PSYCHOLOGY 84
PSYCHOLOGY AND THE SCIENTIFIC MIND
PROFESSOR KEVIN DUNBAR
FALL 2008

Time: M, 9-11
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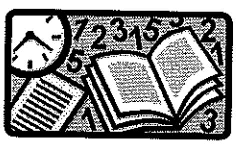
Course Overview. What is science? How do scientists make discoveries? Are there differences between women and men scientists and are they important? How is science learned and taught; is it just a list of facts or are there similar concepts to those learned in music, politics, art, and literature? How do children learn and how does this influence science education. What is the media's role in science and science education? We will explore these topics in a highly interactive course that covers psychological issues in contemporary science, education, and culture. This will be a fun course with some student discussion and participation in class and on blackboard.

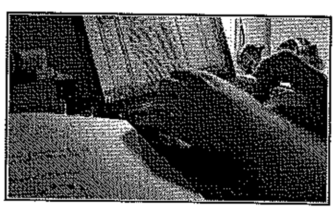


Course Structure: One lecture incorporating student discussions. Lectures will also be handed out in-class. Class starts promptly at 9:10. Be on time.

In Class Discussions and online answers: Science Minutes. Here you will discuss a specific question regarding the readings and lectures for that week. You will break up into small groups of 4-6 students, discuss the topic among each other for 8 minutes, and then each group will present its conclusions to the entire class over blackboard. Each person in the class will present twice over the duration of the course.

Evaluation: (1) One hour Midterm in-class examination consisting of multiple choice questions (15%). (2) final examination consisting of multiple choice questions and short essay type questions covering the entire course (40%). (3) Final essay (30%). (4) In class discussion and blackboard participation (15%). Attendance is mandatory. You must attend all lectures. Attendance is included in participation mark.

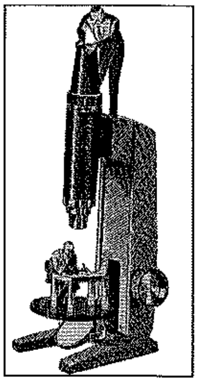
Readings: All the readings for the course are (or will shortly be) available on blackboard. You can download them and print them out or read them on the computer. All readings should be read before the class. This is really, really, really important. You *must* come to class having read the readings.



The Final essay!
You will be given a paper from the area of scientific thinking (such as the papers from this course) and be asked to write an essay on the paper. Papers will be assigned randomly. Your essay consists of (a) a 1.5 page summary of the paper, (b) a four page critique of the paper, and (c) an *original* experiment that that would extend the paper or solve problems with the paper and (d) references to 5 original sources. Essay should be in APA style and writing style is graded.

Students with Disabilities
Any student with a documented disability needing academic adjustments or accommodations is requested to speak to me by the end of the second week of the term, all discussions will remain confidential, although the Student Disabilities Coordinator may be consulted to verify the documentation of the disability.

Psychology 84: Topics and Dates

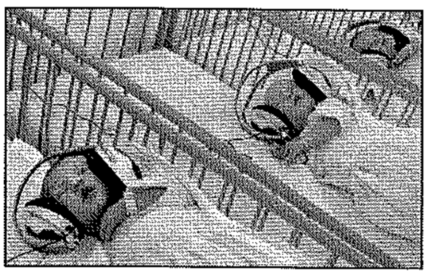


Week 1: (Sept 8) Introduction & Overview of the Course

This week we will first look at the goals of the course and what you will discover when you take the course. I will give an overview of the main issues, assumptions, and controversies in understanding science, science education, and the way that the scientific mind works.

Part 1: Course overview, goals of course: What is science? What is the scientific Mind?
Part 2: Making sense of Science. Popper, Kuhn, and more recent work.

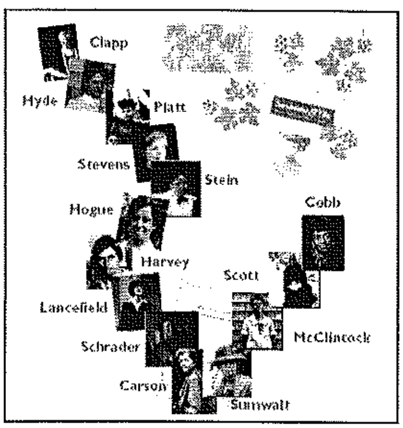
Week 2 (Sept 15): Does the scientific mind develop?



We begin with children learning science. Some have argued that children are incapable of abstract thought necessary for science, others have argued that children are really little scientists. Given these different views, how should a museum present science, schools teach it, and parents family and peers work together

Part 1: The traditional view of development and scientific thinking.
Part 2: Contemporary views of development of scientific reasoning

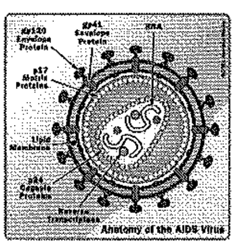
Week 3 (Sept 22). Gender and Science: The issues, the problems, the controversies



Women continue to be a minority in science. What are the reasons for this and what is the role of education in issues of gender and science? This week we will examine the historical background of women in science, where women stand in science today, some recent examinations of women in science and some of the issues regarding the idea that women conduct science in a different way from men. We will also look at some of the issues surrounding the enculturation of women into and out of science.

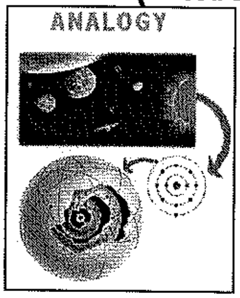
Part 1: The background: History of women and Science, Perspectives on women in science
Part 2: Gender and science education the Summers controversy and the education of girls at the museum.

Week 4 (Sept 29): Finding Causes and being a detective: Causal Reasoning and deduction



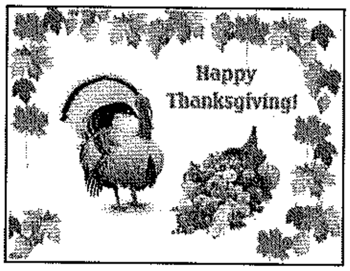
Causal reasoning and deduction are two mental tools that scientists use when generating new theories, hypothesis, experiments, and interpreting data. We will unravel the mechanics of these mental processes and see how scientists use deductive reasoning while making discoveries. We will look at how a leading HIV lab makes discoveries and what this reveals about the scientific mind. In particular we will look at an important issue of how we know whether HIV causes AIDS and the types of causal reasoning that went into this discovery

Week 5 (October 6): Analogy in science and scientific thinking



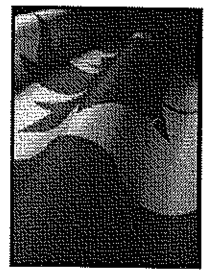
How do we communicate new ideas to someone in science? We use analogies. Analogies are used at all levels of science education from the basic to Nobel prize winning labs. How is it used? When do analogies really help educate and when do analogies get in the way? We will explore the use of analogy generation and the provision of many analogs as tools for scientific understanding..

Part 1: Analogy as a key scientific educational tool
Part 2: Analogy in and out of the scientific laboratory



OCTOBER 13th no class
Thanksgiving

And don't forget to vote on October 14th!



Week 6 (October 20): Midterm & Induction

What types of skills do we use in science? Induction and deduction. We have already looked at Deduction. Today we will unravel the mechanics of induction and see how these they are used and taught. We will take a look at some of the problems that people have, including scientists, in using these skills and how being taught to deal with the unexpected is a key thing that scientists learn, particularly in postgraduate science education.

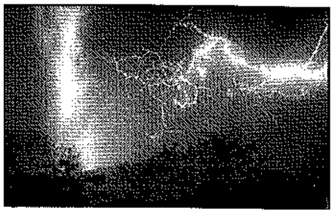
Part 1: **MIDTERM EXAM 9:00-10:00 Be on time!**
Part 2: Inductive reasoning in science

Week 7 (October 27) What are Experiments and how is experimentation taught?

How, and why, do some scientists design experiments without hypotheses? Given the potentially infinite number of experiments that scientists could conduct, how do they decide to conduct an experiment in a particular way? We will look at designing experiments as a form of problem solving. We will look at the teaching of the use of controls and control conditions. We will also look at children and the design of experiments. Can children design an experiment? We will explore this important dimension of the child as scientist controversy.

Part 1: Designing an Experiment: What is done?
Part 2: The University and High School science Lab What is learned?

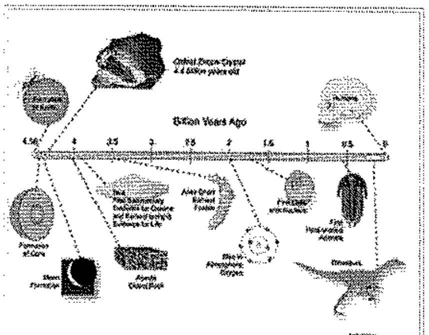
Week 8: Conceptual Change as the goal of science education (November 3)



Many science educators have argued that the key goal of science education and the key goal of learning is large-scale changes in concepts. One area of science education where conceptual change has proved very difficult is physics. We all possess many basic concepts of motion and momentum that that must be overcome in physics education. We will look at ways that educators have used to overcome our Naïve physics and whether they have succeeded or not

Part 1: Conceptual change what is it and why is it so hard
Part 2: How Naïve theories, that we all have, interfere with learning

Week 9: Science & Evolution(November 10)



A typical timeline showing the historical claims of the theory of evolution

Science, science education, and the media are inter-related domains for changing our conceptions of key issues in science. The media influence scientists, the funders of scientists, educators, and the lay public. This week we will explore the roles of the media (from blogs, podcasts, and the internet to the more traditional print, radio, TV, and movies) on a key scientific concept: Evolution. We will explore the multiple strands and conclusions that drive our understanding of evolution from media to the technologies used in education.

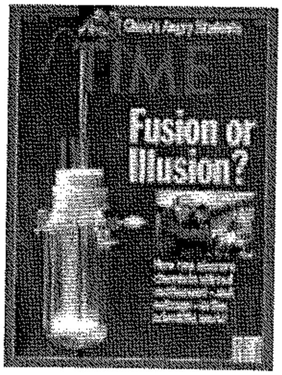
Part1: Evolution: the issues
Part2: Evolution: the consequences

Week 10 (November 17) The accidental scientist: How Scientists harness luck and chance

Many scientists have claimed that their discovery was "fortuitous," "lucky," "pure chance." Like Newton and his apple, the idea just hit them "out of the blue." However, when we analyze the strategies that scientists use in their research, we can see that they structure their research to take advantage of unexpected findings, and that they actually conduct experiments that lead to unexpected findings that they can then exploit. Like a good money manager, scientists hedge their bets and stand ready to take advantage of sudden surprising events. This *is* risky business because it is indeed difficult to predict exactly when and how discoveries will be made; it is the wild side of science. However, successful scientists have developed principled sets of strategies for harnessing chance and dealing with the unexpected. When a scientist sees an odd result in a control condition it is often called "unexpected," or "lucky." It is not luck. It is a mechanism that scientists have developed to discover new processes.

Part 1: Scientists must take risks at all levels: How do they decide what to do
Part 2: Do scientists have fortuitous findings?

Week 11 (November 24) Pathological Science



Some scientists have made spectacular claims only later to find out that they were wrong. Why? We will look at a number of examples of errors in science and show the disastrous effects that these errors have had. Then, we will discuss the two most important factors that lead to these errors: the way that scientists mentally organize their knowledge, and the strategies that they use to extend their knowledge. We will see that a propensity to make errors in reasoning is an inevitable consequence of theory building in science. One of the most important ways that scientists make errors is by "confirmation bias:" Scientists often unwittingly seek evidence that is consistent with their viewpoint, and ignore evidence that is inconsistent with it. This occurs at all levels of science. We will investigate the reasons why this pervasive phenomenon occurs, how it leads to errors in reasoning, and what strategies are effective in circumventing these errors. The fact that scientists make errors highlights the fact that the reasoning strategies that scientists use do not guarantee truth.

Part1: Going beyond the information given: What happens when scientists go too far
Part2:: Confirmation bias and the brain: Is confirmation bias inevitable?

Week 12 December 1: Key issues in understanding the scientific Mind
Is scientific thinking unique? And unresolved issues such as the roles of imagery and group reasoning in science.
Course evaluation
Essay due by beginning of class on December 1st. Must be handed in at this time.

The essay
Each Essay should be written on a computer. It should be single spaced 12pt Times typeface with .5 inch borders, stapled together, have your name and student number on the cover. You should keep a copy of the Essay in case of some problem.

Essays must be handed in by the beginning of the last class. 2% will be deducted from each day the essay is late, including after the class starts! Only certified medical excuses will be accepted. Remeber that computers eat files, so always keep a backup copy of the essay. Also printers have a habit of not working just when you need them, so print early!

Readings Psyc C 84
Science, Education, and the Scientific Mind

Week 1 Introduction & Overview
Capaldi, E.J. & Proctor, R. (2005).Why Science matters. Chapters 1, 3, & 6.

Week 2. Development
Kuhn, D. (2002) What is Scientific Thinking and how does it develop. In U Goswami (Ed.) Blackwell handbook of Child development. PP 371-393.

Harris, P. (2002). What do Children learn from testimony. In. P. Carruthers, M. Siegal, & S. Stich (Eds.) Cognitive bases of Science. Cambridge: Cambridge University Press.

Gopnik, A. Meltzoff, A. & Kuhl, P. (1999). What children learn about things. Chapter 3 of the scientist in the crib. Morrow.

Carey, S. (2001). Concepts. From the journal of Cognition and development

Week 3 Gender
Fox-Keller, E. (1985). Gender and Science. Chapter 4 of Reflections on Gender and Science. Yale University Press.

Summers, L. H. (2005). Remarks at NBER Conference on Diversifying the Science & Engineering Workforce. The office of the President. Harvard University.

Hyde, J.S. (2005). The gender similarity hypothesis. American Psychologist. 60, 581-592.

Crowley, K. Callanan, M.A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. Psychological Science, 258-261.

Tenenbaum, H.R., & Leaper, C. (2003). Parent-Child conversations about science: The socialization of gender inequities? Developmental Psychology

Week 4 Causal reasoning and deduction
Pearl, J. (2000) The art and Science of cause and effect: From J Pearl 2000. Causality. Cambridge. MA: Cambridge University Press pp 332-373.

Gallo, R. (1991). About the causes of Disease (and in particular, Why HIV is the cause of AIDS). In R. Gallo: Virus Hunting, Aids, Cancer, and the human retrovirus. A Story of scientific discovery. New York: NY. Basic Books.pp 276-297.

Johnson-Laird, P.N. (2001). Mental models and deduction. Trends in Cognitive Sciences, 5, 434-442

Week 5 Analogy in science
Holyoak, K.J. & Thagard, P (1994). The Analogical Scientist. In K.J. Holyoak, and P. Thagard. Mental Leaps. MIT Press, Cambridge:MA pp 185-209.

Wong, D.E. (1993). Understanding the generative capacity of analogies as a tool for explanation. Journal of research in science Teaching, 30 1259-1272.

Blanchette, I., & Dunbar, K. (2000). How Analogies are Generated: The Roles of Structural and Superficial Similarity. *Memory & Cognition*, 28, 108-124.

Week 6: Scientific Reasoning: Induction in science
Dunbar, K., & Fugelsang (2006) Scientific Thinking in Holyoak, K. J. & Morrison, R. Cambridge Handbook of Thinking and reasoning

Thagard, P. (2005). Induction, from Mind an introduction to Cognitive science.

Mayer, R. (1992) Inductive reasoning: Thinking as hypothesis testing. From R. Mayer. Thinking, Reasoning and Problem Solving. Freedman, San Franscisco:CA pp 81-113.

Week 7: Designing Experiments

Kuhn, D. Integrating theory and data in Experimental design

Baker, L.M. & Dunbar, K. (2000). Experimental design heuristics for scientific discovery: The use of baseline and Known Standard Controls. International Journal of human Computer studies.

National Academy of Sciences (2005). Laboratory experiences and student learning. Chapter 3 of the nations lab report. National Academy Press. Pp 116-137.

Week 8: Conceptual Change in science and science education

Rolands, Graham, Berry, Mc William (2007). Conceptual change through the lens of Newtonian Mechanics. Science & Education (2007) 16: 21–42

Chi, M.T.H., & Roscoe, R.D. (2002). The processes and challenges of conceptual change. In M. Limon and L. Mason (Eds). Reconsidering Conceptual change: Issues in Theory and Practice. Kluwer Academic Publishers, The Netherlands, pp 3-27.

Zirbel, E.L. (2004). Framework for conceptual change. Astronomy Education Review. 3, 62-76.

Week 9 : Evolution, and science!

Cosmides, L. & Tooby, J. (1995) Evolutionary Psychology: A primer pp 1-26

Climate, Culture, and the Evolution of Cognition (1999). Peter J. Richerson & Robert Boyd

Evolution 2006 @ Berkeley: http://evolution.berkeley.edu/evosite/nature/index.shtml

AAAS 2006. Special event Evolution http://www.aaas.org/programs/centers/pe/evoline/index.shtml

Week 10 The Accidental Scientist

Oliver, J.E. (1991) Chapter 2 of The incomplete guide to the art of discovery. New York:NY, Columbia University Press

Kulkarni, D, & Simon, H.A. (1988) . The processes of scientific discovery: The strategy of Experimentation. Cognitive Science, 12, 139-175.

Dunbar, K., & Fugelsang, J. (2005). Causal thinking in science: How scientists and students interpret the unexpected. In M. E. Gorman, R. D. Tweney, D. Gooding & A. Kincannon (Eds.), *Scientific and Technical Thinking* (pp. 57-79). Mahwah, NJ: Lawrence Erlbaum Associates. Pp. 57-80.

Week 11 Pathological Science and how to avoid it!

Rousseau, D.L. (1992).Case Studies in Pathological Science. American Scientist

Peat, D. (1990). Cold Fusion: The making of a scientific controversy. Chapter 5 Confirmations and refutations.

LeVay, S. (2008). Speech Pathology: The monster study. Chapter 11 of When Science goes wrong: Twelve tales from the dark side of discovery. NY:NY Plume publishing.