Digital Cohabitations: The Social Consequences of Convergent Technologies

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A defining feature of the 'knowledge' economy is its embedding in what Mark Poster once rather tentatively termed the 'mode of information' (Poster:1984) (1)

Today, unlike in the mid-1980s, we can do more than conjecture and can confidently claim that a defining characteristic of the mode of production today is the 'informationalisation' of the forces and relations of production, meaning that information processing and information-related tasks linked to the production of products, information-centred or otherwise, is now germane to all productive sectors of the networked economy and has become the premier means of generating economic value. The logic of information has invaded every conceivable sphere of production and has reproduced it in its image. This is by no means a stand-alone logic for it reflects the latest phase of capital accumulation. In other words, while the key objectives of the capitalist mode of production remains intact – ie, the exploitation of labour and the creation and extraction of surplus, there has been a transformation in the mode of production - changes to the productive forces, in particular the instruments of labour that are the source of material wealth, and in the relations of production, for instance changes engineered by the globalisation of production, labour and culture. Changes to both these spheres are, to a large extent, a consequence of the globalisation of information and the applications of information technologies.

The management and control of knowledge via informational networks is the source of contemporary social, economic and political power. Many marriages have taken place between previously separate technologies – for instance information technologies and biotechnologies, IT and surveillance technologies, IT and military technologies and so on. The informational logic of cybernetics, characterised by information and feedback, and expressed via flows and networks, is the basis for a whole range of productive processes across multiple sectors - biotechnology laboratories, just in time manufacturing, clerical work, classrooms, military strategies, public surveillance, the health industry, agriculture, seed production, national and global governance, investments and financial networks, transport, not forgetting the cultural industries. The informational mode of production, in turn, is located within and sustained by neo-liberalism and the free market. While it would be irresponsible to claim that this new logic has equally affected all production processes throughout the world, given that two-thirds of the world exist within another matrix of development, governed by other technologies, frameworks, options, hopes, expectations - the logic of information is nevertheless, pervasive and global. As markets penetrate into the deepest rural hinterlands, and as information becomes an essential raw material in all major processes and commodities, from the manufacture of genetically modified food (GM) to retroviral drugs for AIDS, to surveillance, it is necessary that critical communication scholars begin to engage with the cybernetic moment, explore its centrality to economic and cultural globalisation, the creation of value and the overall implications of this for society.

Why and how did this mode of information become so universal and dominant within a relatively short space of time? While cybernetics and cybernetic applications were developed in the early twentieth century, its epistemological basis and method of conceiving the world can be traced back to the philosophers of the Enlightenment such as Rene Descartes and Francis Bacon. Cartesian philosophy, that was the basis for the Enlightenment and that provided the logic for modern science and technology, postulated that mind and reason was perfected in the thinking person (male) who was the acme of creation. Matter, in this way of thinking was independent of the mind. Knowledge of the material world was power and the object of power was to subjugate and control the world. And power could be exercised by ordering the world, by extracting and codifying knowledge, on the basis of a mathematics-based, cognitive method, which, for Descartes and his contemporaries, was the method par excellence for the function of rationality. Leela Gandhi (1998:36) (2) has critiqued the reductionism inherent to this way of thinking "To think of the world mathematically,….as mathesis, ..requires a reductive application of a few abstract and generalising principles to the multiplicity of particular things. It requires a progression from theoria, or theory, to praxis, or practice, rather than the other way around". Successive scientific revolutions since then have attempted to create a unitary knowledge of all things – and one can argue that cybernetics, "the science of systems of control and communications in living organisms and machines" has contributed to the ordering of the world in the 21st century.

There were also rather more prosaic reasons for this transformation to the mode of production. Namely economics, the imperatives of trade and the politics of comparative advantage. The global recession in the 1970s and 1980s, the fall in the price of primary commodities and the decline in manufacturing exposed weaknesses in the traditional economy that was based on industrial manufacturing. There was a need for alternative means of value creation. By the early 1980s, computing had emerged as a powerful tool in value creation. The products and processes of digital capitalism were projected as a potential means of reinforcing global economic dominance by USA, Western Europe and Japan over the rest of the world. There was a need to extend, maintain and reinforce market share in the trade of new informational products and lay down the terms of protection for trade in the emerging digital economy. Proposals related to Trade Related Intellectual Property (TRIPs) were included in the Draft Final Act submitted on December 20, 1991 at the Uruguay round of Multilateral Trade negotiations of the General Agreement on Tariffs and Trade (GATT). This proposal was opposed by the developing world, Brazil and India in particular, who were of the opinion that the UN-related, World Intellectual Property Organisation (WIPO) that had been set up to deal precisely with IP issues, ought to oversee global IP-related concerns. Vandana Shiva (1998:85) (3), a foremost critic of the proprietorial economy, has observed that TRIPs was not a result of democratic negotiation. Rather, it was an imposition by three organisations, "…the Intellectual Property Committee (IPC), Keidanren, and the Union of Industrial and Employees Confederation (UNICE)". Shiva points out that "IPC is a coalition of 12 major US corporations: Bristol Myers, Du Pont, General Electric, General Motors, Hewlett Packard, IBM, Johnson & Johnson, Merck, Monsanto, Pfizer, Rockwell and Warner. Keidanren is a federation of economic organisations in Japan, and UNICE is recognised as the official spokesperson for European business and industry". For our purposes, it is interesting to observe that among the twelve US corporations behind the IPC initiative are key corporations that are contemporary leaders in the new synergistic industries – the life sciences, the cultural industries, computing, and military technologies. But this is not the only policy instrument that has been used to protect the comparative advantage of the West – the International Convention for the Protection of New Varieties of Plants – the UPOV Convention, whose entire membership is limited to twenty states from the developed world, extends to plant breeders, namely life science corporations, protection over genetically modified seeds.

What, from a political economy perspective are among the key features that demand an exploration? There are a number of issues including the following: The need to 1) theorise information, from the perspective of inter-sectoral convergences and the universality of information applications across all productive sectors including the manufacture, trade and ownership of genetic and biological information including “human biological information” (1996) (4). James Boyle refers to it as the “homologisation of information” (p.3) (5), the fact that it makes little sense today to distinguish between genetic and electronic information because both types of information have begun to overlap and face the same problems of regulation. When culture and nature are translated and commodified into digital information, the commercial exploitation and ownership of this information does have the potential to become a source of extraordinary power, 2) Monitor the new sources of global economic and political power in an era of convergence, 3) Explore governance and regulation issues in this new economy, namely the organisations, instruments and regimes of intellectual property that protect digital property and 4) Understand and engage with some of the key public issues arising from the interfaces between technological convergences and society not least the new dynamics of exclusion, that Scott Lash (2002)(6) refers to as the “…. new type(s) of stratification, in which social class depends on relations to intellectual property and rights of access to the lifted-out spaces of technological forms of life”(p.24). These new instruments of exclusion are a result of the extension of property values to every conceivable aspect of culture and nature, animate and inanimate, critical to the growth of global capital. This article is a modest attempt to explore some of the issues related to these new convergent technologies that have been built on the basis of a common, inter-operable language – information. The focus in this article is on a key interface - IT and biotechnology, and the social consequences of the ownership and control of biological information from within the larger context of contemporary knowledge concentrations.

To date, few communication scholars have begun to explore critical questions that arise from the interfaces between ICTs and other new technologies such as biotechnology. Scott Lash’s (2002) Critique of Information that attempts to reconceptualise culture, society and agency within the primacy of information flows, Dan Schiller’s (1994) (7) essay on the commodification of information in the digital economy, Nick Dyer-Witheford’s (1999) (8) neo-Marxian understanding of resistance within the new circuits of high-technology capitalism, Sandra Braman’s (2000) (9) engagement with the new meta technologies of power, especially biotechnology and information technology, Kaushik Sunder Rajan’s (2002) (10) observations on patenting and the ‘informationalisation of human biologicals’ and Donna Haraway’s (1991) (11) liberation treatise, a ‘Cyborg Manifesto’, are among a relatively small number of attempts to understand the new and extensive role of information as a vehicle for capital accumulation, and the political consequences of convergent technologies, albeit from different theoretical vantage points. Mention also must be made of Jeremy Rifkin’s (1998) (12), The Biotech Century, for its clear, accessible, critical introduction to a complex area, in particular Chapter 6 ‘Computing DNA’, that explains the cybernetic moment in biology – and the key events that led to the understanding of biology in terms of principles drawn from cybernetics.

Dan Schiller’s (1994:102) (13) observations on the pervasive, cumulative, penetrative logic of information is a useful introduction to the reality of convergence and the informational mode of production - “The transition to an information-intensive economy….does not depend on a narrow sector of media-based products. It is, rather, coextensive with a more or less thoroughgoing socio-economic metamorphosis across a vast and still undetermined range….The convergences and overlaps between genres traditionally of interest to communications research – television shows, newspaper reports, computerised date streams – and genes now subjected to unprecedented manipulation and control via bio-engineering, compel considerations as part of a single conceptual and historical process”. In other words, Schiller maintains that the many marriages of convenience that have taken place between information technologies and a host of other technologies – biotechnologies, nanotechnologies, surveillance technologies, military technologies – make it imperative that the study of the political economy of communication engages with issues and concerns outside of its 'traditional' remit. This is by no means an impossible task given the normally inter-disciplinary nature of communication research. However, this task is not made any easier by the fact that the commodification of information is an extensive, continuous, cumulative and rapid process, transforming all previous productive processes in its image. The question then becomes one of prioritisation – which cross-sectoral information applications impact the most on life processes and affect the survival chances of ordinary people? What emerging structures are supportive of these new economic interests? How and in what way do information technologies impact on these processes? What are the ways in which new property regimes underwrite these developments? And what needs to be done to democratise these technologies and adapt these to the needs of development rather than to that of predatory forms of accumulation?

The Logic of Cybernetics

In order to come to a clearer understanding of the specifics of IT in technological convergences, a basic introduction to the informational basis of cybernetics will be appropriate. Cybernetics, the basis for electronic communication, claims that the maintenance of all life processes over time can be explained by two interrelated applications – information and feedback occurring in continuously integrated real time. Computing is fundamentally built on a cybernetic model of information flows. Computing functions on the basis of binary logic – 1s and 0s, within a continuous process of information and feedback. The computer translates the source codes that are fed into it into machine-readable object codes resulting in seamless, continuous correspondences between inputs and outputs. Computing has become a powerful means of deciphering, intervening, changing, managing and coordinating increasingly vast amounts of external data, including the blueprint of life itself. How did this essentially mathematical, cybernetic model of life become universalised and how did its root principles become the basis for understanding biology and nature?

Cybernetics and Biological Information

When James Watson and Bernard Crick announced the discovery of the DNA double helix in 1960, they used the language of cybernetics to describe their find – the gene, for instance, was described as a code that was programmed and could be deciphered. The gene, in other words, was described in terms of an 'information system' that functioned in relation to all the other genes that made up the human genome. This way of conceptualising biology on the basis of principles drawn from cybernetics was first mooted by Norbert Weiner, who had, as early as in 1948, drawn parallels between machines and organisms "both…used on-off switches in their information processing (neural in one case, electromechanical on the other) and both used "feedback loops" – circular processes beginning in the nervous system, emerging as output through muscular activity, and cycling back into the nervous system through sensory input – to interact with their environments"(1996:309)(14). The physicist Erwin Schrodinger was the first to suggest that the gene was an information carrier and that the physical structure of the gene corresponded to a hereditary code script (Reimer & Fuellen:1) (15). This determinist, mechanistic view of an information-centred understanding of life and of humans as information processing systems is all too common place and is illustrated in this quotation from the contemporary science writer Tom Siegfried (2000:100)(16) – “ In a way thanks to DNA and the genetic code, the life sciences adopted the super paradigm of information even before the computer introduced it to the physical sciences. Information and life were a natural fit. After all, science’s understanding of life is based on Darwinian evolution by natural selection, and selection is, in essence, information processing. It’s all about input and output. In evolution, the environment processes the information presented to it in the form of organisms and produces output – some dead organisms, some live organisms. The information in the live ones survive to make more organisms. DNA, therefore, does not just store information about an individual. DNA is really a record of the selection that has gone on in evolution…DND is the Herodotus of molecules. For chronicling the history of life, it beats stylus and papyrus, quill and parchment, typewriters and paper, or keyboards and floppy disks”. The social shaping role of the environments in which we live in our lives, is rarely, if ever, acknowledged in such writings.

Metaphors borrowed from computing were used to understand life forms as biochemical machines whose efficiency coefficients could be raised by precise genetic reprogramming. Sheldon Krimsky’s (1991:5-6) (17) observations point out the centrality of cybernetic language to the understanding of modern biology. “The modern conception of the cell is based on a cybernetic materialism involving information transfer, energy, feedback signals, primary and secondary matter…replication, and reproduction…In the language of the new cybernetic materialism of molecular genetics, genes or DNA are referred to as “bits of information” or the carriers of the “code” for the production of proteins….DNA is said to be unzipped…Genomes are spoken of as being mapped, DNA as being read or sequenced. The term “gene machine” has been introduced to describe devices that synthesize specified stretches of DNA automatically. The frequently used expression “reprogramming micro-organisms” exploits the language of computers to characterise human-induced changes in the DNA “code”. The brain too is today likened to a bio computer that can be reprogrammed with the right commands leading to all sorts of behavioural changes.

This imaging of natural processes within the logic of the machine was intentional, not least because it helped scientists to subjugate nature under human control. If the cell could be re-programmed to suit the needs of human beings – if it could be used to manufacture products, the commercial opportunities would be limitless. The reduction of the human body to a commodity presents the market economy with another potentially lucrative source of value. Already huge profits are being made from the trade in organs, tissues, cell lines, semen, ova, blood, and the market in transgenics is bound to result in the further commodification of the body.

Soon after, all living organisms came to be understood in terms of information systems that were maintained by corresponding nodes and networks. The genome, for instance, is described as the totality of genetic information in an organism. Computer hardware is, in this way of thinking analogous with the ‘protein’ that processes information in each gene and computer software with the nucleic acid that embodies information. This rather mechanical view of life is based on a deeply conservative paradigm that understands life in terms of ordered predictability. However, this imperative is constrained by the altogether more complex response of Nature. In spite of our best attempts to order the gene in our image, genes remain unpredictable in behaviour. From a human rights perspective, what is deeply problematic is the attempt by policy makers to use these understandings as the basis for planning social policy. Sociobiological explanations that blame the gene, privilege genetic self-interest and genetic causes for medical and social conditions are often used by governments to justify their own lack of investments in creating environments and opportunities for another, more complete development of people and communities.

Bio informatics

Computing and information networks have been absolutely central to the development of this era of commodification. Jeremy Rifkin (1998:181)(18) describes the increasing interfaces between computing and biotechnology that are a result of 'real' correspondences: "It is not only the computer's rules of engagement that make it a suitable communication tool to manage dynamic living systems. The very 'operational language' of the computer is now being grafted onto biological systems. It is this common language that is creating a seamless web between the information and life sciences and making possible the joining together of computers and genes into a single, powerful, technology revolution". What is equally significant is the very nature of these new technologies. They are, as Sandra Braman (2000:1) (19) has observed 'meta-technologies'. These are very different from the previous generation of technologies that depended on a limited amount of inputs for the production of limited outputs. Meta-technologies are infinitely flexible and can be adapted to handle different types of inputs for the creation of a varied range of outputs. To a large extent, the inter-operability between meta-technologies has been facilitated by the universality of digital code.

Computers are however not only used for the storage, analysis and retrieval of data, for purely functional purposes. It has also become the means for modelling, design and simulation, imaging products and processes, and reprogramming life itself. The databases related to the Human Genome Project consist of informational translations of physical data that have been identified through powerful computers based on parallel processing. As Fukuyama (2002:74) (20) has observed "The Human Genome Project would not have been possible without parallel advances in the information technology required to record, catalogue, search and analyse the billions of bases making up human DNA. The merger of biology and information technology has led to the emergence of a new field, known as bioinformatics. What will be possible in the future will depend heavily on the ability of computers to interpret the mind-boggling amounts of data generated by genomics and proteomics and to build reliable models of phenomena such as protein folding". Databanks, in other words are crucial to this enterprise as there is a constant need to datamine, analyse, predict and compare the avalanche of biological information that is constantly being produced.

Databanks, IPRs and Enclosures Around Biological and Cultural Knowledge

The data stored in these banks is the raw material required for the genetic manipulation of living organisms through gene splicing and recombinant DNA technologies – genomics. The genome comprises of 3500 million molecular groups known as bases or nucleotides. Genes consist of strings of literally thousands of sequences of the four nucleotides – adenine, guanine, cytosine and thiamine, and gene sequencing technologies have been used to decipher the 50,000 genes that consist the human genome. This information is located in public and private databases located mainly in Europe, the USA and Japan. These databases in turn are situated and function out of a global grid of informational networks that allow for easy transfers of vast quantities of data. For instance the European Molecular Biology Laboratory (EMBL) based in Heidelberg runs the Nucleotide Sequence Data Library (NSDL), one of two main collecting points for genetic information. This institution “sends out its data on CD-ROMs, which are updated quarterly. It uses the worldwide scientific data network, BITNET, and a newly established European Molecular Biology Network, EMBnet. The laboratory’s database also includes references to other databases, such as the Protein Identification Resource in Washington DC and the Protein Bank Data of 3-D structures of proteins at the Brookhaven National Laboratory in New York. GenBank (the other main data base for genetic information on the human genome based in the USA) and the EMBL database also exchange information with the DNA Database of Japan at the National Institute of Genetics in Mishima”(1990:2) (21). GenBank is currently administered by the National Institutes of Health’s National Centre for Biotechnology Information (NCBI). In July 2000, GenBank held the sequence data for around seven billion units of DNA. The National Centre for Biotechnology Information, Bethesda, Maryland, and SwissProt based at the Swiss Institute of Bioinformatics also host important databanks. As Bob Holmes (2002:58) (22) observes, there are databanks on every conceivable aspect of genetic information “Apart from the DNA Sequence databanks and the protein sequences derived from them, there are now compilations of complete genomes, three-dimensional structures of proteins, physical associations between proteins, databases of which genes are active in which cells and under which conditions, databases of gene mutations and the diseases they cause, and more”. In the early 1980s, the US National Institute of Health and National Cancer Institute launched a programme oriented towards the screening of wild species from the topics aimed at finding compounds for use in anti-HIV and cancer drugs. The collection of germplasm and the location of germplasm databanks indicate another aspect of the source of power in our world today.

The ownership of information is already a critical and contentious area in global cultural, economic and trade policy. Databanks on biological and physical information along with archives on culture and society are increasingly being privatised. Global intellectual property regimes support the creation of enclosures via archives and databases. Together, they can be used to create formidable fortifications around knowledge that are only made available for a fee. Even the large public databanks in the USA that ostensibly are public repositories of knowledge, cannot be accessed by the ordinary citizen – in fact there are highly restricted access procedures that, in the post 9/11 environment, will become even more rigid.

All the major cultural industries are not only content producers but are also increasingly involved in production and distribution. These TNCs are not only owners of the software but also own the hardware and the backbone, the information highways. Sony’s digital archives as well as the archives owned by AOL-Time Warner, News International, Disney, Vivendi and Hollywood, are a source of revenue and is protected by copyright. Similarly, IBM and Microsoft’s armoury of patents are used to maintain their dominance in hardware and software. These repositories of cultural and technical knowledge are complemented by a variety of databases on human and non-human biological information, physical information on sea, land resources, sociological information on populations, military databases and so on. These include the National Library of Medicine’s (US) database on the world’s genetic information – the largest of its kind, and its Protein Identification Resource database on amino acids, the US pharmaceutical giant Merck’s Merck Gene Index, The European Molecular Biology Laboratory, the databases owned by Human Genome Sciences and Incyte Pharmaceuticals, Celera Genomics the Genome Database at Johns Hopkins, germplasm databases owned by seed companies DuPont (USA), Pharmacia (Monsanto-USA), Syngenta (Switzerland), Groupe Limagrain (France), Adventa

(UK/Netherlands), Dow (USA), the public seedbank Consultative Group on International Agricultural Research (CGIAR) (Rome) among others, NASA's Earth observation database on the atmosphere, biosphere, oceans and land surfaces., are among companies that have knowledge of, and have patented a large share of the earth's resources. For instance, Incyte has won 500 patents on full length genes and has applied for 7,000 additional patents on genes. While a few of the larger countries in the developing world have begun to create their own databases – for instance the National Bureau of Plant Genetic Resources in India – the very fact that USAID has contributed to forty per cent of the costs of setting it up " in return for which American scientists have access to seed and data for research"(1992:8) (23), and the fact that companies like Hoechst (Germany) which owned 86,000 patents in 1995 had already screened 90,000 soil samples from India (1996:151) (24), indicate the extent to which aid and bio-prospecting have reinforced the terms of neo-imperial conquest.

While modern molecular biology is centrally dependent on computing for the analysis, storage and retrieval of increasingly vast amounts of data, and bio computing covers a wide range of information processing options - simulation, graphical user interfaces and databases, among other applications, these information interfaces are by no means unique. Information technology and biotechnology have become a key aspect of modern military technologies exemplified by the 'smart bomb', biological and chemical warfare and the continuous remote surveillance of societies in different parts of the world. Electronics, sensors, computers and software, genetic engineering and the development of new materials are meant to enhance the prowess of the new age soldier in an era of informational and biological warfare. The adaptation of cybernetic principles to understand neural processes and human biology has led to fields such as artificial intelligence and to the development of biometric systems used for authentication and identification, for genetic profiling, an obsessive feature of life post 9/11. These new processes and applications are just a handful among literally hundreds of applications that have come about as the result of the advances and correspondences between biotechnology, nanotechnology, materials technology and their interfaces with information technology. The seemingly disparate uses of IT across a range of new applications hides a pervasive 'ordering logic' built on the cybernetic principles of control, command, intelligence and communication.

For those of us whose parameters for the study of a critical political economy of communications were mainly based on an interrogation of the politics, structures, processes, systems and rules pertaining to the extension, maintenance and dominance of the cultural industries – there is an absolute need to address not only the traditional structures of cultural and economic dominance in our globalised world but also the new sources of global cultural, economic and political power and the instruments being used to reinforce this power. In other words, the lessons of the AOL-Time Warner merger and the decline of that partnership may, in the long run, be of less significance than IBM's massive investments in the life sciences. And rather than deal with communication policy issues per se, it is imperative that we interrogate the source of property power in the knowledge economy – the structures, systems and instruments of intellectual property that have become the means of maintaining corporate dominance in the new economy.

The Ownership of Global Knowledge/Resources

On the surface, corporate dominance continues to be a reality in every economic sector. In the cultural industries, despite the recent recession, poor performances and the downturns in dotcoms, AOL-Time Warner and Rupert Murdoch's News International remain dominant. In software, Microsoft. In hardware, International Business Machines (IBM). In non-media sectors, in pharmaceuticals – the first three leaders in terms of sales, profits and percentage share of the global market in 2000 were Glaxo/Smith Kline Beecham, Pfizer and Merck & Co with 19 per cent share of the world market between them. In biotechnology, the leading company was the US based Amgen. The first three among the top agrochemical companies in 2000 were Syngenta(Novartis+AstraZeneca), Pharmacia (Monsanto) and Aventis (AgrEvo+Rhone Poulenc) with a combined 45 per cent share of the world market. Among the three top seed companies in 2000 were DuPont (Pioneer), Pharmacia, and Syngenta. The top three food and beverages corporation included Nestle, Philip Morris and ConAgra Inc. The top three global grocery retailers included Wal Mart (USA), Carrefour (France) and Ahold (Netherlands) (2001) (25). The late 1990s saw same major mergers by industries related to agricultural biotechnology. Chaturvedi (2002:1216) (26) observes that " Monsanto has emerged as the biggest player in the game. In the process it has acquired some of the largest firms in the US commodity markets and holds important patents. For instance DeKalb has 11 per cent of the US commodity market…Similarly, Delta and Pineland is the largest US company for cotton seeds. Monsanto has also acquired the international seed operations of Cargill for $1.4 billion…Ciba and Sandoz have merged their pesticide and seed business of $5 billion to form…Novartis….the merger of Hoechst and Rhone Poulenc to form Aventis (which has) an R & D budget of $3 billion and annual sales of $20 billion all over the world".

Ownership & Control in the Bioinformatics Sector

It can be argued that the more far-reaching developments relate to the new synergies being formed between the IT and biotech sectors. The bio informatics market that is devoted to making sense of the sequence, structure, and function of genes and proteins is an industry worth a projected US$ 6.9 billion in 2007. The IT market in the life sciences is estimated to be in the region of $30 billion in 2004. In fact a report in the Financial Times (2001:II) (27) states that the 140 collaborations between the IT and Life Sciences industries that year covered "…bioinformatics, DNA microarrays (gene chips), data analysis and visualisation, chemical and biological library integration, detection of human genetic variation (SNPs), microfluidics and in silico research (modelling drug effects in computers)". There are a range of bioinformatics companies catering to a variety of interests – custom-built software and consulting services and web businesses and tools and services aimed at pharmaceutical and biotechnology companies. Proteomics – the study of the interaction between genes, proteins and disease is highly computer dependent given the vast quantities of data that need to be generated " computing power measured in teraflops, or trillions of operations per second"(2001:1) (28). Proteomic alliances include Myriad Genetics Inc. with Hitachi Ltd. and Oracle Corp., IBM and MDS proteomics and Oxford Glycosciences Plcs venture with the telecoms equipment group Marconi Plc. Key players of IT fame involved in the life sciences include Compaq, Hewlett Packard, Motorola, Sun, Fujitsu, Hitachi and the leader IBM. IBM, for instance, has begun to invest heavily in the life sciences through making direct equity investments in companies such as MDS Proteomics (Canada), Devgen (Belgium) and Structural Bioinformatics (USA) (2001:II) (29). Owning more than half of the world's top 500 super computers, IBM has a head start on companies involved in a race to build a special super computer 'Big Blue' to analyse the protein structure. IBM's Deep Computing Institute has a Bioinformatics and Pattern Discovery Group which uses supercomputing to solve problems in molecular biology. Among IBM's many patented algorithms are Teiresias and MUSCA that are used for gene-pattern discovery and alignment and SPLASH that is used for pattern discovery. Microsoft's Bill Gates and Paul Allen have invested in a leading biotechnology company aptly named Darwin Molecular that is involved in gene sequencing.

Biotechnology and pharmaceutical companies too have integrated bioinformatic capabilities in house. For instance Lion Bioscience has built bioinformatics capabilities across all divisions within the pharma giant Bayer. Many pharma companies have built strategic alliances with bioinformatics firms, entered into licensing agreements and bought up smaller firms.

Patents in the New Knowledge Economy

These alliances, are in turn built on the IP protections offered by the TRIPS platform and a variety of derivative, or related global and regional IP treaties. These include, among others, the following – Washington Treaty on Intellectual Property in Respect of Integrated Circuits (1989), WIPO Copyright Treaty (1996), Berne Convention (1886), TRIPs (1994) Patent Cooperation Treaty (1970), Budapest Treaty of the International Recognition of the Deposit of Micro organisms for the Purposes of Patent Procedure (1977), the Convention of Biodiversity (1992), the Union of Protection of Plant Varieties (UPOV) and Plant Breeders Rights (1968), regional instruments such as the Biotechnology Patenting Directive of the European Union (1998), the North American Free Trade Agreement (1994), the European Community Patent Convention (1975). As convergence results in applications based on interlocking correspondences between areas that used to previously be autonomous – chemistry, modelling, biotechnology, telecommunications, bio-medical technologies, computing, among other areas, IP issues have become a lot more complex. A single application can be governed by a range of patents which is why it makes sense for the major players in this area to build up a formidable, inter-sectoral IP presence. In fact the patenting of research tools including screening systems, expressed sequence tags (ESTs), techniques related to DNA sequencing among other tools further strengthens control over the downstream research of companies involved in bioinformatics. IBM's leading edge in computer hardware design and innovation is built on an aggressive patents regime. The US Patent and Trademark Office's annual league table of corporate patent filers in 2000 was topped by IBM which had filed 2,886 patents, twice as many as Lucent, the next in line. Many of these patents are licensed – an industry that earned IBM $1.7 billion in profits (2001) (30).

Further Lines of Enquiry

What are the major consequences of this mode of production and how will it impact the lives of ordinary people? There are several concerns and issues that need further exploration. First, the need to interrogate the principles animating this mode of production that are broadly coterminous with variants of socio-biology - self-interest, competitiveness and the survival of the fittest. There is little or no space for communitarian ideals and goals in this discourse, although the PR speak from Monsanto would suggest otherwise. While there may well be enormous positive benefits to be gained from some of these new scientific applications, the fact that the current framework for the development and applications of these new technologies have not been built on a clear commitment to distributive justice, places limits to its obvious potential. In an unequal world built on multiple disparities that have congealed over time, these emerging technologies and the policies that are supportive of the growth and development of these technologies including IPR, are bound to accentuate existing divides. When millions of people are denied universal access to or the affordable use of a basic technology such as the telephone, it is difficult to imagine the positive impact that these new convergent technologies might have on the lives of the poor in the immediate future.

The second concern stems from the fact that we are already living in an era in which as much or more value is given to intangible resources such as information and knowledge as to physical resources such as land and food. While physical survival is based on the consumption of basic resources such as food and, when required, medicine, the very fact that a basic resource such as the seed has been re-commodified within a knowledge economy, makes access and affordable use even more of a problem for the millions, who find survival within the old economy a struggle. In other words, within the informational mode of production, the majority of the world's poor are bound to lead doubly disadvantaged lives. What is the nature of social shapings in an era dominated by these informational meta technologies? Are these social shapings in the interest of ordinary people? To what extent are these developments fueled by commercial rather than real needs? Will transgenic transfers be made accessable and affordable for all or will it remain an option for those who have the means to pay for such treatment?

A third concern has to do with issues of governance and regulation. Countries in the South, that have been herded into the WTO fold, have within the trade framework, no option but to comply with new globally enforced legislations supportive of the informational mode of production – whether this be related to battling cyber crime, increasing national surveillance, creating environments suitable for e-commerce, liberalising trade in GM foods or ensuring stronger IPR protection. In the context of a uni-polar world and the emergence of the USA as the world's number one hegemonic power, this has rather ominous implications.

A fourth concern is the need to combat the evolutionary logic that is rife in scientific and technocratic establishments and that is articulated in global media discourses. There is a global consensus within the neo-liberal framework that successive technological regimes – for instance IT followed by the era of multiple convergent technologies is an inevitable, perfectly logical evolutionary unfolding. In this manner of thinking, the brain is just another computer and technology is neutral. This kind of understanding obfuscates the need for an engagement with the dominant metaphors and ideas of our time, with the politics and economics that result in developments in science and technology and their applications following one direction rather than another. In other words, there is a need to problematise the logic of inevitability, the myth of technological neutrality and to engage with the social constructedness of technology. Countries like Brazil, India and Malaysia are now being primed to become leaders in biotechnology in the South. While there is a need to recognise the potential benefits of new scientific applications, surely we also need to think in terms of co-existing technologies rather than a future shaped by monolithic technologies. The South does not seem to have the space or the power to shape science and technology appropriate to their needs. The issue is not one of biotechnology or but biotechnology and. The issue is about technologies that facilitate deep, integrative visions of development rather than those that are supportive of one-dimensional approaches.

A fifth dimension is the need for an expansive, critical, theoretical exploration of information as a constituent element in this new global mode of production. Information is central to the expansion of capital, at the very core of the globalising world economy. Without such an overview, any critique is bound to be limited by the specificities of particular technologies. These new meta-technologies demand new understandings.

Sixthly, there is a need to grapple with the Pandora's box of ethical implications. We are dealing with hegemonic technologies. These technologies are hegemonic because of their intimacy. Every aspect of our lives – reproduction, consumption, the zones and environments that we inhabit, work in, culture and nature, health and food security, governance and security will, sooner than later, be based on and tied to this informational mode of production. Is the notion of privacy relevant in a context in which individual cell lines and genes are being patented and privatised? How does one begin to re-engage Gramsci and Foucault in the understanding of these new sources of power and every day hegemonies? What are the consequences of the exercise of power for regions, nations, communities? Who benefits from the exercise of this power? Who are its victims? To what extent will this exercise of power result in more harm than good? And finally, the issue of how we can socialise this new mode of production, so that informational applications nurture life, enhance democracy and enable distributive justice.

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(Acknowledge comments on a first draft from Dan Schiller, Chun Ewun Hwi, Sashikala Shetty)

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