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The Evolution of Media Into The Tangible
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INTRODUCTION

Printcrime
The coppers smashed my father’s printer when I was eight. I remember the hot, cling-film-in-a-microwave smell of it, and Da’s look of ferocious concentration as he filled it with fresh goop, and the warm, fresh-baked feel of the objects that came out of it.

The coppers came through the door with truncheons swinging, one of them reciting the terms of the warrant through a bullhorn. One of Da’s customers had shopped him. The police paid in high-grade pharmaceuticals — performance enhancers, memory supplements, metabolic boosters. The kind of things that cost a fortune over the counter; the kind of things you could print at home, if you didn’t mind the risk of having your kitchen filled with a sudden crush of big, beefy bodies, hard truncheons whistling through the air, smashing anyone and anything that got in the way.

Da. What they did to him. When he was done, he looked like he’d been brawling with an entire rugby side. They brought him out the door and let the newsies get a good look at him as they tossed him in the car. All the while a spokesman told the world that my Da’s organized-crime bootlegging operation had been responsible for at least 20 million in contraband, and that my Da, the desperate villain, had resisted arrest.

By the time I turned 18, they were ready to let Da out of prison. I’d visited him three times — on my tenth birthday, on his fiftieth, and when Ma died. It had been two years since I’d last seen him and he was in bad shape. A prison fight had left him with a limp, and he looked over his shoulder so often it was like he had a tic. I was embarrassed when the minicab dropped us off in front of the estate, and tried to keep my distance from this ruined, limping skeleton as we went inside and up the stairs.

“Lanie,” he said, as he sat me down. “You’re a smart girl, I know that. You wouldn’t know where your old Da could get a printer and some goop?”

I squeezed my hands into fists so tight my fingernails cut into my palms. I closed my eyes. “You’ve been in prison for ten years, Da. Ten. Years. You’re going to risk another ten years to print out more blenders and pharma, more laptops and designer hats?”

He grinned. “I’m not stupid, Lanie. I’ve learned my lesson. There’s no hat or laptop that’s worth going to jail for. I’m not going to print none of that rubbish, never again.” He had a cup of tea, and he drank it now like it was whisky, a sip and then a long, satisfied exhalation. He closed his eyes and leaned back in his chair.

“Come here, Lanie, let me whisper in your ear. Let me tell you the thing that I decided while I spent ten years in lockup. Come here and listen to your stupid Da.”

I felt a guilty pang about ticking him off. He was off his rocker, that much was clear. God knew what he went through in prison. “What, Da?” I said, leaning in close.

“Lanie, I’m going to print more printers. Lots more printers. One for everyone. That’s worth going to jail for. That’s worth anything.”

1 Adapted from Doctorow, Cory, Overclocked, New York, Thunder’s Mouth Press, 2007, pp. 2-4
Cory Doctorow gives us a glimpse into a dystopian future that is entirely, albeit regrettably, possible. It echoes and extrapolates the draconian, example setting measures that today's music and film industries have been taking to protect their intellectual property. The rest of this introduction serves as a summary of what is to come in the text.

During the prehistory of mankind, the human race unconsciously became dissatisfied with the rate at which they were evolving biologically, and invented media, which created a different kind of evolution. This allowed them to share information, and pass it on to future generations, so ideas could be built upon, and evolve, themselves. Unlike the continuous nature of biological evolution, media technology advances in sudden growth spurts. Each time a new medium is discovered, a huge cultural shift is set to follow.

Currently we are part of the way through one of these cultural shifts, spawned by the Internet. In fact, we're only at the beginning. Some evidence for this lies in the changing role of the Internet in our lives, how corporations are reacting, and how people are reacting to the corporations.

One of the most useful affordances of the Internet for the general population is the sharing of information. This has increased people's appetites for information drastically. This has consequently led to a lot of trouble concerning intellectual property, due to piratic activity online. Moral values aside, piracy can't be stopped. There are too many people to deal with individually, there aren't enough prison cells in the world².

Doctorow has made the book, from which the short story above is taken, freely available online.  

² [http://entertainment.timesonline.co.uk/tol/arts_and_entertainment/article694986.ece](http://entertainment.timesonline.co.uk/tol/arts_and_entertainment/article694986.ece) (17/05/07) - “GERMANS risk two years in prison if they illegally download films and music for private use under a new law agreed yesterday.”
Information is destined to be free. Freely available knowledge can be built upon and create an open, positive feedback system, unimpeded by proprietary measures.

Doctorow's 'printer' uses a technology similar to today's rapid manufacturing. This is a means of creating one-off tangible objects directly from digital data. It's currently in its infancy, but with the exponential rate of technological advancement, it will soon be feasible for such machines to become domestic appliances, manufacturing all manner of products that could be downloaded from the Internet\(^3\). If piracy of intellectual property is still a big issue by then, this new technology will blow it out of proportion. However, if there is a more open societal infrastructure for the propagation of media by then, the world will become a more prosperous place and these machines will create wealth.

Replicators are the future of these machines. Machines that can create almost anything. Perhaps, such machines are some way off into the future. They are media convertors, translating data into the real world. They will give a new purpose to media. The implications for society are immense.

\(^3\) see Appendix B: Correspondence With Professor Adrian Bowyer
A HISTORY OF MEDIA

“Francis Bacon did not need to tell us that 'knowledge is power.' Intuitively, human beings have known this from the time someone first discovered not known before about the surrounding world and communicated that discovery to others.” Foster Stockwell writes in his “History of Information Storage and Retrieval.” There’s a bigger reason than just learning for the sake of mastering the unknown. Early man had knowledge of basic stone toolmaking. Passing this knowledge to the next generation allowed them to use it to aid their survival, and possibly to build upon its technology. Why do we communicate? To survive (primarily.)

In the early 20th Century, homeless people in the US, known as Hobos, developed a basic symbol writing system which illustrates the point that the most fundamental use for communication is to survive:

 Origins of Media

The original form of data storage on the planet was DNA, the plans used in constructing an organism in the reproductive process. Every single living organism contains these instructions. This primordial form of media is ultimately what created life, humans and culture. Furthermore, it contains the

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information to replicate itself, and in effect, design itself through evolution. This prerequisite of self-replication is exactly what Doctorow's “printcriminal” wanted to achieve.

Single celled organisms, over aeons, eventually evolved into humans. They had brains. Despite the brain's wonderful capabilities, it has a few inadequacies. These were the driving factors behind the invention of media:

Firstly, some kinds of data take a long time to absorb, long strings of numbers, for example. Secondly, memories can be forgotten as easily as they are learnt. Memories decay at different rates, depending on the synaptic strength between neurons (physically, how deep an impression it has made into the brain's hardware).\(^6\)

The final shortcoming of the brain, is that it is private to its user: its contents are inaccessible to others without a means of external communication. Humans invented speech. This acted as fast and accurate media between one brain and another. There was still a problem with speech, because of its temporal nature. The listener of the knowledge had to be there to hear the speaker. The natural evolution of this would be to create a solid, permanent record that persists through time.

**Human-Readable Media**

Writing evolved slowly, from decorative cave paintings (*fig. 2*) to stone tablets(*fig. 3*), from drawings to crude ambiguous symbols, to complete, accurate writing systems, that could not be misinterpreted any more than spoken language can.

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\(^6\) Sprenger, Marilee, *Learning and Memory*, London, ASCD, 1999
The first known modern writing system, called Cuneiform, was used in Sumer (now south-east Iraq) as early as 3000BC. This was used to write onto clay tablets with a stylus. Then the tablets were fired in a kiln to make them permanent. Only men were allowed to learn to write. The writing was used to write on monuments and epitaphs, glorifying the achievements their dedicatees so that they would be, in a sense, immortalized. It was the first medium to allow people to record information accurately, for future generations to read and build upon. It also spawned the concept of deliverable letters, a useful form of indirect communication we still use today.

The first books were written by hand. They started appearing in the 7th Century, and were religious texts, written by monks, who saw the painstaking process of writing it as an act of devotion to God. “The monks who sat for years, working on single chapters of the Bible, were not reproducing books. They were making the word of God manifest in the world.” The rise of universities in the 1200’s gave rise to books of non-religious content being written. There was a growing demand for new information to be broadcast as more people became literate.

In 1452 a German engraver named Johann Gutenberg invented the movable type printing press. This allowed for mass production of printed media. Books were now cheaper, more accurate, and now

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7 http://communication.ucsd.edu/bjones/Books/ (15/06/07)
8 http://en.wikipedia.org/wiki/Johannes_Gutenberg (15/06/07)
longer precious, rare commodities. The invention of printing “altered the cultural landscape of early modern Europe. The new medium created a 'communications revolution' that increased the amount and accuracy of information available and made scribal copying of books obsolete.” The data rate at which media could travel had increased dramatically. It also increased the desire in people for information, whetting their appetites.

Machine-Readable Media

In 1801, Joseph Marie Jacquard, invented a mechanical loom which created patterns which were stored on hole-punched cards - punchcards. This concept is the first example of progression from human-readable information, to machine-only encoded information, that can alter the state in which the machine works. It was the first real ancestor of the computer. The punchcard technology that these looms employed was still used up until over 200 years later in the giant IBM computers of the mid 20th Century.

In his book, Jaquard’s Web, James Essinger proclaimed that “the potential of the Jacquard loom extended far beyond silk-weaving.” The book is subtitled “How a hand loom led to the birth of the information age,” due to the fact that it was the first way to describe to a machine in its own language, what it was supposed to do. The Jacquard loom has displayed something more sophisticated than that: it was the first example of intangible data that is automatically and repeatably translated into the tangible real world, in the form of patterned fabric. Therefore, it was also the ancestor of the rapid manufacturing machines of today.

Before the invention of the telegraph, the only way to transmit information remotely over a long distance was to physically deliver the message. “The telegraph, which first became available for

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10 Essinger, James, Jacquard’s Web, Oxford, Oxford University Press, 2004, p. 43
Within a few years messages could be sent all over the Western World, relatively instantaneously. It was the advent of the global community, not only bringing news and information, but closing the gap between geographical locations.

In the late 1970’s affordable personal computers became available. They could accurately store vast, volumes of data. Libraries, no less. Along with computers came files and software. These enabled us to abstract the world into a digital form and gave us the tools to visualize and manipulate it. It also gave us a virtual space, in which to create, which was much more versatile than a drafting table, an easel or a musical score. The computer has become such a useful tool to humans that it has become almost ubiquitous among the population of the Western world.¹²

¹¹ Blondheim, Menahem, News Over the Wires, Cambridge, Harvard University Press, 1994, p. 3
ON THE HORIZON OF THE NEXT REVOLUTION

The Internet

It was only a matter of time before people started to consider connecting computers via telecommunications networks. This ability to move vast amounts of information at tremendous speeds has revolutionized businesses. Even money itself can be controlled through the internet. It has shrunk the World; it makes no difference if one requests information from a computer in the next room, or from one on the other side of the world. Physical location has become completely transparent. The Internet has really sealed this physical gap between countries and continents. To repeat what Blondheim said about the telecommunications revolution, “it could become a great equalizer.” The same thing has happened with the Internet. Online, a schoolchild’s voice is as loud as a Prime Minister’s.

One dictionary definition of media is “one of the means or channels of general communication, information, or entertainment in society, as newspapers, radio, or television.” Therefore the Internet is a huge leap in media technology with exponential advantages in volume, speed and spread of information compared to its predecessors. This has led to a vastly increased thirst in people for information. The Internet allows people to be saturated in it.

Businesses have deeply come to rely on computers and the Internet. Storing and sending patient records, financial transaction information and other documents. Many businesses themselves are completely in the hands of computers, from banks to publishing houses. If their data were to vanish overnight there would be no point in turning up to work the next day. For many companies it has been a means to do away with the overheads of a shop-front, a so-called “brick-and-mortar” store. EBay is an example of a service that even allows a user to bypass the overhead of website

development costs to sell their goods.

For the general population it has become many things: an exhaustive (if occasionally unreliable) encyclopedia, a free and powerful communication tool, a meeting-place, a superstore that stocks everything, a place to express one’s views or opinions, and of course a media black market. If Google can't find it, then it just doesn't exist.

Many people in the Western world rely on digital media to store their personal information on a day to day basis. We trust computers with our intangible assets: our work documents and our music collections, for example. We have hundreds of address book entries, thousands of photos, correspondence, and countless other pieces of information, which would be irreplaceable if lost, and could be considered to be invaluable to us.

**Online Community**

The purpose of the Internet is evolving. In the earlier years, it was the website owner who wrote or decided on the content that their website would offer. Today, there is an increasing number of websites who's content is determined or written by the users. Of course this can lead to some questionable content, but the net value of this new affordance is positive.

User determined content most commonly manifests itself as a democratic approach to news aggregation. For instance, Reddit.com is a website that links to articles on news websites. Any visitor to the site can submit a link to an article onto the website. This will make it appear to other readers who can read it and vote on whether it’s worth reading. The higher the ranking, the higher on the page it appears. The overall effect of this is that you get the best news – the news that the other readers of the site found interesting. Articles that don't get any votes don't appear on the page.
User written content is more direct. Possibly the biggest example is Wikipedia.org, the online encyclopedia, where all the content is created by its users. Any visitor to the site can add pages, and edit or delete any pages, including the front page. Vandalism and misinformation is obviously a problem, but on the whole the project has succeeded in amassing a huge amount of useful information.

The Internet has spawned many communities, but usually the environment for the community has been in the form of flat web pages. A company called Linden Research Inc. has created “a 3D online digital world imagined and created by its residents”\(^{14}\). It’s ambitiously named “Second Life”, an alternative to First Life, presumably real life. The fact that it’s popular implies that there are many people who feel like the Internet is an extension of real life, and that an online community has to offer something on par with real life communities.

This gradual move to a more community-based Internet is the beginning of another cultural shift. However, this time, it will be a shift more benefiting the masses than the corporations. Joichi Ito agrees, “It is clear that the Internet has become a global agora, or gathering place. Effective global conversation and debate is just beginning. We are on the verge of an awakening of the Internet, an awakening that may facilitate the emergence of a new democratic political model”\(^{15}\). The general public have unrestrained communication in an open forum.

This is not to say that the technology of the Internet itself is not evolving. “We’ve come to love the Internet, both because it is so rich in content and inexpensive and, perhaps more importantly, because it allows us to define how we communicate. As its ability to carry richer forms of media

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\(^{14}\) http://secondlife.com/ (21/07/07)

advances, we’ll find ourselves using it more and more.” The authors of “The Future of Telephony” have not missed the point, but there is more: the Internet is an environment people inhabit. We can adapt it to react to our changing needs, not just improve it in a linear fashion.

16 Van Meggelen, Jim, Smith, Jared, Madsen, Leif, Asterisk: The Future of Telephony, Sebastopol, Cambridge, O'Reilly, 2005 pp. 200
THE IRREPRESSIBILITY OF PIRACY

GameDude says:

I used to work at Best Buy and someone stole a couple CD's from the cases...I wonder why they just didn't download it.

The-Bavis says:

To rephrase: "Why steal something when you can steal it?"17

Theft and Intangibility

To look at how design and creative works in general could be pirated in the future, we must first look at the precursors of today – intangible products. The music and movie industries currently sell CD's and DVD's in stores and on the Internet, in the same way t-shirts or hairdryers are sold. The difference is that a CD's value is not directly attached to its physical manifestation. The important part of the product is its intangible contents, the part that’s easy to copy. If information is copied without the person copying having purchased what they’re copying, it counts as theft.

Wikipedia defines theft: “The actus reus of theft is usually defined as an unauthorised taking, keeping or using of another's property which must be accompanied by a mens rea of dishonesty and/or the intent to permanently deprive the owner or the person with rightful possession of that property or its use.”18

This data theft cannot be theft under the traditional definition. The original media is still there, it’s just been replicated. It is still immoral, though. The creator of the media released the media into the public, but on the condition that it is not copied without permission.

Many people copy music from computer to computer without permission or license. Most of the

17 http://www.cheapassgamer.com/forums/archive/index.php/t-1332.html (07/05/07)
same people would not, however, consider it acceptable to steal the same piece of music from a shop. Part of this is because the issue of convenience of download versus going to a store to buy it (reword this). Part of this is also because people in this materialistic world find it difficult to attach the same value to the data contained on a music CD as they do the actual CD. It doesn’t feel as bad as stealing because the original thing is still there.

**Countermeasures**

To combat the issue of convenience, there have been a number of attempts to provide a cheap, easy and legal alternative to illegal downloads.\(^{19}\) Despite being financially successful, it still hasn’t been able to curb illegal downloading.

Record companies have tried many digital methods to copy protect their music. For instance Apple, the biggest player in legitimate music downloads, have encrypted the music that customers buy from their iTunes Music Store, which will only play back in their proprietary software and devices. This copy protection is so easily defeatable, it appears to be token in its existence. To bypass the encryption, one would only need to record the music to a blank CD, and re-import the music from the CD.

![USBM WARNING: Consuming or spreading this material may be deemed subversive by the United States Bureau Of Morality. If you or someone you know has engaged in subversive acts or thoughts, call: 1-866-445-6580 BE A PATRIOT - BE AN INFORMER!](image)

*Fig 4: Copyright warning on the Nine Inch Nails album, Year Zero*

Some musicians, the ultimate victims of music theft, are beginning to feel that the act of copying

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music is inevitable and unavoidable. Nine Inch Nails, a big-selling industrial rock band, have this satirical copyright notice on their CD (fig. 4): "USBM WARNING: Consuming or spreading this material may be deemed subversive by the United States Bureau of Morality. If you or someone you know has engaged in subversive acts or thoughts, call 1-866-445-6580."²⁰

![Copyright statement on Andy Warren's CD](image)

Fig 5: Copyright statement on Andy Warren's CD

The website Downhillbattle.org suggests in its manifesto on its front page: “Five major record labels have a monopoly that’s bad for musicians and music culture, but now we have an opportunity to change that. We can use tools like filesharing to strengthen independent labels and end the major label monopoly.

“How do musicians get paid for downloads? Simple: collective licensing lets people download unlimited music for a flat monthly fee ($5-$10) and the money goes to musicians and labels according to popularity. This solution preserves the cultural benefits of p2p, gets musicians way more money, and levels the playing field.”²¹ This would clearly mean the “major record labels” downsizing, something that they are probably not very interested in doing.

Irrepressibility

Piracy isn’t new territory for the music industry. The advent of the medium of audio cassettes in the 1980’s caused the British Phonographic Industry (BPI) to launch a campaign called “Home Taping is Killing Music” (fig. 6). Almost 30 years on, music is still very much alive.

Fig 6: BPI’s Anti-Piracy Campaign: Home Taping is Killing Music

The impact that this new information society has had on the music industry is that it can no longer sell its product as other tangible goods can be sold. Regardless of the morality of illegally copying intellectual property, the fact remains that there will never be a way to keep it from happening. In the very worst case, if a person can hear the sound of music, they can just as well record it. The same goes for anything that can be seen can be recorded with a camera, and anything that can be touched can be measured.²²

Even tangible objects are not safe from piracy, although domestic piracy isn’t really possible today. On a larger scale, however, Chinese manufacturers have copied everything from Fisher-Price toys to BMW cars.²³

²² Obviously, recording sound from a speaker sounds like there would be deterioration in sound quality, but this is an extreme example of what people could do if there was absolutely no other way round. Something similar already happens with pirates in cinemas with camcorders.
In his book, *Free Culture*, Lawrence Lessig displays a strong stance on piracy. “Despite the many justifications that are offered in its defense, this taking is wrong. No one should condone it, and the law should stop it.” This text doesn't delve to deeply into the morality of copyright infringement because it is a moot point. It will happen anyway. “Major record labels” are currently in the same situation as candle-makers were when electricity was invented.

“Bernard of Chartres used to say that we are like dwarfs on the shoulders of giants, so that we can see more than they, and things at a greater distance, not by virtue of any sharpness on sight on our part, or any physical distinction, but because we are carried high and raised up by their giant size.”25

Open Source

“Generically, open source refers to a program in which the source code is available to the general public for use and/or modification from its original design free of charge, i.e., open. Open source code is typically created as a collaborative effort in which programmers improve upon the code and share the changes within the community. Open source sprouted in the technological community as a response to proprietary software owned by corporations.”26

The Open Source Movement is a product of the Internet's capabilities as a communications channel. Like-minded individuals have been able to form communities and collaborate to build software products that they can give away free of charge.

The first question that might spring to mind is one of quality. If something is free, how can it be as good as its commercial counterpart? One only needs to look at what’s currently available. Firefox, the web-browser and Linux the operating system are two examples. This text was created using free

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open source alternative to Microsoft Word, called OpenOffice. To date OpenOffice has been downloaded over 98 million times.\textsuperscript{27} This shows that high standard products can from an open source model.

Development can be supported by donations and other sources of revenue, such as selling support services, manuals, conferences and bespoke configurations. However, much of the work is done for free, by people who enjoy doing it for the pleasure of creation.\textsuperscript{28}

\textbf{Spawned By Corporations}

As the above definition explains, “Open source sprouted in the technological community as a response to proprietary software owned by corporations”. These corporations have spawned rivals for themselves. One Laptop Per Child was a project to develop a laptop $100 US which will be distributed in developing nations to improve education. Microsoft offered their Windows operating system for the machine, but eventually Linux was chosen over Windows.

A half-way house has also been set up, called the Creative Commons. “Creative Commons defines the spectrum of possibilities between full copyright — all rights reserved — and the public domain — no rights reserved. Our licenses help you keep your copyright while inviting certain uses of your work — a 'some rights reserved' copyright.”\textsuperscript{29} This license was created with artists and musicians more in mind than software developers. There are already millions of files under this license, mostly music, video, artwork, books and of also, software.

\textbf{The Realm of the Tangible}

\textsuperscript{27} \url{http://stats.openoffice.org/index.html} (28/09/07)
\textsuperscript{29} \url{http://creativecommons.org/learnmore/} (27/09/07)
Open source is focused on software. The Creative Commons is focused more broadly on intangible media. The license that most open source software uses is called the GNU General Public License (GPL) which is a “free, copyleft license for software and other kinds of works.” Other kinds of work.

Free culture is creeping into the realm of the tangible. A company called Playatech, which refers to its product line as “A Planet-Friendly Alternative To IKEA”, offers the plans of its furniture for free on its website. A Hexayurt (fig. 7) is “an emergency structure which is cheap, self-contained and easily packed for transportation,” which has detailed construction instructions on its website.

![Fig 7: A Hexayurt](image)

These initiatives are emerging from this cultural shift associated with the move towards a more community-based Internet. People want to collaborate because of their benevolent, creative nature, but up until recently there wasn't quite the critical mass of like-minded people who could easily communicate with each other.

DOMESTIC RAPID MANUFACTURING

“Any sufficiently advanced technology is indistinguishable from magic.”

This text has dealt with how information is traded (legally or otherwise) as a product online, and how it’s possible to download plans for tangible products and make them yourself. As domestic rapid manufacturing develops, people will start buying (or otherwise acquiring) information that will translate itself directly into the tangible, making these products for you.

Commercial Rapid Manufacturing

Rapid manufacture is a collection of methods for automated construction of real objects from a computer model – translating digital files from the virtual realm into the real world. They are essentially the precursors to Cory Doctorow’s 3D printer. A rapid manufacturing machine (fig. 8) would take an input of a CAD file, and raw materials, then create the object described by the CAD file in real life. These machines, however, can currently use only a limited variety of materials, and often only one material at a time.

These machines are not mere sculpting devices, limited to static, solid objects, though. Moving parts such as gear assemblies, hinges and springs can be created as if they had already been assembled. Boeing uses this technology in manufacturing and has used it on parts of the International Space

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Mass Customisation

One of the main advantages of such a machine is that it can create objects without the need for a mould or other tooling as used in conventional manufacturing processes. This means that making single, one-off objects costs just the price of the materials and energy consumed. There is no setup cost. It allows personal customization on a mass-market scale.

It is this one-off nature of the machine that lends itself to “individualised production.” Forward-thinking designers and manufacturers have exploited this fact already, and created infrastructures to provide the customer with a variation of a design that is unique. Future Factories is one such example. There, website asks you to “envisage a future with 'living' consumer products, forms that grow, change and mutate on-screen. At any given moment a product may be frozen creating a unique design, digitally manufactured and delivered to the door.” The concept has yet to be commercialised but the technology is available today.

Home is Where the Factory Is

This individualistic approach to manufacturing is also what will put them in the home. Conventional manufacturing techniques need an infrastructure and investment, which out of the scope of the individual. In the manufacturing alone there are setup costs which make it feasible only to make products in vast numbers, in turn making it feasible for businesses to pursue. Rapid manufacturing, on the other hand, makes it affordable to manufacture single objects, thus democratising manufacturing. Plummeting costs and rapid technical developments are pushing these machines

34 http://home.att.net/~castleisland/ind_11.htm (03/10/07)
35 Atkinson, Paul, Future Factories, Huddersfield, University of Huddersfield, 2003, p. 4
36 http://www.futurefactories.com/ (29/09/07)
37 For instance, if the machine that moulds plastic water bottles costs £60,000, and the raw material cost for each bottle is two pence, the company would have to sell 20,000 bottles at 5 pence to break even.
onto the fringes of the consumer market. The Desktop Factory is one such example.\textsuperscript{38}

What's more is that some rapid manufacturing machines themselves are being developed with the public interest at heart. At Bath University, a project named RepRap (\textit{fig. 9}) ("\textit{short for Replicating Rapid-prototyper}\textsuperscript{39} has been developed to create a rapid manufacturing machine that is capable of replicating itself. When the first iteration is finished in 2008, the machine will cost approximately £300 to make, and be able to build most of its own parts, excluding electrical. The plans for the device are freely available on the project's website, licensed under the terms of the GPL, which is open source. This way, manufacturers have been excluded from the picture entirely, because this machine is also a manufacturing plant of itself.

\textsuperscript{38} A company called Desktop Factory has just launched a rapid manufacturing machine aimed at homes and schools for a price of $4,995 - \url{http://www.desktopfactory.com/} (29/09/07)
\textsuperscript{39} \url{http://reprap.org/bin/view/Main/WebHome} (23/08/07)
Nanotechnology

Looking to the future, Nanotechnology has been fabled as the ultimate technology. The general idea is to construct machinery on an molecular scale, the absolute lowest limit of scale physical objects can be made. These machines, dubbed nanobots, can then directly work with atoms and molecules to build structures. If a large number of these tiny nanobots were to work collaboratively, they could create much larger structures very quickly. Anything from diamonds to supercomputers. The key to creating so many nanobots is to design them to replicate themselves.

This technology sounds whimsical and far off in the future at the very best, but nature has given us a head start. It already has a mechanism for constructing objects from plans, in the form of biological reproduction. It even has a CAD file-format for the plans with which to construct these objects: DNA. Construction of custom DNA to design biological machines is what geneticists have been doing for some time now. Eric Drexler cites a pharmaceutical company that modified bacteria to manufacture human insulin. These bacteria are the nanobots. If DNA can hold enough information to build vastly complex living organisms such as ourselves, surely it can be used to create simpler things.
From the current volume of illegally copied media, we can see that people value data much less when it is a product, because of its intangibility, but what if this were turned on it's head? What if information, that could be potentially stolen, could be used to create tangible goods?

The RepRap project, as discussed in the previous chapter, “has been called the invention that will bring down global capitalism, start a second industrial revolution and save the environment”\(^{40}\) This section explores some of the issues concerning domestic manufacturing.

**A Future Consumer Model**

Bruce Sterling proposes a future where a consumer’s goods are digitally manufactured on demand. “Until you express your desire for this object, it does not exist. You buy a [product] with a credit card, which is to say, you legally guarantee that you want it. It therefore comes to be.”\(^{41}\)

However, in the near future, rapid manufacturing will also be in the hands of the general public, so why not incorporate that into the model? One could argue that domestic rapid manufacturing machines wouldn’t be as technologically advanced as their industrial counterparts. This could be true, but it would be a generational gap, and there would come a critical point where domestic manufacturing meets the needs of the consumer. Many online articles draw parallels in the development of the RepRap and [Fab@Home]\(^{42}\) projects with the DIY approach that created the computer industry boom. New Scientist quotes Hod Lipson, founder of the [Fab@Home] project, “'We think it's a similar story to computers,' he explains. 'Mainframes had existed for years, but personal computing only took off in the late seventies.' A cheap self-assembly computer called the Altair 8800,

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40 [http://www.guardian.co.uk/christmas2006/story/0,,1956793,00.html](http://www.guardian.co.uk/christmas2006/story/0,,1956793,00.html) (12/09/07)
42 Another open source rapid prototyping machine. See [http://fabathome.org/](http://fabathome.org/)
launched in 1975, sparked the rapid development of personal computing, he notes: 'We hope *Fab@Home* can do the same for rapid prototyping.'\(^43\)

**Potential for Piracy**

We could update Sterling’s model to include the presence of domestic rapid manufacturing. The consumer could download the design, and manufacture it in the home, eliminating a number of overheads including logistics and manufacture costs for the seller. The consumer would only be paying for the design, so the manufacturer is no longer a manufacturer, but a design firm. Sterling also says, “*The object is no longer an object, but an instantiation.*”\(^44\) Surely, objects have always been instantiations of designs, (whether described in the medium of the brain, a drawing or a digital file,) but soon people will have the instantiators.

This new model is unreasonable because one can instantly see potential for piracy, because the digital design file could be shared illegally, and manufacturing the product would be a way to protect this file. However, as we have seen in music and film downloading, if there is a will, there is a way. If the product can be touched it can also be measured, or scanned, and the design would be shared illegally. As Adrian Bowyer puts it, “*If individuals have the ability to make most goods for themselves then the ideas of patents, registered designs and trademarks will go the same way as music copyright.*”\(^45\) It doesn't matter whether the buyer or the seller manufactures the product, piracy will find its way in.

Domestic manufacturing will not mature overnight. The technology must progress to a critical point before it can make useful products that could replace their mass manufactured counterparts. Even

\(^{43}\) [http://technology.newscientist.com/article/dn10922-desktop-fabricator-may-kickstart-home-revolution.html](http://technology.newscientist.com/article/dn10922-desktop-fabricator-may-kickstart-home-revolution.html) (02/10/07)


\(^{45}\) Bowyer, Adrian, ‘Breed Your Own Design’ in Icon, October 2007, pp. 103-106
then, at the beginning, the machines will only be able to make a subset. As the technology gradually creeps up, other subsets of products would be domestically manufacturable.

**Rise of the Replicator**

The previous chapter talked of rapid manufacturing and of nanotechnology, these are two distinct technologies, but they are both a means to the same end: instantiation of tangible objects from intangible representations in the form of data (be it encoded in binary or DNA). The only significant difference in terms of output is resolution. For the rest of this text, the former shall be considered as the early stages of the latter, and the machines shall be referred to as replicators.

Storrs J. Hall thinks that, “*Many affluent Americans and Europeans are quite comfortable today, thank you. It's not politic to come right out and say 'I've got mine, screw you,' but an industry has sprung up of apologists who will try to demonize any technology that seems to have the capability of drastically improving the human condition for everyone.*” Of course many well-to-do many people will oppose the introduction of replicators into society, because it could cripple established monopolies. Luckily, development of some of these machines is being done openly and accessible to the public, as with the RepRap project. It’s impossible to stop a project receiving funding if no-one is funding it.

Conversely, as replicator technology advances and is able to manufacture extremely complex devices, it could become extremely useful (used to manufacture replacement organs for humans), or even dangerous (used to manufacture weaponry) in the hands of powerful organisations. This is an ethical question developers unfortunately won’t get to ask themselves, because someone else will always develop it. Ed Regis quotes nanotechnology visionary, L. Eric Drexler, “*These days, whenever Drexler heard someone arguing against nanotechnology, saying that it shouldn't be developed*”

because of the changes it might bring, because of the dangers, because it was 'scary', the same thought always popped into his head: Good luck stopping it."\(^{47}\) Despite the possible dangers, the prospect of such technology is too valuable not to developed it. Whether development is funded by greed or benevolence, it will nonetheless be developed.

### Replicators for Everyone

A fundamental feature of replicators is that they can manufacture themselves. We have seen this in the aspiration of the RepRap project, and in the nature of nanotechnology. The commercial value of developing a machine that can build itself is practically worthless. As Adrian Bowyer states, "*the total sales figures would be one.*"\(^{48}\) This is one of the main reasons the RepRap project has been placed in the public domain.

### A Slow Death For Consumerism

As mentioned previously, as the development of replicators progresses, different consumer industries will successively be choked, until they will all be subject to piracy. Replicators could spell the end of consumerism, and in general, have a profound effect on society. It will not happen overnight, though. There will be no sugar-rush period, where people are feverishly taxing this new Aladdin’s lamp for everything they ever wanted. Since the effect will be gradual, society will have time to adapt.

Ed Regis writes, "*When absolutely every last person in the neighborhood could produce their own Hope Diamond in the kitchen, how much more stylish would it be, how much more democratic, to wear, instead, a piece of hand-made wrought iron.*"\(^{49}\) This text argues that by this point, the human race will have long accepted the fact that most consumer goods are no longer a statement, and the thought of replicating a "*Hope Diamond*" wouldn't have crossed most people’s minds.

\(^{48}\) Bowyer, Adrian, 'Breed Your Own Design' in *Icon,* October 2007, pp. 103-106
CONCLUSIONS

We are currently at the beginning of a cultural shift, spawned by the creation of the Internet. The Internet is a vastly superior form of media compared to earlier forms. We haven't quite discovered the full implications of this medium to our cultural development, but it's clear that it's creating a wide channel for communities to form, collaborate and share information. The result is a more open society that gives the human race more potential as a collective.

The Internet has also facilitated a new kind of piracy. This has caused industries of intangible products to go to great lengths to protect their intellectual property. This, in turn, along with the advent of the Internet itself, has encouraged the growth of free culture movements, to the point where they are seen as competition.

A new technology is on the horizon. One that will enable us to translating digital information into the tangible as physical objects, products. This seems so appealing to a society that has such a consumer lust and an information hunger given to us by the Internet. Indeed, the Internet is the precise reason why these replicators will have such a profound effect. It is the source of the information that they will feed off.

With replicators, the potential damage that the two pronged attack of piracy and free culture could inflict to Industry is enormous. Replicators will be capable of creating wealth without money, instead of just converting monetary wealth into material wealth like the traditional consumer model. As more things become free to replicate, people will need money less. This machine would cause a massive revolution in the way we live our lives, albeit very slowly. Clarke imagines this new world: “the Twentieth Century's debates between capitalism and communism would seem quite meaningless. All
material possessions would be literally as cheap as dirt.”

Real Value

So what will replace consumerism? The word ‘value’ will return to a purer meaning. Clarke goes on to say, “When material objects are all intrinsically worthless, perhaps only then will a real sense of values arise. Works of art would be cherished because they were beautiful, not because they were rare. Nothing – no 'things' – would be as priceless as craftsmanship, personal skills, professional services.”

People will see value in designs themselves rather than the objects they manifest themselves as, in the intangible rather than the tangible, in benevolence, rather than physical wealth. Information will become more valuable than the objects they create. In other words, wealth will move from the realm of the tangible to the digital, to media.

Open Design

One of the most critical areas where people do work is in the fields of medicine and pharmacy. Currently, the patents protecting drugs essentially fund their research and development. But then, why do people become doctors? Obviously today, it’s a good source of income, but people clever enough to make it through a Medicine degree, could just as well take Law, and do better financially. Many do it simply to help sick people.

If there is no industry to fund design then who will design? We already have a basic model for it, in the form of open-source. People currently develop software for the sheer pleasure of creation. Bowyer wrote, “the need for employment went away they wouldn’t stop creating – almost all creative people do what they do because of an inner compulsion, and that will remain because it’s biologically hard-wired.”

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52 See Appendix B: Correspondence with Adrian Bowyer
The New Currency

Storrs J. Hall quite rightly suggests, “People will need to produce something to trade in order to get land or other limited resources. They’ll probably need to produce something and give it away in order to get other people’s respect and attention.” In a world where money is nigh on obsolete, there must be some successor of currency that can facilitate the trade of things that cannot be replicated.

Hall goes on to say, in his book, *Nanofuture*, that this currency must be information. “The instructions for your robots are information. Entertainment produced and consumed is information. Specifications for anything to be built in your [replicator] is information.” More generally, the new currency will be cultural contribution.

The means for media to be directly translated into tangibility is possible today in limited terms. As these terms grow to include a wider vocabulary of objects, society will be challenged to grow out of consumerism. The end of this journey lies far ahead in the future, but this text maintains that it is entirely within the realm of the possible. Fortunately, this future will be very different from Doctorow’s.

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The coppers smashed my father's printer when I was eight. I remember the hot, cling-film-in-a-microwave smell of it, and Da's look of ferocious concentration as he filled it with fresh goop, and the warm, fresh-baked feel of the objects that came out of it.

The coppers came through the door with truncheons swinging, one of them reciting the terms of the warrant through a bullhorn. One of Da's customers had shopped him. The police paid in high-grade pharmaceuticals — performance enhancers, memory supplements, metabolic boosters. The kind of things that cost a fortune over the counter; the kind of things you could print at home, if you didn't mind the risk of having your kitchen filled with a sudden crush of big, beefy bodies, hard truncheons whistling through the air, smashing anyone and anything that got in the way.

They destroyed grandma's trunk, the one she'd brought from the old country. They smashed our little refrigerator and the purifier unit over the window. My tweetybird escaped death by hiding in a corner of his cage as a big, booted foot crushed most of it into a sad tangle of printer-wire.

Da. What they did to him. When he was done, he looked like he'd been brawling with an entire rugby side. They brought him out the door and let the newsies get a good look at him as they tossed him in the car. All the while a spokesman told the world that my Da's organized-crime bootlegging operation had been responsible for at least 20 million in contraband, and that my Da, the desperate villain, had resisted arrest.
I saw it all from my phone, in the remains of the sitting room, watching it on the screen and wondering how, just how anyone could look at our little flat and our terrible, manky estate and mistake it for the home of an organized crime kingpin. They took the printer away, of course, and displayed it like a trophy for the newsies. Its little shrine in the kitchenette seemed horribly empty. When I roused myself and picked up the flat and rescued my poor peeping tweetybird, I put a blender there. It was made out of printed parts, so it would only last a month before I’d need to print new bearings and other moving parts. Back then, I could take apart and reassemble anything that could be printed.

By the time I turned 18, they were ready to let Da out of prison. I’d visited him three times — on my tenth birthday, on his fiftieth, and when Ma died. It had been two years since I’d last seen him and he was in bad shape. A prison fight had left him with a limp, and he looked over his shoulder so often it was like he had a tic. I was embarrassed when the minicab dropped us off in front of the estate, and tried to keep my distance from this ruined, limping skeleton as we went inside and up the stairs.

“Lanie,” he said, as he sat me down. “You’re a smart girl, I know that. You wouldn’t know where your old Da could get a printer and some goop?”

I squeezed my hands into fists so tight my fingernails cut into my palms. I closed my eyes. “You’ve been in prison for ten years, Da. Ten. Years. You’re going to risk another ten years to print out more blenders and pharma, more laptops and designer hats?”

He grinned. “I’m not stupid, Lanie. I’ve learned my lesson. There’s no hat or laptop that’s worth going to jail for. I’m not going to print none of that rubbish, never again.” He had a cup of tea, and he drank
it now like it was whisky, a sip and then a long, satisfied exhalation. He closed his eyes and leaned back in his chair.

“Come here, Lanie, let me whisper in your ear. Let me tell you the thing that I decided while I spent ten years in lockup. Come here and listen to your stupid Da.”

I felt a guilty pang about ticking him off. He was off his rocker, that much was clear. God knew what he went through in prison. “What, Da?” I said, leaning in close.

“Lanie, I’m going to print more printers. Lots more printers. One for everyone. That’s worth going to jail for. That’s worth anything.”
Marek Bereza (MB): How has the proliferation of internet piracy affected your views on the moral issues of rapid manufacturing and whatever their descendents may be?

Adrian Bowyer (AB): By internet piracy, I take it you mean things like illegal MP3 swapping. I have an open mind on the question of whether copying something is morally reprehensible. On the one hand, people instinctively feel proprietorial about their ideas; on the other anyone with an idea instinctively wants to tell everyone else about it.

Clearly these two impulses are in opposition, and their ubiquity means that they must both form part of our evolved moral and social sense. IP law comes down entirely on the side of possession, which seems to me overly asymmetric. In the modern world it also has the effect of benefiting large corporations much more than individuals (who usually can’t afford to assert their rights in the courts).

I think that the example of music is instructive. When MP3 came in the record industry promptly forecast the death of musical creativity. This death has been conspicuous by its failure to materialize. Instead the very same technology has given rise to an unprecedented flowering of composition as musicians use it to connect directly to their audience without the intervening impediments of marketing decisions, production costs, and geographical distance.

I suspect we'll see exactly the same arguments and the same flowering of creativity when people start downloading and making physical objects.

MB: In the next 50 years or so, do you think that rapid manufacturing will become a consumer product? (i.e. used in a domestic situation creating objects not for professional or hobby purposes)
**AB:** Yes. I think it is well-nigh inevitable.

**MB:** As rapid manufacturing technology develops, what will it do to our culture? This is a broad question. What I mean is, will it eventually lead to the end of materialism?

**AB:** No - not the end of materialism; we will always need material objects. But it may mean the end of consumerism. Why do people buy Rolexes and Bentleys? Not to tell the time or to get about - there are more financially efficient ways to do both. They do it to show off to other people with whom they wish to have children - these things are our peacock's tail. But when everyone can have anything, we'll have to find more subtle ways of showing off...

**MB:** Do you think that governments will successfully exert control over these machines to prevent the above? (As in Cory Doctorow's "Printcrime")

**AB:** No. Again, MP3 is the model. Copyright law has had essentially zero impact on music copying, despite the fact that it is against the law all over the planet. One has to remember that governments seem powerful, and indeed they are in some ways. But against very large numbers of people they are powerless.

Technology - all technology - is fundamentally about making it easier to do things. Though sometimes this ease puts power in the hands of the state (speed cameras), more often - statistically - it puts power in the hands of the individual (public key cryptography). That is because there are more people than there is state. It's simply a question of numbers.

I suspect that we are seeing the dying phase of two institutions that (coincidentally) are about three
hundred years old. One is the large corporation, and the other is the idea of running a big contiguous geographical area by a committee of people. The informal groupings enabled by our communications technology are in the process of swamping them both.

**MB:** Eventually, will these machines evolve into star-trek like replicators (with some help from our tiny nanobot friends)?

**AB:** Possibly. But I suspect that the evolution will be the other way. We live on a planet that has been knee-deep in nano-replicators for three billion years (indeed, your knees are made from them). Increasingly we will create new organisms from existing ones to do everything that we want. It's so much more efficient to start with something that already works than to start with a blank sheet of paper.

**MB:** And, Finally... If replicators succeed in exponentially taking over the world, and consumerism collapses, what will happen to critical R+D that big businesses fund, such as the pharmacy industry? What if open development of drugs doesn't cut the mustard?

**AB:** Well - if any life-saving technology doesn't cut the mustard then lots of people die as surely as night follows day. But if, to take your example, open development of drugs don't work, then there will be no economic force causing the destruction of the pharmacy industry; it will continue to prosper precisely because the alternative didn't work. Conversely, if open-source drug development does work and the pharmacy industry does go to the wall, then it won't matter because we will have created a successful alternative.

Most R+D is done by creative people. They happen to be employed by big companies because that
is a mutually beneficial arrangement. But if the need for employment went away they wouldn’t stop creating – almost all creative people do what they do because of an inner compulsion, and that will remain because it’s biologically hard-wired. Those few artists whose art makes them rich don’t stop painting, even if their bank balance would allow them to.
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