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BIOTECHNOLOGY & INDIGO DYE

ISSUE: Bio-synthesis of indigo dye.
PRODUCT: Indigo is a blue dye used primarily for coloring denim jeans.
IMPACT: Biological production of indigo dye has potential to eliminate chemical production in U.S., Germany and Japan; may result in process which is less energy intensive and more environmentally sound.
PARTICIPANTS: Amgen Corp. has collaborative effort with Eastman Kodak Co. (see company profile)
ECONOMIC STAKES: Estimated (US) \$250 million world market (\$125 million U.S. market)
WHEN: Commercial product likely in early 1990s.

Biotechnology offers a new means of production which will someday make synthetic production of certain chemicals, dyes, pigments, etc. obsolete. This issue of RAFI Communique examines how biotechnology may be used to displace synthetic production of indigo dye.

Indigo dye was traditionally a plant-derived product which was replaced by a technique for synthetic production around the turn of the century. Now, using biotechnology, the production of indigo dye has come full circle. Using genetic engineering to modify cells, Amgen Corp. is now producing indigo dye in the laboratory. If commercially successful, bio-synthesis of indigo dye will someday make chemically-produced indigo obsolete.

HISTORY OF INDIGO DYE

The blue dye, indigo, has been used since ancient times. The dye was traditionally derived from Indigofera, a species of leguminous plants found in tropical regions. Over 40 species of Indigofera are indigenous to India, where large-scale indigo plantations were established in the 1800s as a primary source of indigo for the European textile market.

In 1897, when a German chemical company first marketed a synthetically-produced indigo dye, there were some 574,000 hectares of indigo cultivated in Bihar and Bengal states of India. By 1911, only 86,600 hectares remained, and by 1920,

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the region's industry had virtually disappeared.¹

The rapid demise of indigo cultivation was devastating to the economy of Bihar and Bengal. British imports of indigo dye fell from 1.8 million (British pounds) in 1876 to only 48,000 (British pounds) in 1913.² Many former indigo workers, unable to find alternative sources of income, were victims of famine which struck the region. In 1984, a group of U.S. sociologists observed that, "the parts of India that formerly were most dependent on indigo cultivation still have not recovered from the effects of this technological innovation."³

CHEMICAL PRODUCTION OF INDIGO DYE

Today, synthetic indigo dye is produced in Germany, the United States and Japan. The vast majority of the blue dye is used for coloring cloth--especially blue denim jeans. The world's largest producers of indigo dye are BASF (Fed. Republic of Germany), Imperial Chemical Industries (UK), Buffalo Color (USA) and Mitsui Toatsu Chemicals (Japan). Worldwide, the market for indigo dye is valued at an estimated \$250 million.

BIO-SYNTHESIS OF INDIGO DYE

In 1983, scientists at Amgen Corp. (Thousand Oaks, California, USA) were experimenting with enzymes engineered to eat moth balls. Purely by accident, the scientists discovered that the enzymes were excreting a blue, indigo-colored dye.

According to Amgen, the bio-synthesis of indigo dye is "a trick of nature." The company's patented technique involves the growth of genetically-altered e. coli cells in a special nutrient medium which results in the excretion of indigo dye. (The process does not involve the use of plant germplasm.)⁴

Even though the process does not involve indigofera (or any other plant), Amgen is confident that their product will be regarded as⁵ "natural indigo" because it involves fermentation.

According to Amgen, bio-synthesis of indigo dye has significant advantages over synthetic production. In contrast to the standard chemical production of "indigo," Amgen's biological approach is much less energy intensive, is non-toxic, and does not result in harmful by-products. The company predicts that it will be "at least a few years before commercialization" of an indigo product. Amgen is now working

collaboratively with Eastman Kodak Co. (Rochester, New York, USA) to see if indigo can be economically produced on a commercial scale.

Amgen's Director of Strategic Planning, Dr. Phil Whitcome, describes the company's work with indigo as a "test case." Indigo, the single biggest dye used in the United States, is just one of many chemical products that may be the target of future biotechnology research. According to Dr. Whitcome, "Environmental pressures will force people to look for alternative production...In the future, we will take for granted that you can engineer cells to produce specialty chemicals."

CONCLUSION

Traditional methods for chemically-produced indigo dye result in a product which is heavy (80% water) and thus difficult and costly to transport over long distances. If commercially viable, biological production of indigo dye will make it possible to decentralize indigo production and result in easier access for textile manufacturers.

Past issues of RAFI Communique have looked at biotechnology's impact on agriculture and how these new technologies may transfer production of certain Third World commodities to laboratories and factories in the industrialized world. (see for example, "Vanilla and Biotechnology", January, 1987). The case of indigo dye illustrates how biotechnology will dramatically transform industrial production of certain chemicals--replacing synthetic production with a biological means of production which (in some cases) is less toxic and more environmentally sound.

COMPANY PROFILE
Biotechnology Companies Working on Indigo Dye

Amgen (Thousand Oaks, California, USA), a publicly-held biotech company founded in 1980. With 1986 revenues of \$23.4 million, Amgen was ranked the 3rd largest biotech company in 1987. The company specializes in human health care and specialty chemical products through application of recombinant DNA technology and molecular biology. Also developing livestock products (bovine and porcine growth hormones) with corporate partners.

Eastman Kodak Co. (Rochester, New York, USA), with 1986 sales of (US) \$11.5 billion, Kodak ranks # 26 on Fortune Magazine's list of largest U.S. industrial corporations. The company is a major player in biotechnology, focusing primarily on animal nutrition, agricultural technology and pharmaceuticals. In addition to their own in-house research and development, the company had up to 19 different partnerships with small biotechnology companies in 1986-87.

NOTES

- ¹ Martin-Leake, Hugh. "An Historical Memoir of the Indigo Industry of Bihar", Economic Botany, October-December, 1975, p. 368.
- ² Brockway, Lucile H., Science and Colonial Expansion: The Role of the British Royal Botanical Gardens, Academic Press, 1979, p.29.
- ³ Buttell, F.H., Kenney, M., and Kloppenburg, J., "Socio-Economic Impact of Product Dislocation" in ATAS Bulletin: Tissue Culture Technology and Development, November, 1984, p. 50.
- ⁴ Personal communication with Dr. Bert Ensley, Manager of Scientific Affairs, Division of Specialty Chemicals, Amgen, July, 1988.
- ⁵ Amgen believes that the United States Food and Drug Administration, the govt. agency which regulates food and drug products, will consider their product as "natural indigo".
- ⁶ Personal communication with Dr. Phil Whitcome, Director of Strategic Planning, Amgen, July, 1988.
- ⁷ Ibid.