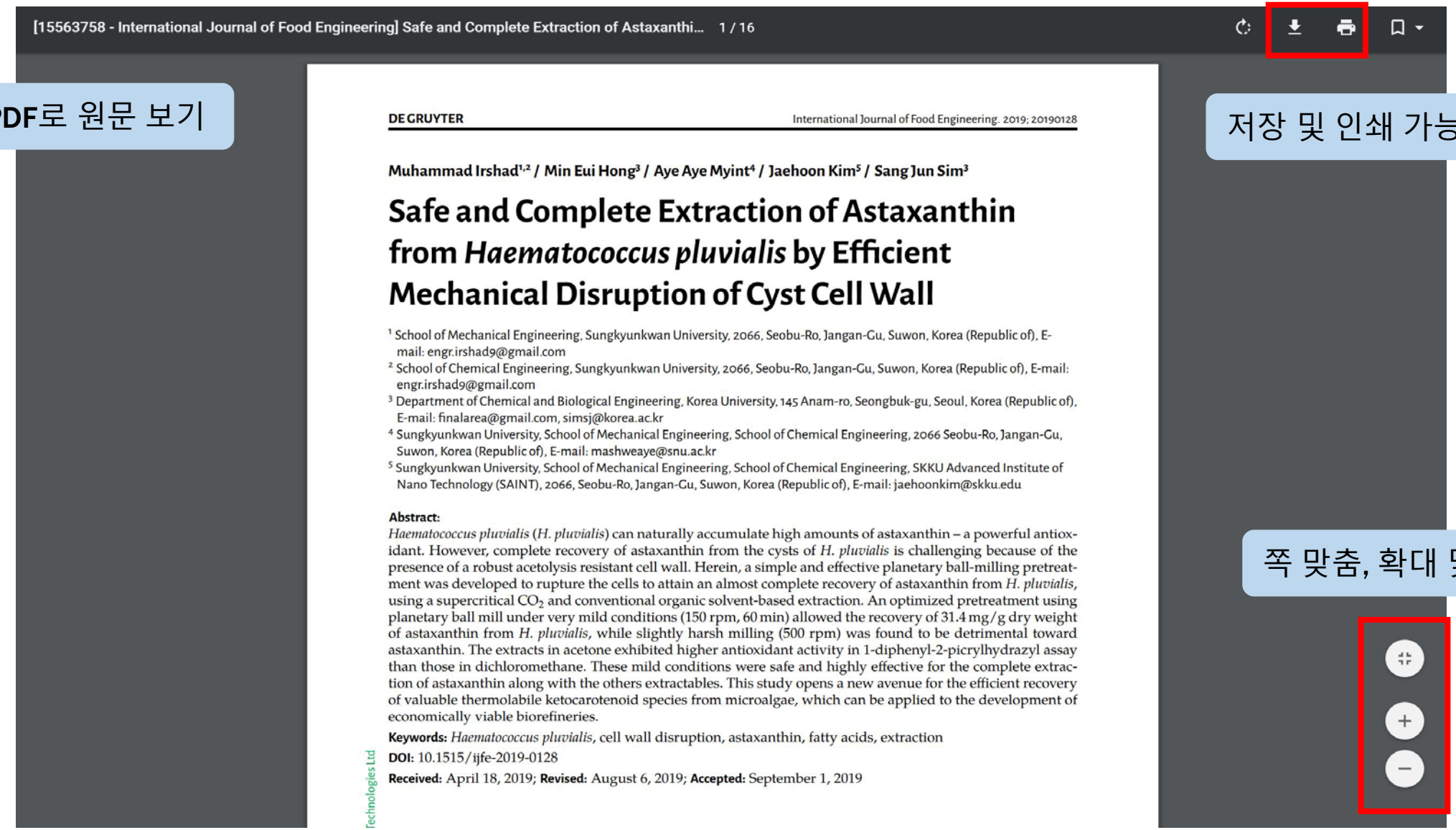

DE GRUYTER International Journal of Food Engineering. 2019; 20190128

Muhammad Irshad[1,2] / Min Eui Hong[3] / Aye Aye Myint[4] / Jaehoon Kim[5] / Sang Jun Sim[3]

Safe and Complete Extraction of Astaxanthin from *Haematococcus pluvialis* by Efficient Mechanical Disruption of Cyst Cell Wall

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Abstract:
Haematococcus pluvialis (*H. pluvialis*) can naturally accumulate high amounts of astaxanthin – a powerful antioxidant. However, complete recovery of astaxanthin from the cysts of *H. pluvialis* is challenging because of the presence of a robust acetolysis resistant cell wall. Herein, a simple and effective planetary ball-milling pretreatment was developed to rupture the cells to attain an almost complete recovery of astaxanthin from *H. pluvialis*, using a supercritical CO_2 and conventional organic solvent-based extraction. An optimized pretreatment using planetary ball mill under very mild conditions (150 rpm, 60 min) allowed the recovery of 31.4 mg/g dry weight of astaxanthin from *H. pluvialis*, while slightly harsh milling (500 rpm) was found to be detrimental toward astaxanthin. The extracts in acetone exhibited higher antioxidant activity in 1-diphenyl-2-picrylhydrazyl assay than those in dichloromethane. These mild conditions were safe and highly effective for the complete extraction of astaxanthin along with the others extractables. This study opens a new avenue for the efficient recovery of valuable thermolabile ketocarotenoid species from microalgae, which can be applied to the development of economically viable biorefineries.

Keywords: *Haematococcus pluvialis*, cell wall disruption, astaxanthin, fatty acids, extraction
DOI: 10.1515/ijfe-2019-0128
Received: April 18, 2019; **Revised:** August 6, 2019; **Accepted:** September 1, 2019

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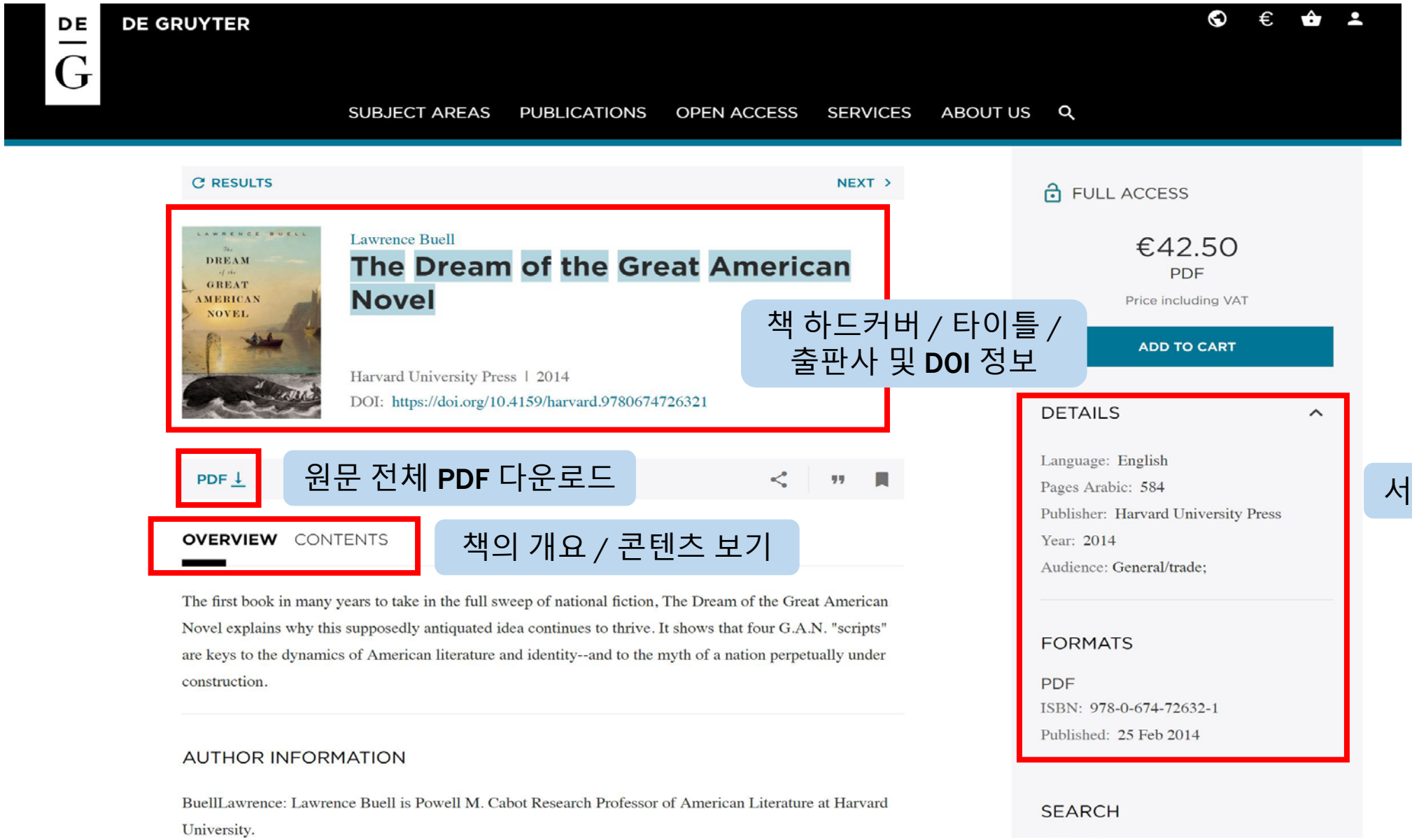

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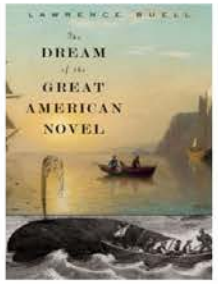

Lawrence Buell

The Dream of the Great American Novel

Harvard University Press | 2014

DOI: https://doi.org/10.4159/harvard.9780674726321

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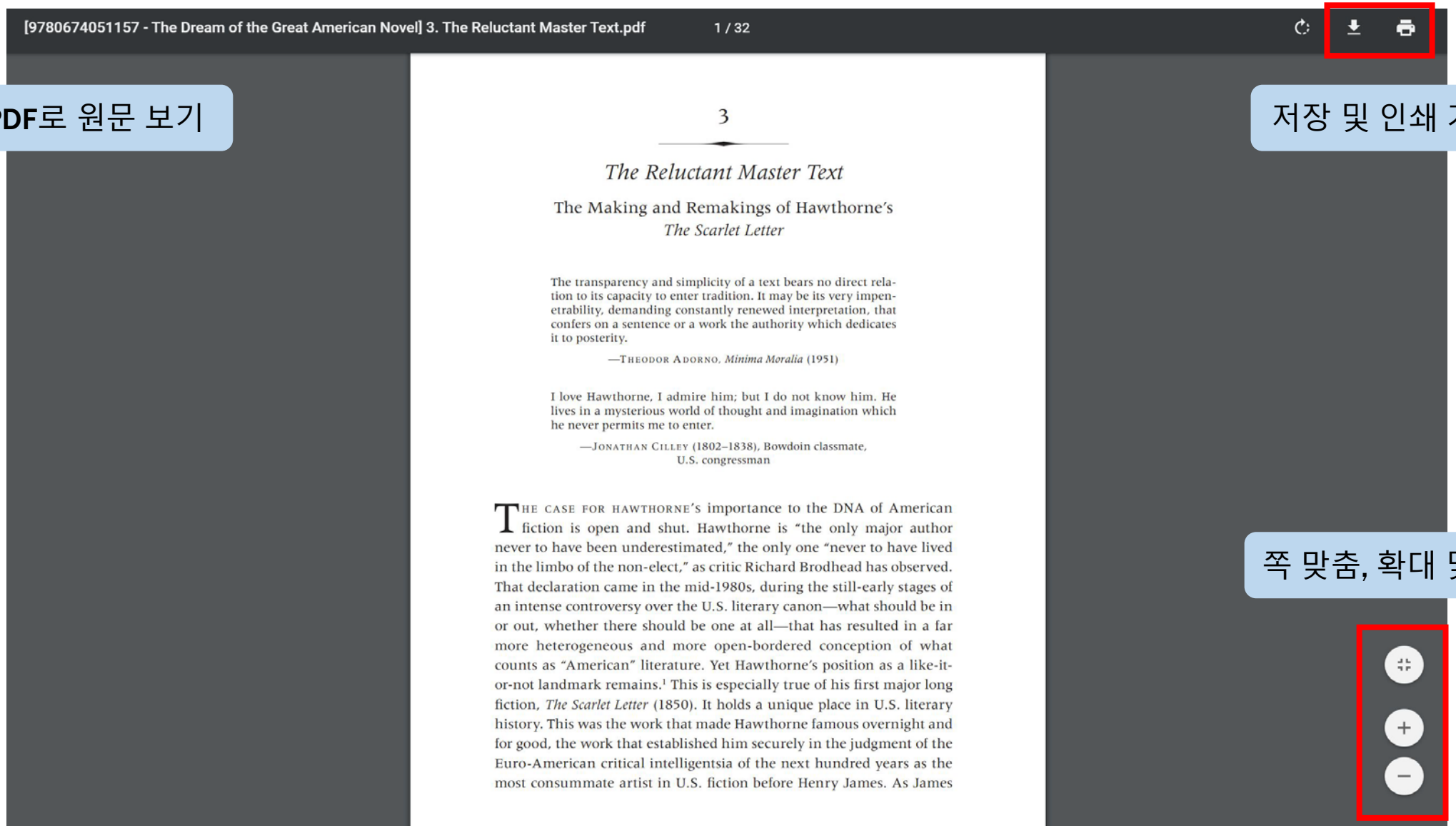

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The Reluctant Master Text

The Making and Remakings of Hawthorne's
The Scarlet Letter

The transparency and simplicity of a text bears no direct relation to its capacity to enter tradition. It may be its very impenetrability, demanding constantly renewed interpretation, that confers on a sentence or a work the authority which dedicates it to posterity.

—Theodor Adorno, *Minima Moralia* (1951)

I love Hawthorne, I admire him; but I do not know him. He lives in a mysterious world of thought and imagination which he never permits me to enter.

—Jonathan Cilley (1802–1838), Bowdoin classmate, U.S. congressman

The case for Hawthorne's importance to the DNA of American fiction is open and shut. Hawthorne is "the only major author never to have been underestimated," the only one "never to have lived in the limbo of the non-elect," as critic Richard Brodhead has observed. That declaration came in the mid-1980s, during the still-early stages of an intense controversy over the U.S. literary canon—what should be in or out, whether there should be one at all—that has resulted in a far more heterogeneous and more open-bordered conception of what counts as "American" literature. Yet Hawthorne's position as a like-it-or-not landmark remains.[1] This is especially true of his first major long fiction, *The Scarlet Letter* (1850). It holds a unique place in U.S. literary history. This was the work that made Hawthorne famous overnight and for good, the work that established him securely in the judgment of the Euro-American critical intelligentsia of the next hundred years as the most consummate artist in U.S. fiction before Henry James. As James

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