Psychology in a Post-Genomics

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The draft DNA sequence of the human genome was announced in June 2000, two years ahead of schedule. Some party-poopers grumble that the four nucleotide letters that constitute the DNA alphabet are not GATC, but HYPE. They complain that the DNA sequence by itself does not tell us how we can begin life as a single fertilized cell and end up with trillions of cells containing the same DNA but expressing different genes. It doesn't cure any diseases.

It is true that sequencing the human genome is just a first step towards understanding how genes work. But it is a giant step. It will greatly speed up the pace of discovery in genetics, even though the current pace makes your head spin. We will soon be in a post-genomics world in which all genes and all DNA variability are known.

The major beneficiary of this new world will be research on complex traits that are influenced by multiple genes as well as multiple environmental influences. This is where psychology comes in. Behavior- the most complex trait of all-is already becoming a focus for DNA analysis. As explained below, psychology will be *more* important, not less important, in a post-genomics world.

The next step toward the post-genomics world-identifying all genes-will soon be completed. Only about 5 percent of all DNA involves genes in the classical sense, where the DNA code is transcribed into RNA and translated into amino acid sequences. Analyzing the DNA sequence for signposts of genes has led to dramatically reduced estimates of the number of genes, down from original estimates of 100,000 genes to perhaps half that number. Although this would seem to make the task of identifying all genes less daunting, the other 95 percent of the genome may not be just tagging along for the ride. There are examples in which some of this un-translated DNA regulates the expression of genes.

Identifying genes is one thing, but understanding how they work will take much more time. This is especially true for genes in complex systems like behavior that are influenced by many genes and many environmental factors.

The agenda for understanding the function of genes-called *functional genomics*- is generally viewed as a bottom-up strategy in which the gene product is identified by its DNA sequence and the function of the gene product is traced through cells and then cell systems and eventually the brain. This view is captured by the new phrase *proteomics* which focuses on the function of gene products (proteins) rather than genes.

But there are other levels of analysis at which we can understand how genes work. At the other end of the continuum is a top-down level of analysis that involves the behavior of the whole organism. In other words, psychology. For example, we can ask how the effects of specific genes unfold in behavioral development, how they interact with experience, and how they play out in terms of psychological theories. This top-down "behavioral genomics" level of analysis is likely to payoff more quickly in

prediction, diagnosis, and intervention than the slow build-up of knowledge through cell systems.

SNPs on Chips

Psychology will really arrive in the post-genomics world not when all genes are known but when all DNA variation in the genome is known. People talk about sequencing *the* human genome. But there is no single genome. About one in every thousand DNA bases is different for at least 1 percent of the population. These 3 million DNA differences in the human genome of about three billion DNA bases are responsible for the ubiquitous genetic influence that we find throughout psychology.

The Human Genome Project at the National Institutes of Health is now directing its efforts toward identifying at least 10 percent of these DNA differences, especially those that are in genes. Most of these DNA differences involve a substitution of a single base pair, called single nucleotide polymorphisms (SNPs, pronounced “snips”). DNA “chips” are now available to analyze thousands of an individual’s SNPs in a few minutes.

DNA chips (analogous to silicon chips) are microarrays the size of a postage stamp that can identify whether one form of a particular SNP or the other or both are present in an individual’s DNA. DNA chips are being developed for SNPs for all genes related to human diseases–even common diseases like cardiovascular disease for which many genes are involved. It will not be long before we see “SNPs on chips” for behavior.

Early Warning System

When SNPs on chips become available, psychology will enter the post-genomics world, like it or not. For clinical psychology, the major benefit of SNPs on chips will be the ability to predict genetic risk more precisely than using family morbidity. This early warning system will facilitate the development of primary interventions that prevent or ameliorate disorders before they occur. These interventions are likely to be behavioral rather than biological. For complex traits, such interventions are unlikely to involve high-tech solutions like genetic engineering. SNPs on chips will also affect diagnosis and treatment.

In these ways, finding specific genes associated with psychopathology will make clinical psychology even more valuable. With behavior-based interventions, psychologists will eventually be in the business of controlling gene expression.

The post-genomics world will also have a huge impact on psychological research. DNA will serve as an integrating force across diverse disciplines and will open up new scientific horizons for understanding behavior. A DNA dimension can be added to any psychological research, although large samples will be needed to detect genes of small effect. No longer will genetic research require twins and adoptees. Blood is not needed to obtain DNA–cheek swabs can be used to collect DNA through the mail for just a few dollars. Although a few psychology departments already have their own molecular genetic laboratories, economies of scale suggest that most DNA analysis will be done using large-scale companies. Psychology has much to contribute and to gain in a post-genomics world, but its passport to this new world is training.

Psychology departments are doing their students a disservice if they do not provide training in genetics. Clinical psychologists use the acronym ‘DNA’ to mean that a client ‘did not attend.’ When the history of this post-genomics millennium is written and ‘DNA’ is entered in psychology’s list of accomplishments, I hope that it will mean ‘deoxyribonucleic acid’ rather than ‘did not attend.’