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Rage Against the Machine:

Rethinking Education in the Face of Technological Unemployment

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Analysts debate the impact that emerging technology will have on the future of jobs. One side argues that the transformations wrought by this next wave of automation or technological unemployment will follow the historic precedent of previous economic upheavals since the advent of industrialization—temporary job loss followed by overall gains in new opportunities. The other side asserts that things will be different this time around and that we will need to be prepared for what Martin Ford (2015) has called a "jobless future." No matter the exact outcome (which will probably reside somewhere in between these two extreme alternatives), it will certainly have an effect on education and the task of preparing and credentialing individuals for employment. In fact, a recently published Pew Research Center report found considerable disagreement among experts concerning the impact of automation on future employment opportunity. But the one thing all respondents agreed on was the immediate and pressing need to rethink education: "Our public institutions—especially our educational system—are not adequately prepared for the coming wave of technological change" (Pew Research Center 2014, 55).

The following chapter argues for a recalibration of education to meet the demands of the 21st century by 1) identifying two major challenges to existing concepts, structures, and methodologies and 2) describing updates and modifications ("mods") that can be instituted to respond to these opportunities. The use of the terms "update" and "mod" in this context might need some clarification. In computer software, especially games, "updates" are official changes to a program's underlying structure. They are "top-down" reformulations or patches developed and implemented by the institution in order to retool or rework the system's basic operations. "Mods," by contrast, are end-user modifications that are designed to make a program function in ways not conceived of or intended by the original manufacturer. In other words, mods are bottom-up (and often unauthorized) hacks aimed at repurposing the existing system to better respond to and facilitate the actual needs of users. Following this precedent, this chapter will consider both updates and mods for existing educational systems. Updates are necessary insofar as there are important structural changes that can only be made at the institutional level.

These changes, however, often take considerable time and effort to develop and implement successfully. Mods are necessary to respond to this problem. The opportunities and challenges of emerging technology are far too important, influential, and rapid for students and teachers to have the luxury to wait for top-down institutional changes. For this reason, mods are deployed to rework the existing system in order to make it respond to and serve more immediate concerns.[1]

1. Gainfully Unemployed

In a widely publicized study from the Oxford Martin School, Carl Benedikt Frey and Michael A. Osborne (2013) predict that 47% of jobs in the United States are at risk of being automated out of existence. The exact impact of this potentially massive job loss is something that remains open to debate: Will this be a momentary hiatus in employment opportunities, or will this unemployment be the "new normal" with a much larger percentage of the adult population not working? What is not debated, however, is the fact that there could be a significant number of adults that will, at one time or another, be unemployed or underemployed. In response to the economic and social pressures exerted by this, researchers like Wendell Wallach (2015) and Martin Ford (2014) have advocated for alternative forms of capital redistribution. The argument is rather simple and direct. As employment opportunity is increasingly threatened by emerging technology, "the mechanisms that get purchasing power into the hands of consumers begins to break down, and demand for products and services suffer" (Ford 2014, 264). If this break down in purchasing power is more than just a temporary set-back, it could destabilize the national economies and threaten existing social structures. "If technological unemployment outstrips job creation," Wallach argues, "forward-thinking governments could forestall political unrest through some form of capital redistribution such as a robust welfare system or guaranteed minimum income" (2015, 159). And there are a handful of "universal basic income" pilot projects currently being tested in places like Ontario, Canada (Cowburn 2016) and Holland (Diez 2015).

But throwing money at the problem is not necessarily the solution. Work is not just a matter of wealth redistribution and "purchasing power." It is also a connected to and involved with personal identity and social standing. In fact, as it has been formulated in "the protestant work ethic," working is a moral obligation and unemployment is generally perceived to be a personal failure. In the United States, for example, "the unemployed" (already a problematic term) are typically situated in political debates not as individuals displaced by inequities in the current system of employment opportunity but as social parasites looking for a handout from the

government. As a result, unemployment, even temporary unemployment, has a less than laudable social profile. But this perception is just that; it is a perception. It is a matter of the way individuals have been educated—formally within school and informally in contemporary culture—to think about work and its social value. It is, in other words, a matter of ideology. The real challenge, then, is to reconfigure education to prepare students not just for employment but also for unemployment, whether long term or temporary. Although it may sound counter intuitive, we need to teach individuals and our culture as a whole how to be both employed and gainfully unemployed. And the fact that this idea seems counter intuitive is sufficient evidence that we do not yet have a clue as to how one goes about doing this or why.

Compare, for instance, the "promise" of wide spread unemployment to the reality of being out of work. In a TED talk from 2012, Andrew McAfee, co-author with Erik Brynjolfsson of *The Second Machine Age,* paints a rather utopian picture of technological unemployment: "So, yeah, the droids are taking our jobs, but focusing on that fact misses the point entirely. The point is that then we are freed up to do other things, and what we're going to do, I am very confident, what we're going to do is reduce poverty and drudgery and misery around the world." But what actually happens when individuals are "freed" from the drudgery of work? Currently the vast majority of unemployed men (in the United States, at least) spend the day in their pajamas watching television (Halpern 2015, 6). Emerging technology, therefore, promises to liberate us from the drudgery of work, but we do not necessarily know what can or should be done with all this new "free time."

1.1 System Updates

There are at least two institutional changes that will be necessary to respond to this challenge. First, we need devise broad-based education programs that can address both opportunities for work and the challenges of being without work. Recent initiatives in higher education have given increased emphasis (and funding) to specializations in the STEM (Science Technology Engineering Math) fields, and for good reasons: that is where the best employment opportunities have been situated. In this effort, however, many universities have found it necessary to curtail or significantly modify requirements in the social sciences and humanities. In one of the more visible signs of this development, Japan's minister of education, Hakubun Shimomura, called on his nation's 86 public universities either to discontinue programs in the social sciences and humanities "or to convert them to serve areas that better meet society's needs" (Grove 2015). Though there has been considerable debate about the exact

impact this directive will have on the shape of higher education within Japan (Steffensen 2015), it is an indication of the way competing priorities are being addressed at a time of increased budgetary stress. Cultivating specialization in one of the STEM fields is undoubtedly necessary for preparing students to be able to deal with the opportunities and challenges of working with emerging technology. But this should not be done at the expense of other forms of instruction that can help provide the context for understanding and dealing with the social impact and consequences of employing these systems. Education is not and should not be a zero sum game. As Russell Bailey, the director of the library at Providence College, reported to the Pew Research Center: "The propensity for narrow job-training instead of broader career-training will restrict and limit employability for many, until or unless they accept longer-range, broader career-training as the default path to ongoing employability" (Pew Research Center, 2014, p. 55). For this reason, the future may belong to a new kind of broadly educated professional. Not simply because these individuals will, as Arun Sundararajan (2015) argues, be more adequately prepared to take advantage of new forms of self-employment in the "sharing economy" or "crowd based capitalism" (6), but also because it provides individuals with the knowledge and skill to make sense of and work through those periods of time when one might not be working or have access to gainful employment. To put it in McAfee's terms, if individuals liberated from the drudgery of work will be "freed up to do other things," we may need a more active effort to define and develop what "other things" can be done and are worth doing.

Second, , we need to rethink the neo-liberal narrative that has, for better or worse, come to shape the way education is currently conceptualized and funded. Typically higher education, especially in the United States, has been marketed and justified in terms of "hire education." Promoted in this fashion, education is routinely situated as a personal investment and, for this reason, students are able, theoretically at least, to justify going into debt to fund the opportunity. But if employment after graduation becomes less certain, it becomes increasingly difficult to justify making expenditures that will have little or even no return on investment. As of 2014, US student-loan debt totaled in excess of $1.1 trillion dollars, which averages out to $30,000 per student (White House 2014 and Lorin 2016)In order to maintain this system—and to do so at a time when universities and colleges have increasingly come to rely on student tuition for basic operating revenue—there will need to be a steady stream of high-paying jobs available to graduates, both to ensure repayment of existing loans and to convince future students to participate in the program. In the face of increasing employment uncertainty and instability, however, it is hard to sustain this system without the entire thing becoming a pyramid scheme.

In order to respond to this, we will need, on the one hand, to revise the narrative of higher education, repositioning education as a public good and not a personal investment, and, on the other hand, to devise practical methods for publicly funding education that does not shift the burden to individual students. The former is a task for educators and public policy makers, and it concerns the narratives we tell ourselves about education and its social value. The purpose of public education, within the framework of the US at least, was always to produce informed citizens capable of carrying out the task of self-governance. And as the challenges of self-governance increase, with the need to sort out and make sense of things like self-driving cars, nanotechnology, and learning algorithms, so too does the responsibility to provide citizens with the necessary knowledge and data to make informed decisions. For this reasons, the proper funding of public education is neither optional nor a luxury for the few, it is one of the fundamental responsibilities of 21st century democratic governments.

1.2 User Generated Mods

Curricular modifications and alternative funding schemes are clearly going to be necessary. But getting traction with these large-scale systemic changes is not going to be easy or quick. In the interim, students and teachers need "boots on the ground" solutions that can be implemented in the short term, if not immediately. First, and concerning what happens at the classroom level, faculty can and should begin to incorporate critical reflection on employment, personal identity, and social status in their courses. The coupling of identity and work is culturally and historically specific; it is based on particular ideological formations that have a long and rather successful history behind them. Instructors should neither take these arrangements for granted nor perpetuate their influence by remaining silent on the subject. We need to identify and make these assumptions the explicit object of investigation, irrespective of the discipline or field. In other words, individual teachers have the opportunity to get their students actively involved in thinking about work, the significance it has within contemporary culture, and the way that it interacts with our own understanding of identity and social responsibility. This direct engagement with and critique of the ideology of "hire education" is necessary not to undermine the usual way of doing things but to empower students to understand how their expectations have been organized and why. Achieving this objective can be accomplished in the university classroom rather easily by asking students to reflect on and respond to the question "Why am I here?" This inquiry, which can be pursued either as a short writing project or in discussion, is not only a good way to begin a new semester—a kind of "ice-

breaking" exercise—but offers students the opportunity to articulate and examine the often unquestioned assumptions about education and its role in their lives.

Second, students also play a crucial role in this "modding" of education. The link between education—higher education in particular—and employment is something that is (again for very understandable reasons) widely recognized by the student population, especially those individuals who are first generation university students. For several generations now, the official story has been persistent and consistent: better education = better jobs. As the connection between education and employment opportunity begins to unravel or at least loosen up to such an extent that the one is not necessarily and directly related to the other, students and their families will need to reexamine what they believe education is for. Though this effort might seem to be a pressing concern for students pursuing studies in the liberal and fine arts, it is becoming increasingly necessary in many of the professional fields that had been situated as directly feeding into employment opportunity, i.e. law and business. According to a report from May of 2016, the law firm BakerHostetler "hired" an implementation of IBM's Watson to assist with research for the firm's bankruptcy cases. The AI, affectionately named "Ross," is expected to take the place of a large cohort of human paralegals and attorneys (Turner, 2016). Similar displacements are occurring in the financial services industry, where algorithms are now being used not just for the routine work of the office clerk but also for research and analysis and direct client relations (Popper 2016). "We are," explains Daniel Nadler of the financial start-up Kensho, "creating a very small number of high-paying jobs in return for destroying a very large number of fairly high-paying jobs, and the net-net to society, absent some sort of policy intervention or new industry that no one's thought of yet to employ all those people, is a net loss" (Popper 2016). In other words, automation will not displace all employment opportunities; there will continue to be a few very good paying jobs at the high end of the spectrum. But the entry-level and middle-management positions that have traditionally been the target of professional education will be in increasing short supply.

Challenging prevailing assumptions is no easy task, especially when tuition and fees constitute a significant financial burden. Nevertheless we need to begin questioning or at least developing some critical perspective on the "education means employment opportunity" narrative. In effect, we need to decide—each one of us individually and together—"What is education for?" Although this might initially look like an existential crisis for institutions of higher education, it is really about the needs and expectations of those individuals and communities that these institutions serve.

2 DIY Futures

At the same time that we begin to question and challenge the assumed tight coupling of education and work, we will also need to recognize that whatever new opportunities develop in the wake of emerging technology, they will certainly require some form of preparation. The problem for educators is that we often find ourselves in the odd position of needing to devise curriculum and pedagogical opportunities for occupations that do not yet exist or at least are not yet fully realized so that one might know what will be needed in terms of skills and knowledge. But this is only a problem if we think about education as responding to the needs of industry as it is currently configured or imagined. There is another way to look at it, which has the effect of reversing the direction of this vector.

Consider two rather remarkable examples from the last wave of technological innovation. When Marc Andreessen was a student at the University of Illinois, he did not pursue a major in e-commerce or complete course work necessary to get a job with an Internet company. Neither of these existed. Instead he, along with Eric Bina (who unfortunately often gets left out of the story), created NSCA Mosaic, the first graphical web browser, which became one of the enabling technologies of e-commerce and helped make the Internet companies of the 1990's tech-explosion possible in the first place. The same might be said for Facebook CEO, Mark Zuckerberg. Zuckerberg, who attended but did not graduated from Harvard University, did not pursue a degree in social media in hopes of landing a job with one of the major players in the industry. He helped invent social media by hacking together the PHP code that eventually became Facebook. Clearly these examples are the exception and not the rule. But they indicate a different way to think about higher education and its relationship to employment. Instead of preparing individuals to take advantage of existing opportunities—opportunities that are volatile insofar as they might not exist by the time current students matriculate—we need to develop educational structures that also encourage and help students to invent the future.

2.1 System Updates

Getting students actively involved in innovation is nothing new. This has been and remains one of the principal objectives and the *raison d'etre* of the research university. But institutions can and should be doing much more to encourage and support this kind of entrepreneurial activity, especially when it comes to technology transfer and commercialization policies. Although universities have long been involved in commercializing innovations developed by their faculty and students, it has only been since the 1970's that policies and

offices dedicated to this effort have been institutionalized. This development received significant legislative support when, in 1980, the US Congress passes the Bayh-Dole Act, which shifted ownership of Federally funded research (i.e. NSF, NEH, NIH, etc.) from the US government to the university where the research project was conducted.

University ownership has distinct advantages for both the researcher and the institution. For the researcher, whether s/he is a member of the faculty or a student using university facilities and resources, the technology licensing office (TLO), as these facilities are commonly called, provides assistance in obtaining the necessary IP (intellectual property) protections and arranging licensing agreements with third parties. In effect, the TLO provides a technology transfer and commercialization service. For the institution, the TLO has become an important revenue generating resource. One of the most widely studied and lucrative university-owned patents is the Cohen-Boyer (C-B) patent, which involves techniques for the creation of genetically engineered microorganisms. "Over its 17-year life," Martin Kenny and Donald Patton (2009, 1409) write, "C-B produced in excess of $255 million in revenues for Stanford University and the University of California."

Despite (or perhaps because of) this success, recent studies of existing models and commercialization policies find numerous contradictions, inconsistencies, and misaligned incentives. As Kenney and Patton (2009, 1413) explain: "The licensing experience of Marc Andreessen….illustrates the pitfalls. When Andreessen joined James Clark to form Netscape in 1994, they attempted to negotiate a license with the University of Illinois but found the process so frustrating that they ultimately rewrote the browser code entirely." Meanwhile, successfully negotiated licensing agreements with other corporations, like Microsoft, who used the original Mosaic code as part of their Internet Explorer browser, netted the U of I a total of $7 million. If students have difficulties using, developing, or licensing the innovations they have developed or have helped develop, then the existing commercialization policies cease being a useful service and start interfering with future opportunities.

For this reason, universities need either to reform the current system or to devise alternative models for research commercialization. Kenny and Patton (2009), for their part, suggest two alternatives: vesting ownership with the individual inventor or placing all university produced innovation in the public domain and available, without restriction, to any and all users. The former "would remove research commercialization from the control and mission of the university administration and would decentralize it to the inventors" (1415). Under the latter, "the university administration would no longer be involved in licensing, [and] the university would

return to its role as a platform for research and instruction" (1414). Although neither model necessarily does away with the university TLO, they do introduce a significant shift in who owns and controls the products of university research and innovation. Consequently there are good reasons to believe that universities might not be entirely satisfied with these particular alternatives. "While meant to be used for further research," Kenny and Patton explain, "TLO income is attractive to administrators because the funds are, in fact, largely unencumbered, thereby providing wide discretion on how they are spent. Often the support monies for TLO personnel can originate from public funds, either federal or state. This asymmetry offers a powerful incentive—restricted funds can be spent to operate the TLO, while earnings are far less restricted. The strength of this incentive is difficult to measure, but it may be considerable as more flexible funds are invariably in short supply" (2009, 1410). What is needed, therefore, is to formulate some reasonable balance between the financial interests of the institution and the rights of faculty and students to develop and commercialize their own innovations.

2.2 User Generated Mods

As with the first set of updates, this restructuring of the policies and procedures of innovation ownership and commercialization is not going to be resolved quickly or effortlessly. For this reason, students and teachers also need more immediate bottom-up strategies. First and foremost, students should know and understand their university's policy for technology transfer and commercialization. Although most, if not all institutions of higher education have some explicit policy regarding this, not all universities are created equal. In most cases, employees of the university (i.e. faculty, graduate assistants, research assistants, etc.) are required, as part of their employment contract, to disclose and assign ownership of their efforts to the university. The same requirement does not necessarily apply to students. This does not mean, however, that student innovation is automatically exempt. At many institutions, student research is exempt only in cases where the innovation was produced without the use of *significant* university resources or facilities. MIT (2016), for instance, provides the following stipulation: "When an invention, software, or other copyrightable material, mask work, or tangible research property is developed by M.I.T. faculty, students, staff, visitors or others participating in M.I.T. programs using significant M.I.T. funds or facilities, M.I.T. will own the patent, copyright, or other tangible or intellectual property." What constitutes "significant use" is obviously important and open to considerable interpretation, but what is clear is the fact that student innovation, under this particular stipulation, could be wholly owned by the institution.

Consequently, students should know in advance what is and what is not possible in the context of their university's policies and procedures. Knowing the requirements and the exceptions to the requirements can help one to avoid running into complicated legal problems after the fact. And in this effort, faculty play a crucial role. It is (or at least should be) the responsibility of faculty to get students reading university policy statements regarding technology transfer and commercialization and to help them understand the practical consequences of these policies for their own work. Although this material is not typically perceived to be part of the curriculum, instructors in all fields and disciplines need to help their students understand both the opportunities and the challenges of their innovation efforts.

Second, students, especially at the undergraduate level, need to begin to think beyond the limitations of the major. The organization of the university into disciplines, each with its own specific degree requirements and set of qualifying criteria, is an administrative convenience useful for allocating resources, processing student throughput, and credentialing graduates. The system, however, is not necessarily useful for students, who may need to draw on and recombine instructional resources from across the institution in the process of responding to new technological opportunities. This is especially true in situations where the principal challenge is not just technological, like machine learning. Take for example, two events from March of 2016, Google DeepMind's AlphaGo, which took 4 out of 5 games of Go against one of the most celebrated human players of this notoriously difficult board game, and Tay.ai, a Microsoft Twitterbot that had learned to become a hate-spewing, neo-Nazi racist in less than 8 hours of interaction with human users.

Both AlphaGo and Tay are weak AI systems that mobilize some aspect of machine learning. AlphaGo, as Google DeepMind (2016) explains it, "combines Monte-Carlo tree search with deep neural networks that have been trained by supervised learning, from human expert games, and by reinforcement learning from games of self-play." In other words, AlphaGo does not play the game by following a set of pre-calculated moves fed into it by human programmers. It is designed to formulate its own instructions from game play. Although less is known about the inner workings of Tay, Microsoft explains that the system "has been built by mining relevant public data," i.e. that they trained its neural networks on anonymized information obtained from social media, and that it was designed to evolve its behavior from interacting with users on Twitter, Kik, and GroupMe. What both systems have in common is that the engineers who designed and built them have no idea what the systems will eventually do once they are in operation. As one of the creators of AlphaGo has explained, "Although we have programmed

this machine to play, we have no idea what moves it will come up with. Its moves are an emergent phenomenon from the training. We just create the data sets and the training algorithms. But the moves it then comes up with are out of our hands" (Metz 2016).

Responding to the opportunities and challenge made available by mechanisms that do things that are "out of our hands" will require a combination of knowledge and skills that transcend the borders separating what C. P. Snow (1998) described as "the two cultures." Students specializing in one of the technical disciplines will, on the one hand, need to develop the knowledge-base and intellectual skill-set to understand, anticipate, and evaluate the social consequences of the technologies they will be asked to develop and release into the world. This capability cannot be imparted by a single specialized course in "engineering ethics," but will require a much more sustained engagement with the best thinking about the "human condition" as it has been cultivated in art, literature, and philosophy. Likewise, students specializing in one of the "human sciences" need to investigate what ~~this kind of~~ technological innovation means for our concept of the human and the legacy of human exceptionalism. They will need to recognize that information and communication technology are not just tools of human endeavor but, as Luciano Floridi (2014) has described it, a paradigm shattering "fourth revolution" in how we think about ourselves and our place in the world.[2] What is needed, then, to put it in a kind of shorthand formulation, are technology innovators who also understand the profound intricacies of the human condition and philosophers and artists who can deal with and hack code. Unfortunately the established structure of the university often discourages this kind of broad interdisciplinary effort. For this reason, and rather than waiting for structural change to trickle down, teachers and students should actively work to remix education by drawing on and repurposing the wide range of resources available within the university structure, even if (and especially if) doing so cuts across boundaries that have been carefully arranged, managed, and protected.

3 Ceci Tuera Cela

From the vantage point of the long tail of history, emerging technologies, especially innovations in information and communication systems, have always confronted existing educational institutions with a significant challenge. Recall, for instance, the introduction of movable type and the printed book. At the time that books were considered "emerging technology," they confronted the established medieval institutions of knowledge production and distribution—which in Europe meant the Catholic Church and its affiliates—with something of an

existential crisis. Although there are numerous examinations of the causes and consequences of this transformation in the scholarly literature, one of the more vivid illustrations can be found in Victor Hugo's *Notre-Dame de Paris* (1978, 188): "*Ceci tuera cela.*" The statement is attributed to the archdeacon Frollo, and it concerns his rather pessimistic assessment of the impact of Gutenberg's invention: "For some moments the Archdeacon contemplated the gigantic edifice in silence; then, sighing deeply, he pointed with his right hand to the printed book lying open on his table, and with his left to Notre Dame, and casting a mournful glance from the book to the church: 'Alas!' he said. 'This will destroy that'" (Hugo 1978, 188).

The anecdote has been recounted many times not just in the history of print media and technology but also by recent efforts to explain subsequent innovations in information and communication technology, like the personal computer and the Internet (cf. Bolter 2001). But "destroy" is perhaps too strong a word in this context. Obviously, the book did not (literally) raze the gothic edifice. It merely challenged and displaced its function as the principal mode of knowledge production, accumulation, and distribution. Though it may have taken several hundred years, European institutions eventually figured out how to accommodate the technology of print to existing structures and systems. Similarly, the introduction of the personal computer did not put an end to writing, the teaching of composition, or the publication of books. The fact that you are reading about this in a book—whether the letters have been applied to the surface of the pulped flesh of dead trees or are being displayed as intricate patterns of glowing pixels on the screen of a mobile device—is sufficient evidence. Once again, educational institutions learned—and obviously not without some critical hesitation and significant missteps—how to scale the curriculum to the opportunities and challenges of this new technology. Following this precedent, we can anticipate that the current crop of emergent technologies will most probably conform to the contours of this hype cycle. Doing so, however, will require reworking existing educational programs from both ends of the spectrum—developing top-down updates in the structure and operations of the institution and encouraging bottom-up mods that can have an immediate impact on the lives and careers of both teachers and students.

Notes

1. This approach is deliberate and strategic. In a recent course on AI, Robots and Communication, I asked my students to investigate the opportunities of emerging technology, the challenges of technological unemployment, and the possible futures for higher education. This effort lead to the development of a detailed list of policy initiatives that could be instituted by the university. I had originally intended the exercise to be empowering by giving students the opportunity to reflect on and help shape the direction of their education. But it unfortunately had the exact opposite effect. Looking at the list of reforms, we realized that the proposed updates were well beyond what any of us individually or even in collaboration could possibly achieve. Policy initiatives are certainly important and necessary. But what my students taught me during this semester is that we also need bottom-up strategies that can be instituted immediately in order to respond quickly and directly to the opportunities and challenges students will inevitably face in the next 5 years. It is with this idea in mind, that I dedicate this chapter to my students in COMS 493 at Northern Illinois University, spring of 2016.

2 The term “fourth revolution,” which is the title to Floridi’s book from 2014, refers to the most recent iteration in a sequence of profound transformations in the way human beings conceive of themselves and the world they occupy. The first revolution, Floridi argues, occurred with Nicholas Copernicus, whose heliocentric model of the solar system challenged human exceptionalism by unseating human beings as the presumptive “center of the universe.” The second revolution follows from the work of Charles Darwin, whose theory of evolution demonstrated that the human being was not an exceptional creature situated apart from the other animals on planet earth but part of a continuum of entities developing out of common ancestors. The third revolution, as Floridi develops it, is attributed to Sigmund Freud, who challenged the notion of Cartesian rationalism and demonstrated that the human mind is not necessarily transparent to itself. The fourth revolution proposed by Floridi is a product of information and communication technology, which has, as he argues, once again reoriented how we think about thought (computational theories of the mind), our bodies (DNA code), and the entire cosmos (infosphere). For a brief introduction, see BBC Radio 4’s video “The Fourth Revolution” available at https://www.youtube.com/watch?v=W06fWz1mWNg

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