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Microfluidic Platforms, Genetic Databases, and Biosociality

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Introduction

THIS SHORT PAPER examines how the development of portable, low-cost devices (known as microfluidic platforms) may affect how human genetic data are collected and analyzed. By integrating several diagnostic functions onto a hand-held device, microfluidic platforms (MFPs) are likely to have profound impacts on health care. In theory, small samples can be analyzed at the point-of-care, and results available in minutes to health care providers and others. To achieve these goals, MFPs will probably require integration with human genetic databases through wireless and wired networks. To understand the implications of this technology, we will explore the intersection of microfluidic platforms with human genetic databases using Paul Rabinow's concept of "biosociality."

Microfluidic platforms

Microfluidic platforms are microsystems that incorporate microelectronic and biological components onto a hand-held device. Such devices are currently under development, and within 5–10 years are expected to revolutionize how health care providers monitor human health. By placing the capabilities of a large diagnostic lab in a platform the size of a wrist watch, point-of care applications including genetic testing, pharmacogenetic testing, and assessment of viral load (e.g., to assess the effectiveness of a vaccine or degree of infectivity) may become commonplace in medical clinics, pharmacies, and elsewhere. To assist in making diagnoses, MFPs will require real-time data acquisition and integration with human genetic and other kinds of databases.

With a team of scientists, medical practitioners, and social scientists, the authors of this paper are involved in the development of MFPs for medical, forensic, environmental, agricultural, and national security applications.[1] Our team's goal is to develop an open system architecture device that will integrate several functions at the microscale on a microfluidic chip. Such chips are pieces of glass or plastic which have several finely etched channels running through them. With the assistance of microscale pumps and other miniaturized devices on the chip, the handheld device (into which the chip is inserted) uses electrical forces to separate components from a sample, and on-board optical technologies for analyzing constituent parts. For medical applications, miniaturized devices for performing on-board polymerase chain reaction (PCR) of DNA samples are being developed to run on these chips. It is anticipated that these devices can conduct several genetic tests in parallel, and use single nucleotide polymorphism (SNP) analysis for identifying responders and non-responders to particular pharmacological agents. The non-medical applications for this technology include genetic identification at crime scenes, water quality monitoring for pathogens, identifying genetically modified plants in the field, and providing data for threat assessments at airports on suspicious materials. In short, MFPs will usher in a new genetic age that will reshape society in profound ways. Their portability, anticipated low cost, and flexibility require that we consider how such technologies renegotiate the often invisible contract between nature and culture.

Biosociality

Paul Rabinow's (1999) concept of "biosociality" refers to a transformative condition under which both nature and scientific work in the life sciences become increasingly revealed as cultural practice.

> If sociobiology is culture constructed on the basis of a metaphor of nature, then in biosociality, nature will be modeled on culture understood as practice. Nature will be known and remade through technique and will finally become artificial, just as culture becomes natural. Were such a project to be brought to fruition, it would stand as the basis for overcoming the nature/culture split (Rabinow 1999, 411).

Biosociality addresses the emerging trends in the conceptual, metaphorical, and discursive boundaries between science and culture. Rabinow argues that biological theories and metaphors, like sociobiology, have become increasingly popular to describe concepts like life, health, culture, and community. For instance, the use of language to describe DNA as the "book of life" promotes a view of life that is maintained, ordered, and understood according to biological principles alone (Kay 1999; Petersen and Bunton 2002). However, with biosociality science loses much of its cultural authority since nature, natural artifacts, and the natural sciences are exposed as socio-cultural practices.

Biosociality and MFPs

The development of MFPs for human genetic testing represents a turning point within the nature/culture divide. As with many genetic issues, MFPs have embedded within them scientific and cultural artifacts that are manifested in debates such as nature versus nurture. On the one hand, such devices have the potential to intensify existing tendencies to explain behavior, health, personality, etc. in strictly biological terms. The very process of looking for genes, SNPs, viral loading, and other biological markers is reduc-

1 Mehta shares a $1.5 Million CDN grant from the Canadian Institutes of Health Research entitled "Novel Platforms for Genetic Analysis."

tionist in nature, and likely to stimulate the development of a range of techno-scientific solutions like gene-based therapy, germ line therapy, etc. On the other hand, MFPs have the potential to reveal in exquisite detail the genetic variation in the human genome. As developments in genomics, proteomics, and metabolomics progress, MFPs may usher in a new cultural appreciation for difference, and reveal many of the flaws and attribution errors associated with defining health in binary terms (e.g., healthy versus unhealthy). It is at this juncture that MFPs converge with biosociality. To understand how such convergence occurs, we turn our attention to some key elements of biosociality; namely, risk management, identity formation, exposing the cultural practices of science, and the creation of a post-disciplinary society.

Risk management

Rabinow (1999) contends that contemporary genetic science is based on a discursive power. Drawing primarily upon Foucault's (1978) conceptions of knowledge/power and biopower,[2] Rabinow argues that the discourse of genetic science is aimed at regulating the body, and is currently disguised through the language of risk management rather than surveillance and control, and as benevolent intervention and cure rather than as discipline. Currently, the impact of genetic testing technologies on populations as a whole is limited. Few individuals have undergone genetic testing, and most tests conducted are for carrier identification (e.g., Cystic Fibrosis, Tay-Sachs Disease, and Sickle Cell Trait), prenatal diagnosis (e.g., Down Syndrome), newborn screening (e.g., Phenylketonuria), and late onset disorders (e.g., Huntington's Disease). The development of MFPs may change this by making available a wider range of tests to a larger segment of the population.

Under the guise of individual monitoring and population health surveillance, MFPs have the potential to increase the medicalization of health care by placing a premium on testing and personal risk management. From a strictly rational perspective, such testing is associated with improving diagnosis, minimizing adverse drug effects and improving their efficacy, and identifying individuals who may be particularly susceptible to environmental and occupational exposures to chemicals, radiation, and other hazards. Although laudable on some levels, such testing may lead to systemic genetic discrimination that could create a genetic divide that parallels other divides in our society (e.g., digital, informational) (Nelkin and Tancredi 1994). Since health is strongly correlated with socio-cultural factors and inequalities (e.g., age, gender, wealth, ethnicity, level of marginalization), a society where MFPs are used without critical regard runs the risk of entrenching a form of biological (genetic) determinism (Nelkin and Tancredi 1994), and the geneticization of medical knowledge and health care practice (Hedgecoe 1999;

2 Biopower refers to Foucault's analysis of the way that power/knowledge discourses serve to rationalize and order bodies at two intersecting levels: the body of society (further theorized with the notion of "governmentality") and the body of the individual (further theorized with the concept of "technologies of the self"). Biopower highlights the social construction of knowledge, in the first instance, but also identifies the way that populations and individual selves are interpellated by and ordered through power/knowledge systems.

Lippman 1991; ten Have, 2001). Furthermore, the integration of MFPs with human genetic databases magnifies this tendency significantly due to the simultaneity of decentralizing and centralizing a range of power effects. By their very nature, MFPs are tools of decentralized data collection and local analysis. Instead of biological samples being sent to centralized laboratories for analysis, MFPs bring the lab to the clinic and other points-of-concern. Simultaneously, MFPs will require access to comprehensive human genetic databases. The discrepancy between the ubiquity of MFPs as medical diagnostic tools and access to databases that could prove expensive to access (especially if owned by the private sector), opens up new avenues for analyzing the power effects of this technology, and our changing understanding of the relationship between nature and culture (biosociality).

Identity formation and risk factors

Rabinow suggests that new cultural formations will emerge out of biology. He uses the development of new support groups as an example, whereby individuals who are "at-risk" of developing a particular kind of disorder may come together (due on their encoded status as "at-risk") to form a new social group or network based upon a cultural construction of biological categories. This is especially salient where there are significant gaps between diagnosis and therapies. For Rabinow (1999, 411), the Human Genome Project exemplifies this cultural transformation such that the "new genetics will cease to be a biological metaphor for modern society and will instead become a circulation network for identity terms and restriction loci, around which and through which a truly new type of auto-production will emerge, which I call biosociality…"

MFPs are likely to accelerate, at least initially, the tendency for new social groups to form based along at-risk states, even if the risk is only probabilistic in nature. As such, risk is not a result of specific dangers posed by the immediate presence of an individual or a group, but rather of the combination of interpersonal factors that make a risk probable. Prevention then is surveillance not of the individual but of likely occurrences of diseases, anomalies, and deviant behaviors that place a premium on monitoring populations instead of individuals. Although MFPs are used at the level of the individual, and have an intrinsic capacity to focus biopower at this level, it is in the use of this technology for generalizing from individuals through genetic databases that the subtler effects of biosociality begin to emerge.

Exposing the cultural practices of science

The concept of biosociality relates to an emerging condition whereby biological explanations of society will be less dominant, and where the cultural and social metaphors that define science will emerge. In other words, science will model itself after social values, thereby exposing the cultural practices of science. For example, Rabinow contends that what is now considered natural will become exposed as a cultural construct, or artificial. This tendency to view science as culture is being driven in part by particular technologies that highlight the nature of scientific uncertainty. For instance, MFPs are the result of interdisciplinary research in microbiology, genetics, microfluidics, microscience and nanoscience, engineering, photonics, bioinformatics, and several other areas. The crossing of disciplinary boundaries to create and use this technology reveals several gaps in general scientific understanding, and particular gaps in understanding how to address multiple kinds of uncertainty (e.g., laminar flow in liquids, quantum effects at the nanoscale, genetic markers, etc.). Handling these uncertainties, both individually as scientists and as teams of scientists, reveals the cultural practices of individual scientific disciplines to scrutiny, thereby leading toward biosociality. On another level, the choice and configuration of databases for referencing the results flowing from MFPs reveals other kinds of uncertainties that also expose science to increased scrutiny and demythologizing forces.

In search of a post-disciplinary society

Rabinow appears to embrace the prospects of biosociality because he contends that in biosociality, in an era of artificiality, the boundary between nature and culture will be ruptured and problematized. He contends that a post-disciplinary society will privilege neither nature nor culture, and hopes that both will increasingly be evaluated by ethical standards. By showing how science is artificial, and based upon the creation of artificial "natural" things, science will be exposed as culturally loaded rather than as neutral. For Rabinow (1996), this condition depends upon an anthropologizing of the West where the taken for granted objectivity of science is exposed as cultural practice, and where genetic science in particular is shown as discursive, ideological, and based upon well-entrenched knowledge/power systems. MFPs will accelerate the trend towards problematizing the split between nature and culture. In the same way that various genome projects have shown the high degree of similarity between the genomes of mice and humans (thereby weakening our collective perception of superiority to so-called lower life forms), MFPs will rupture the currently sanctioned comparisons that institutions and individuals make between the able-bodied and disabled, and the healthy and unhealthy. On the surface this appears to be a paradox since MFPs are likely to increase, in the early years, the tendency toward geneticization. However, the use of this technology in conjunction with human genetic databases will ultimately expose the distinctions between culture and science as untenable, and dangerous if held onto too tightly.

Conclusion

These new diagnostic tools have the potential to intensify existing social, ethical, and legal dilemmas on a scale like never before. For example, the speed and precision of MFPs will make the development of thoughtful genetic information policies all the more essential. As policy makers continue to struggle with defining the clinical utility of existing genetic profiling procedures, MFPs will likely allow for the collecting, storing, and sharing of even more information more quickly. Initially, the use of this technology is likely to accelerate concerns about genetic discrimination, geneticization, and the increasing scientization of culture. However, as MFPs, and the databases they rely on, become commonplace, several contradictions between nature and culture will be exposed. Our intent is to continue to draw upon the concept of biosociality to more fully understand and empirically analyze specific intersecting sites of nature/culture and power/knowledge in the production of MFPs, genetic databases, and their respective publics.

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