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Environment, genes, and intelligence: A Briefing for M.U.T.

Members of the Massachusetts Union of Teachers are to be commended for their pro-active stance toward many educational policy issues. In view of the recent advances in genetics, it is understandable that conflicting statements in the popular press about the role genes play in intelligence have lead to confusion about whether education really can boost IQ.

This briefing will take the form of "research highlights" that provide **selected** views and ideas about genes and environment across several disciplines – anthropology, psychology, and biology – but not, of course, in the depth or breadth that would be required for such a complex and long-standing debate. Teachers are encouraged to use the references provided at the end to follow up on aspects that pique their interest or speak to their experience. We begin with a survey of commonly used genetic metaphors in the media.

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> *The tendency has always been strong to believe that whatever received a name must be an entity or being, having an independent existence of its own, and if no entity answering to the name could be found, men did not for that reason suppose that none existed, but imagined that it was something particularly abstruse and mysterious. – John Stuart Mill (quoted in Gould, 1995)*

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Metaphors

The metaphor of a "genetic blueprint" has been examined by a number of writers. Brigitte Nerlich and Iina Hellsten (2004) provide a fascinating look at the use of metaphors around the time of the Human Genome Project (HGP). They compared the metaphors used in reports from a major science journal – *Nature* – and a major U.K. newspaper - *the Guardian/The Observer* – during a 2 month span surrounding key HGP events that occurred in 2000, 2001 and 2003. The predominant metaphors in use included 'code', 'book of life', 'map', and 'blueprint.' They report that while *Nature* never used the phrase 'book of life,' and only used 'code' or 'map' in a literal sense, there was widespread use of all four metaphors in the newspaper. Rather than new metaphors emerging to characterize the complexity surrounding genes, they found that there were few challengers; indeed, continuity in metaphor use was a major finding.

Celeste Condit's *The meanings of the gene* (1999) is an erudite, gracefully written book that covers the public debates about human heredity. Her study had the advantage of utilizing both critical and quantitative methodologies; that is, she combined the analysis of various forms of discourse as portrayed in magazines, newspapers, congressional reports, and television news, with testable propositions about those components in discourse. Utilizing three coders to count the frequencies of these components, she performed quantitative analyses that helped to inform her critical interpretation. Condit found that as the code metaphor became increasingly literalized (no longer needing explanation), the genetic blueprint metaphor increased to fulfill the purpose of "helping to explain the new scientific emphasis on the human genome as a whole rather than

on genes in isolation" (p. 160). While critics of the blueprint metaphor railed that it was no more than a deterministic wolf in sheep's clothing, Condit tested college students about their understanding of the blueprint metaphor and found instead that there was a broad range of interpretations: of the 137 respondents, 38 offered explicitly deterministic explanations; 58 responses were explicitly non-deterministic; 9 respondents offered interpretations that included both deterministic and non-deterministic statements. She notes that the students interpreted the blueprint metaphor as a "partial accounting, as a probabilistic rather than deterministic forecast and as malleable" (p.167).

Matt Ratto's article on "splicing metaphors" gives some indication of the direction in which the blueprint metaphor may morph next. He offers "foundation" and "profile" as metaphors that reveal changes in the direction of large-scale genetic research (2006, p. 46). Used in the context of projects like the Human Genome Project and more specifically the GenomEUtwin project in Finland, Ratto says that the shift from *foundation* (used by the HGP) to *profile* (GenomEUtwin) is indicative of a movement away from genetic archiving and description and towards more sophisticated attempts to make sense of the results of past genomic research. He also sees in the use of the *profile* metaphor "an often explicit recognition of the limitations of purely genetic techniques and the desire to direct attention towards the complicated relationship between genes, lifestyle, and the environment (p.49). Metaphors can thus be used to signal changes in priorities in science.

These articles and others reflect on the role that metaphors play in communicating complex scientific concepts, especially to a lay audience. Writing in *Science*, John Avise states that the hope for any metaphor in science is that it may bring otherwise unfamiliar subjects to life, make connections not otherwise apparent, and stimulate fruitful inquiry. A danger is that a metaphor can restrict rather than expand research horizons. Many genomic metaphors have elements of truth, and each may have its time and place (2001).

An image or metaphor not found in the literature but which may provide a richer concept of the interaction between genes and environment is the kaleidoscope. Almost everyone has held a kaleidoscope to light and witnessed the way in which even a slight shift will allow a whole new pattern to emerge. The various small, colored pieces create the patterns that are displayed through mirrors in the tube. These colored pieces can be said to represent each person's genetic material interacting with their environment. Even small adjustments to the environment can result in different patterns to form. Viewed in this way, the trait of intelligence can be thought to be dynamically created through the interactions of genes and environment.

Some views from anthropology and psychology

Anthropologists have looked at the intersection of genetics and culture. A recent article by Ehrlich and Feldman (2003) presents one such overview, but it is not claimed that their view is representative. The article begins with the standard explanation of genotype (the particular set of genes an organism has) versus phenotype (the observable characteristics of the organism due to its biochemistry, physiology, morphology, etc.). They give a short historical section on how the understanding of behavioral traits has changed over time: from genetic determinism in the

prewar decades that led to eugenic practices, restricted immigration and racial policies, to its gradual fading - due especially to the reaction to Nazism.

They date the beginning of the 1960s as a time when books with a hereditarian bias began to appear, such as Ardrey's "Territorial Imperative" and Morris's "The Naked Ape." In their opinion, however, the greatest plug for the genetic basis of behavior came with the publication of Arthur Jensen's 1969 article,"How much can we boost IQ and scholastic achievement?" Although subsequently found to be based on fraudulent data, Jensen's article had a big impact and, in their view, established a tradition that "attempts to allocate to genetics a considerable portion of the variation in human behaviors" including measured IQ and school performance" (p. 87).

Jensen's thesis, which Ehrlich and Feldman energetically refute, is characterized as follows: "...the high heritability (a statistical value) of IQ made it unlikely that environmental intervention could succeed in improving the educational performance of disadvantaged children; the fault lay in their genes." Ehrlich and Feldman believe that the concept of heritability has been widely misinterpreted as diagnostic of the underlying causes of variation of IQ among people. In fact, they say, calculated heritabilities give us *no* information concerning the *causes* of our actions…We have no idea about how the complex interactions between genes, regulation of genes, protein structures, protein concentrations, and environments would be manifest in a measurable trait or behavior (p.90). They quote Lewontin's famous quip that "In the United States, the highest correlations between parent and offspring for any social traits are for religious sect and political party. Only the most vulgar hereditarian would suggest the Episcopalianism and Republicanism are directly coded for in the genes" (Lewontin, 1984 in Ehrlich and Feldman, 2003, p. 90).

Much of the confusion regarding the effects of genes on intelligence stems from the misuse of the statistical concept of "heritability." Michael Rutter, et al. states that, from the outset, geneticists have emphasized that "heritability is a statistic that applies to <u>population</u> variance and <u>not to individuals or to traits</u> as a fixed feature. A high heritability means that genetic factors account for much of the variation in the liability to show a particular trait in a particular population at a particular point in time. It does <u>not</u> mean that genetic factors play a major role in the causation of that trait in any one individual. Equally, it does not mean that genetic factors account for that particular proportion of the population variance for that trait in all circumstances. If genetic conditions change, or if environmental circumstances alter, the heritability will not remain the same" (2001, p.246). The bottom line is that although behavioral geneticists may have never been in doubt about the difference between the technical term "heritable" and the colloquial "inherited," the distinction was lost somewhere along the way in media and popular science accounts, leaving people with the impression that an unchangeable stock of 'intelligence' is literally inherited.

By understanding the technical meaning of the concept of heritability, teachers will be in a position to appreciate that an even larger hole in Jensen's thesis can be made by reference to the way that genetic mechanisms actually "work." Teachers are referred to the technical but very readable discussion by Rutter, Moffitt and Caspi (2001) on how many complex interactions and the multiple processes of messenger RNA, transcription, translation, and gene expression all

work together. Rather than there being direct effects of a single gene on a single outcome, they say, it is more appropriate to think of a dynamic process in which the effects of a single gene are influenced by multiple inherited DNA elements and by the actions of environments (p. 230).

The comments above may give the impression that the notion of intelligence is itself unproblematic, but this is certainly not the case. The first point to be made is that a person's intelligence is not reducible to their IQ, or intelligence quotient. IQ has been defined somewhat tongue-in-cheek as that which intelligence tests measure. Theories of intelligence abound in the literature. The general consensus is that the major components in intelligence are verbal intelligence, problem-solving ability, and practical intelligence (Winn, 2001).

Robert Sternberg and Elena Grigorenko (2004) offer a perspective on how culture interacts or shapes our ideas of intelligence. Based on their cross-cultural studies with children in Kenya, Jamaica, Russia, Tanzania, Zambia, and with Alaskan Eskimo children, Sternberg and Grigorenko contend that "intelligence" cannot fully or even meaningfully be understood outside its cultural context. They agree that there are mental operations and processes (such as problem solving) that transcend or are present in all cultures, but "…the operations one performs to solve problems gain expression in performance differently from one culture to another. As soon as one assesses performance, one is assessing mental processes and representations *in a cultural context*" (p.1428, italics in original). This is not a trivial distinction. According to the definition given in the *Dictionary of Biological Psychology* (2001), intelligence cannot be observed directly, but it can be inferred from observable behavior. The tests of intelligence such as the Stanford-Binet and Weschler Intelligence Scale for Children that are used commonly in schools come from a tradition that stresses analytic or cognitive abilities. Sternberg, on the other hand, favors a "triarchic" theory of intelligence – one that measures creative and practical abilities as well as analytical skills.

Two important points are raised in the Sternberg and Grigorenko article that are particularly valuable for teachers to think about. The first is their idea of "successful intelligence." While we tend to think of IQ as an indicator of academic excellence or potential, they prompt us to ask not just what intelligence is, but what is intelligence important for? They define 'successful intelligence' as one's ability to achieve success in life in terms of one's personal standards, within one's socio-cultural context. An example they state is that successful teachers and researchers achieve success through many different blendings of skills rather than through any single formula that works for all of them (p.1428). The second point is the obvious observation that intelligence may be different things in different cultures. They use studies from various cultures to demonstrate that there is a social component to intelligence in many parts of the world. Using your intelligence may thus mean not only doing well in a narrow scholastic sense, but also being able to get along with others by forming harmonious relationships.

Views from biology

An interesting set of theoretical perspectives on development, heredity, and evolution can be found in developmental systems theory (DST), although proponents of this view stress that DST is not a single unified theory. The attraction of this approach is that it rejects the dichotomy between "genetic" and "environmental" – or between nature and nurture. Metaphors such as

those noted above – blueprint, code, program, have given rise to a mistaken role and characterization for the gene. Michael Bradie, in a book review of *What genes can't do* by Lenny Moss (2003) gives a good account of how Moss developed his ideas of Gene-P and Gene-D as an effort to counter the genetic determinism that can result from inaccurately using metaphors (and thinking) about genes. These are two different ideas and their conflation into "gene" being understood as a discrete DNA sequence (a gene-D property) *and* a causally privileged role in predicting and explaining phenotypic expressions, such as blue eyes, is both common and mistaken (Bradie, 2003).

In simplified terms, DST maintains that if both genetic and environmental factors are necessary for development, then both can be considered causal. Adherents of DST claim that much more is inherited than genes, and at least some features of environments can also be inherited (Godfrey-Smith, 2000). Most particularly, DST opposes the use of concepts borrowed from social and economic life to establish a 'developmental division of labor,' in which genes are attributed an executive or managerial role and everything else is secondary (p.324). Rather than looking at genes and environment and haggling over the contribution of each, DST considers the developmental system as central. Defined by Susan Oyama, with whom DST is most closely associated, a developmental system is "a mobile set of interacting influences and entities" comprising "all influences on development" at all levels, including the molecular, cellular, organismal, ecological, social, and biogeographical" (Oyama, 2000, in Godfrey-Smith, 2000).

What this means and why it is relevant to teacher's concerns about the "innateness" of something like intelligence, is that it opens up our understanding of our own biology (including genetics). Rather than viewing genes as something that deterministically sets in stone a child's potential for intellectual growth and development, the developmental systems theory approach allows that there are many "interactants" that can influence growth and development, including pre-natal influences. That is, "within the organism, these [may] include the extracellular matrix, DNA sequences, mRNA, hormones, metabolites, and enzymes…Beyond the organism, the developmental interactants include habitat, behaviour, temperature, nutrition, social structure, and (depending on the system) even gravity and sunlight (Robert, Hall and Olson, 2001, p. 955).

This brief survey of ideas from anthropology, psychology, and biology should help dispel the notion that education is wasted on those who appear to have been dealt a bad hand in the kind of analytic intelligence measured by standardized tests. Teachers know by virtue of their experience that many bright children may never accumulate A's on their reports and tests and that intelligence cannot be defined so narrowly. Indeed, as Lee J. Cronbach observed in a volume of essays published in the Harvard Educational Review 1969 along with Arthur Jensen's polarizing essay:

> *The educator's job is to work with the environment; teaching him about heredity can do no more than warn him not to expect any easy victories. Heritability of individual differences is not his concern. Even if, after education, rankings in ability were to correlate perfectly with some measure of the pupil's ancestors, the educator ought to be providing the best possible instruction he can for every pupil he faces (p. 197).*

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