

**Econ 486X**  
**Science and Technology and Economic Growth**  
**Fall 2003**

**Professor Wallace Huffman** - 382A Heady Hall, 294-6359  
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Office Hours: T,Thu 1-2, Fri 2-3, and by appointment

**Class meeting:** MWF 1:10pm, Agronomy 2026

**A. Course Objectives:** Review of sources and differences in economic growth experiences of nations; sustainability of economic growth; convergence in economic growth rates; sources of technical change, including endogenous or induced technical change and rise of institutionalized research and invention; technical innovations and industrial change; the role of physical sciences, including chemistry and information science and technology, and biological sciences, including agriculture and biotechnology, in modern economic growth; economics of adoption, diffusion and technology transfer; interrelationships between public and private sectors; economics of science and technology policy, including intellectual property rights, universities of science and technology, sources of funding and funding mechanisms, and organization of science and technology.

**B. Grading:**

1. Exams: Midterm	35%
Final	45%
2. Short paper on any topic of course: 4 pages (Undergraduates)	20%
10 pages (Graduates)	

**C. Course Outline and Reading list (see separate sheets)**

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**Outline**

**I. Introduction**

**II. Theories of Economic Growth**

**III. The Sources of Technical Change**

**A. Discovery, Invention, and Innovation**

**B. Technical and Institutional Innovation**

**C. Technology Adoption, Diffusion, and Transfer**

**IV. Technical Innovation and Industrial Change**

**A. Physical Sciences**

**1. Chemicals**

**2. Semi -Conductors**

**B. Biological Sciences**

**1. Agriculture**

**2. Biotechnology**

**V. Science and Technology Policy**

**Required Text:**

(1) Ruttan, Vernon. *Technology, Growth, and Development*. New York: NY: Oxford University Press, 2001.

(2) Jones, C.I. *Introduction to Economic Growth*. 2nd Edition, New York, NY: W.W. Norton & Co., 2002.

**Science and Technology and Economic Growth****I. Introduction**

1. Leshner, A. I. "Public Engagement with Science," *Science* 299(Feb 14, 2003): 97.
2. Jones, C.I. "The Facts of Economic Growth," in *Introduction to Economic Growth*, Norton, 2002.
3. Pritchett, L. "Divergence, Big Time," *Journal of Economic Perspectives II* (Summer 1997): 3-17.
4. Kennedy, D. "Two Cultures," *Science* 299(Feb 21, 2003): 1148.
5. Editor. "Biotechnology: The Fear Factor," *Nature* 20(Oct 2002): 957.

**II. Theories of Economic Growth**

1. Yang, X. "Classical Development Economics," in *Economic Development and the Division of Labor*. Blackwell Publishing, 2003, pp. 20-31.
2. Jones, C. "The Solow Growth Model," in *Introduction to Economic Growth*.
3. Jones, C. "Empirical Application of Growth Models," in *Introduction to Economic Growth*.
4. Jones, C. "The Economics of Ideas," in *Introduction to Economic Growth*.
5. Jones, C. "The Engine of Growth," in *Introduction to Economic Growth*.
6. Jones, C. "A Simple Model of Growth and Development," in *Introduction to Economic Growth* and "Sources of U.S. Economic Growth in a World of Ideas," *American Economic Review* 92(March 2002): 220-239.
7. Davis, D.R. and D.E. Weinstein. "Bones, Bombs, and Break Points: The Geography of Economic Activity," *Amer. Econ. Rev.*(Dec 2002): 1269-89.
8. Carlaw, K.I. and R.G. Lipsey. "Externalities, Technological Complementarities and Sustainable Economic Growth," *Research Policy* 31(2002):1305-15
9. Nelson, R. "How New is the New Growth Theory?" *Challenge* 40(Sept-Oct 1997): 29-58.

**III. The Sources of Technical Change****A. Discovery, Invention, and Innovation**

1. Ruttan, V.W. "The Process of Invention and Innovation," in *Technology, Growth, and Development: An Induced Innovation Perspective*. New York, NY: Oxford University Press, 2001 pp. 63-69.
2. Nelson, R. and P.M. Romer. "Science, Economic Growth and Public Policy," *Challenge* 39(Mar-April 1996): 9-21.
3. Nelson, R. "On the Uneven Evolution of Human Know-How." *Research Policy* 31(2002): 1-14.

4. Cohen, W.M., R.R. Nelson, and J.P. Walsh. "Protecting their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or not)," Nat. Bur. Econ. Res., Working Paper 7552, Feb. 2000.

## **B. Technical and Institutional Innovation**

1. Ruttan, V.W. "Technical and institutional Innovation," in *Technology, Growth, and Development*, pp. 100-146.
2. Knack, S. and P. Kiefer. "Institutions and Economic Performances Cross-Country Tests using Alternative Measures," *Economic Politics* 7(1995): 207-227.
3. Jones, C.T. "Infrastructure and Long Run Economic Performance," in *Introduction to Economic Growth*.
4. Mazzoleni, R. and R. Nelson. "The Benefits and Costs of Strong Patent Protection: A Contribution to the Current Debate," *Research Policy* 27(1998): 278-284.
5. Ginarte, J.C. and W.G. Park. "Determinants of Patent Rights: A Cross-National Study." *Research Policy* 26(1997): 283-301.
6. Griliches, F. "Patent Statistics as Economic Indicators: A Survey," *Journal of Economic Literature* 28 (1990): 1661-1707.
7. Wright, B. "The Economics of Invention Incentives: Patents, Prizes, and Research Contracts," *American Economic Review* 73(1983): 707-728.
8. Henderson, R., A.B. Jaffe, and M. Trajtenberg. "Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting," *Review of Economics & Statistics* 80(Feb 1998): 119-127.
9. Botero, J., S. Djankov, R. LaPorta, F. Lopez, and A. Sheifer. "The Regulation of Labor," World Bank Research Paper, May 2003.

## **C. Technology Adoption, Diffusion, and Transfer**

1. Ruttan, V.W. "Technology, Adoption, Diffusion and Transfer," in *Technology, Growth, and Development*, pp. 147-176.
2. Evenson, R.E. and Y. Kislev. "Research and Productivity in Wheat and Maize," *Journal of Political Economy* 81(1973): 1309-1329.
3. Geroski, P.A. "Models of Technology Diffusion," *Research Policy* 29(2000): 603-625.
4. Griliches, Z. "Hybrid Corn and the Economics of Innovation," *Science* 132(July 29, 1960): 275-280.

## **IV. Technical Innovation and Industrial Change**

### **A. Physical Sciences**

#### **1. Chemicals**

- a. Ruttan, V.W. "Technical Change in the Chemical Industry," in

*Technology, Growth, and Development*, pp. 286-315.

b. Arora, A., R. Landau, and N. Rosenberg. *Chemicals and Longer-Term Economic Growth: Insights from the Chemical Industry*. New York, NY: John Wiley and Sons, 1998.

## 2. **Semi-conductors**

a. Ruttan, V.W. "The Computer and Semi-Conductor Industry," in *Technology, Growth and Development*, pp. 316-365.

b. World Bank. *Knowledge for Development*. World Development Report 1998/99. New York, NY: Oxford University Press 1999.

c. Jorgenson, D.W. "Information Technology and the U.S. Economy," *American Economic Review* 91(Mar 2001): 1-32.

d. Gust, C. and J. Marquez. "International Comparisons of Productivity Growth: The Role of Information Technology and Regulatory Practices," *Labour Economics* 324(2003).

## B. **Biological Sciences**

### 1. **Agriculture**

a. Huffman, W.E. and R.E. Evenson. "The Development of a System of Agricultural Sciences," in *Science for Agriculture*. Ames, IA: Iowa State University Press, 1993, pp. 30-64.

b. Committee to Review the Role of Publicly Funded Agricultural Research on the Structure of U.S. Agriculture, "Structural Impacts of Research," in *Publicly Funded Agricultural Research and the Changing Structure of U.S. Agriculture*. Washington: National Academy Press, 2002, pp. 30-51.

c. Huffman, W.E. "Modernizing Agriculture: A Continuing Process," *Daedalus* 127(Fall 1998): 159-175.

d. Huffman, W.E. and R.E. Evenson. "Research Contribution to Crop Improvement," in Huffman and Evenson, *Science for Agriculture*, 1993, pp. 152-180.

e. Ruttan, V.W. "Technical Change and Agricultural Development," in *Technology, Growth, and Development*, pp. 179-234.

f. Olmstead, A. and P. Rhode. "Induced Innovation in American Agriculture: A Reconsideration," *J. Pol. Econ.* 101(Feb 1993): 100-18.

g. Griliches, Z. "Hybrid Corn and the Economics of Innovation," *Science* 132(July 29, 1960): 275-280.

h. Olmstead, A. and P. Rhode. "Reshaping the Landscapes: The Impact and Diffusion of the Tractor in American Agriculture, 1910-1960," *Journal of Economic History* 61(Sept 2001): 663-698.

j. Evenson, R.E. and D. Gollin. "Assessing the Impact of the Green Revolution, 1960 to 2000." *Science* May 2, 2003.

k. Huffman, W.E. "Human Capital, Education and Agriculture," in G.H. Peters and P. Pingali, *Tomorrow's Agriculture: Incentives, Institution,*

- Infrastructure and Innovation*. Burlington, VT: Ashgate Publishing Co., 2001, pp. 207-222.
- l.Kislev, Y. and W. Peterson. "Prices, Technology, and Farm Size," *Journal of Political Technology* 90(1982): 578-595.
- m.Huffman, W.E. and R.E. Evenson. "Structural and Productivity Change, in U.S. Agriculture, 1950-1982," *Agr. Econ.* 24(2001):127-147.
- n.Huffman, W.E. "Private R&D Investments in Agriculture: The Role of Incentives, Public Policies, and Institutions," *Economic Dev & Cult Change* 51(Nov 2003).
- o.Pardey, P.G. and N.M. Beintema. *Slow Magic: Agricultural R&D a Century after Mendel*, Washington D.C.: International Food Policy Research Institute (IFPRI), Oct 26, 2001.

## 2. Biotechnology

- a.Ruttan, V.W. "The Biotechnology Industries," in *Technology, Growth, and Development*, pp. 368-422.
- b.Johnson, D.K.N. and V. Santaniello. "Biotechnology Inventions: What Can We Learn from Patents?" in V. Santaniello, R.E. Evenson, D. Zilberman, and G.A. Carlson, eds., *Agriculture and Intellectual Property Rights*, New York, NY: CABI Publishers, 2000, pp. 169-196.
- c.Foltz, J.D., B. L. Barham, and K. Kim. "Synergies or Tradeoffs in University Life Science Research." *Department of Applied Economics*, University of Wisconsin, June 2003.
- d.Fernandez-Cornejo, J. and W.D. McBride. *Adoption of Bioengineered Crops*, USDA, ERS, AER-810, May 2002.
- e.Falck-Zepada, J.B., G. Traxler and and R.G. Nelson. "Surplus Distribution from the Introduction of a Biotechnical Innovation," *American Journal of Agricultural Economics* 82(May 2000): 360-369.
- f.Qaim, N. and D. Zilberman. "Yield Effects of Genetically Modified Crops in Developing Countries." *Science* 299(2003): 900-902.
- g.Paarlberg, R.L. *The Politics of Precaution: Genetically Modified Crops in Developing Countries*. The John Hopkins University Press, 2001.
- h.Huffman, W.E. "Production, Identity Preservation and Labeling in a Market Place with Genetically Modified (GM) and non-GM Foods," *Plant Physiology*, forthcoming.
- i.Huffman, W.E., M. Rousu, J.F. Shogren, and A. Tegene. "Consumers Willingness to Pay for Genetically Modified Food Labels in a Market with Diverse Information: Evidence from Experimental Auctions," *Journal of Agricultural & Resource Economics*, forthcoming.
- j.Huffman, W.E., M. Rousu, J.F. Shogren, and A. Tegene. "Consumers' Resistance to Genetically Modified Foods in High Income Countries: The Role of Information in an Uncertain Environment," Department of

- Economics, Iowa State University, July 2003.
- k.Barham, B.L., J.D. Foltz, D. Jackson-Smith, and S. Moon. "The Dynamics of Agricultural Biotechnology Adoption: Lessons from rBST in Wisconsin, 1994 & 2001," *Amer. J. Agri. Econ.*, forthcoming.
- l.Arntzen, C.J. "Technology Progression in Plants Used for Food and Medicine," in A. Eagleshaw, C. Carlson, and R.W.F. Hardy, *Integrating Agriculture, Medicine and Food for Future Health*. NABC Report 14 on Food and Health, New York, NY: National Agricultural Biotechnology Council, 2000, pp. 43-50.
- m.Dhar, T. and J.D. Foltz. "Market Structure and Consumer Valuation in the rBST-Free and Organic Milk Markets," Department of Applied Economics, University of Wisconsin, July 2003.
- n.Nestle, M. "Food Safety is Political," in *Safe Food: Bacteria, Biotechnology and Bioterrorism*. Berkeley, CA: University of California Press, 2003, pp. 1-26.

## V. Science and Technology Policy

- 1.Ruttan, V.W. "Science and Technology Policy," in *Technology, Growth, and Development*, pp. 534-599.
- 2.Vogel, G. "Patent Swords and Shields," *Science* 299(Feb 14, 2003):1018-19.
- 3.Narin, F., K.S. Hamilton, and D. Olivastro. "The Increasing Linkages between U.S. Technology and Public Science." *Research Policy* 26(1997): 317-330.
- 4.Nelson, R. "The Market Economy, and the Scientific Commons," Columbia University, Jan 26, 2003.
- 5.Adams, J.D., E.P. Chiang, and K. Starkey. "Industry-University Cooperative Research Agreements," *Journal of Technology Transfer* 26(Jan 2001):73-86.
- 6.Adams, J.D., J.L. Jensen, and E.P. Chiang. "The Influence of Federal Laboratories R&D on Industrial Research." *Rev.Econ&Statist*, forthcoming.
- 7.Adams, J.D. "Comparative Localization of Academics and Industrial Spillovers," *Journal of Economics Geography* 2(July 2002): 253-278.
- 8.Huffman, W.E. and R.E. Just. "Agricultural Research: Benefits and Beneficiaries of Alternative Funding Mechanisms," *Rev Agricultural Economics* 21(Spring-Summer 1999): 2-18.
- 9.Committee on Opportunities in Agriculture, NRC. "Executive Summary" in *Frontiers in Agricultural Research: Food, Health, Environment, and Communities*. Washington, D.C.: National Academy Press, 2002.
- 10.Binenbaum, E., C. Notterburg, P.G. Pardey, B.D. Wright, and P. Zambrona, "South-North Trade, Intellectual Property Jurisdictions, and Freedom to Operate in Agricultural Research in Staple Crops," *Economic Development and Cultural Change* 51(2003):309-335.

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7. Davis, D.R. and D.E. Weinstein. "Bones, Bombs, and Break Points: The Geography of Economic Activity," *Amer. Econ. Rev.*(Dec 2002): 1269-89.
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5. Ginarte, J.C. and W.G. Park. "Determinants of Patent Rights: A Cross-National Study." *Research Policy* 26(1997): 283-301.
6. Griliches, F. "Patent Statistics as Economic Indicators: A Survey," *Journal of Economic Literature* 28 (1990): 1661-1707.
7. Wright, B. "The Economics of Invention Incentives: Patents, Prizes, and Research Contracts," *American Economic Review* 73(1983): 707-728.
8. Henderson, R., A.B. Jaffe, and M. Trajtenberg. "Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting," *Review of Economics & Statistics* 80(Feb 1998): 119-127.
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- a. Ruttan, V.W. "The Computer and Semi-Conductor Industry," in *Technology, Growth and Development*, pp. 316-365.
- b. World Bank. *Knowledge for Development*. World Development Report 1998/99. New York, NY: Oxford University Press 1999.
- c. Jorgenson, D.W. "Information Technology and the U.S. Economy," *American Economic Review* 91(Mar 2001): 1-32.
- d. Gust, C. and J. Marquez. "International Comparisons of Productivity Growth: The Role of Information Technology and Regulatory Practices," *Labour Economics* 324(2003).

### **B. Biological Sciences**

#### **1. Agriculture**

- a. Huffman, W.E. and R.E. Evenson. "The Development of a System of Agricultural Sciences," in *Science for Agriculture*. Ames, IA: Iowa State University Press, 1993, pp. 30-64.
- b. Committee to Review the Role of Publicly Funded Agricultural Research on the Structure of U.S. Agriculture, "Structural Impacts of Research," in *Publicly Funded Agricultural Research and the Changing Structure of U.S. Agriculture*. Washington: National Academy Press, 2002, pp. 30-51.
- c. Huffman, W.E. "Modernizing Agriculture: A Continuing Process," *Daedalus* 127(Fall 1998): 159-175.
- d. Huffman, W.E. and R.E. Evenson. "Research Contribution to Crop Improvement," in Huffman and Evenson, *Science for Agriculture*, 1993, pp. 152-180.
- e. Ruttan, V.W. "Technical Change and Agricultural Development," in *Technology, Growth, and Development*, pp. 179-234.
- f. Olmstead, A. and P. Rhode. "Induced Innovation in American Agriculture: A Reconsideration," *J. Pol. Econ.* 101(Feb 1993): 100-18.
- g. Griliches, Z. "Hybrid Corn and the Economics of Innovation," *Science* 132(July 29, 1960): 275-280.
- h. Olmstead, A. and P. Rhode. "Reshaping the Landscapes: The Impact and Diffusion of the Tractor in American Agriculture, 1910-1960," *Journal of Economic History* 61(Sept 2001): 663-698.

- j. Evenson, R.E. and D. Gollin. "Assessing the Impact of the Green Revolution, 1960 to 2000." *Science* May 2, 2003.
- k. Huffman, W.E. "Human Capital, Education and Agriculture," in G.H. Peters and P. Pingali, *Tomorrow's Agriculture: Incentives, Institution, Infrastructure and Innovation*. Burlington, VT: Ashgate Publishing Co., 2001, pp. 207-222.
- l. Kislev, Y. and W. Peterson. "Prices, Technology, and Farm Size," *Journal of Political Technology* 90(1982): 578-595.
- m. Huffman, W.E. and R.E. Evenson. "Structural and Productivity Change, in U.S. Agriculture, 1950-1982," *Agr. Econ.* 24(2001):127-147.
- n. Huffman, W.E. "Private R&D Investments in Agriculture: The Role of Incentives, Public Policies, and Institutions," *Economic Dev & Cult Change* 51(Nov 2003).
- o. Pardey, P.G. and N.M. Beintema. *Slow Magic: Agricultural R&D a Century after Mendel*, Washington D.C.: International Food Policy Research Institute (IFPRI), Oct 26, 2001.

## 2. Biotechnology

- a. Ruttan, V.W. "The Biotechnology Industries," in *Technology, Growth, and Development*, pp. 368-422.
- b. Johnson, D.K.N. and V. Santaniello. "Biotechnology Inventions: What Can We Learn from Patents?" in V. Santaniello, R.E. Evenson, D. Zilberman, and G.A. Carlson, eds., *Agriculture and Intellectual Property Rights*, New York, NY: CABI Publishers, 2000, pp. 169-196.
- c. Foltz, J.D., B. L. Barham, and K. Kim. "Synergies or Tradeoffs in University Life Science Research." *Department of Applied Economics*, University of Wisconsin, June 2003.
- d. Fernandez-Cornejo, J. and W.D. McBride. *Adoption of Bioengineered Crops*, USDA, ERS, AER-810, May 2002.
- e. Falck-Zepada, J.B., G. Traxler and R.G. Nelson. "Surplus Distribution from the Introduction of a Biotechnical Innovation," *American Journal of Agricultural Economics* 82(May 2000): 360-369.
- f. Qaim, N. and D. Zilberman. "Yield Effects of Genetically Modified Crops in Developing Countries." *Science* 299(2003): 900-902.
- g. Paarlberg, R.L. *The Politics of Precaution: Genetically Modified Crops in Developing Countries*. The John Hopkins University Press, 2001.
- h. Huffman, W.E. "Production, Identity Preservation and Labeling in a Market Place with Genetically Modified (GM) and non-GM Foods," *Plant Physiology*, forthcoming.
- i. Huffman, W.E., M. Rousu, J.F. Shogren, and A. Tegene. "Consumers Willingness to Pay for Genetically Modified Food Labels in a Market with Diverse Information: Evidence from Experimental Auctions," *Journal of*

- Agricultural & Resource Economics*, forthcoming.
- j.Huffman, W.E., M. Rousu, J.F. Shogren, and A. Tegene. "Consumers' Resistance to Genetically Modified Foods in High Income Countries: The Role of Information in an Uncertain Environment," Department of Economics, Iowa State University, July 2003.
- k.Barham, B.L., J.D. Foltz, D. Jackson-Smith, and S. Moon. "The Dynamics of Agricultural Biotechnology Adoption: Lessons from rBST in Wisconsin, 1994 & 2001," *Amer. J. Agri. Econ.*, forthcoming.
- l.Arntzen, C.J. "Technology Progression in Plants Used for Food and Medicine," in A. Eagleshaw, C. Carlson, and R.W.F. Hardy, *Integrating Agriculture, Medicine and Food for Future Health*. NABC Report 14 on Food and Health, New York, NY: National Agricultural Biotechnology Council, 2000, pp. 43-50.
- m.Dhar, T. and J.D. Foltz. "Market Structure and Consumer Valuation in the rBST-Free and Organic Milk Markets," Department of Applied Economics, University of Wisconsin, July 2003.
- n.Nestle, M. "Food Safety is Political," in *Safe Food: Bacteria, Biotechnology and Bioterrorism*. Berkeley, CA: University of California Press, 2003, pp. 1-26.

## **V. Science and Technology Policy**

- 1.Ruttan, V.W. "Science and Technology Policy," in *Technology, Growth, and Development*, pp. 534-599.
- 2.Vogel, G. "Patent Swords and Shields," *Science* 299(Feb 14, 2003):1018-19.
- 3.Narin, F., K.S. Hamilton, and D. Olivastro. "The Increasing Linkages between U.S. Technology and Public Science." *Research Policy* 26(1997): 317-330.
- 4.Nelson, R. "The Market Economy, and the Scientific Commons," Columbia University, Jan 26, 2003.
- 5.Adams, J.D., E.P. Chiang, and K. Starkey. "Industry-University Cooperative Research Agreements," *Journal of Technology Transfer* 26(Jan 2001):73-86.
- 6.Adams, J.D., J.L. Jensen, and E.P. Chiang. "The Influence of Federal Laboratories R&D on Industrial Research." *Rev.Econ&Statist*, forthcoming.
- 7.Adams, J.D. "Comparative Localization of Academics and Industrial Spillovers," *Journal of Economics Geography* 2(July 2002): 253-278.
- 8.Huffman, W.E. and R.E. Just. "Agricultural Research: Benefits and Beneficiaries of Alternative Funding Mechanisms," *Rev Agricultural Economics* 21(Spring-Summer 1999): 2-18.
- 9.Committee on Opportunities in Agriculture, NRC. "Executive Summary" in *Frontiers in Agricultural Research: Food, Health, Environment, and Communities*. Washington, D.C.: National Academy Press, 2002.

10. Binenbaum, E., C. Notternburg, P.G. Pardey, B.D. Wright, and P. Zambrona, "South-North Trade, Intellectual Property Jurisdictions, and Freedom to Operate in Agricultural Research in Staple Crops," *Economic Development and Cultural Change* 51(2003):309-335.