"Labor and Technology" in *A Companion to American Technology*, Carroll Pursell, ed. (Oxford: Blackwell Publishing, 2005), 212-230.

How does technological change affect the way work gets done? How do social and cultural factors shape the organization of work and the design of workplace technologies? What does it mean to be "skilled" or "unskilled"? Historians of technology have been most attracted to questions about labor concerning the physical process of work itself (rather than issues such as the formation of unions or labor politics). In opening up the technological "black boxes" of tools, machines, and workprocess, they endeavor to understand how the material and social aspects of labor are intertwined, each shaping the other. In the past, topics of broader interest in the field, including the history of engineering (especially Taylorism) and innovation in industrial manufacturing processes, helped guide the development of scholarship. More recently, the field has also given attention to the relationships between paid and unpaid work, and production and consumption. Scholars have also focused on the definition and proliferation of technological knowledge and to the role of gender in shaping work and technology.

**An Overview of Themes**

In 1932, at the height of the Great Depression, Edsel Ford (1893-1943) commissioned the Mexican muralist, Diego Rivera (1886-1957), to create a series of frescoes illustrating the theme "Detroit Industry" in the central courtyard of the Detroit Institute of the Arts. Rivera was a Marxist, deeply critical of the class relations of monopoly capitalism. But he was also a technophile, a believer in technological progress and an enthusiast about many of the material products of industrialization (Downs 1999).

The images he created for the DIA express his ambivalent and complex understanding of the costs and benefits of industrialization. They simultaneously celebrate the technological ingenuity of Detroit's industrialists and the sublimity of large machines, while condemning the dehumanizing qualities of work within these "master machines," in ways that continue to capture the imaginations of historians.

Rivera interpreted the theme of "Detroit industry" broadly. The mural's twenty-seven panels depict a variety of topics from the origins of agriculture to the production of poison bombs. However, the largest and most central panels depict the assembly line and foundry at Ford Motor Company Rouge automobile assembly plant. "The Rouge," as it was widely known, was the ambitious creation of Edsel's father Henry Ford (1886-1957). It was, at the time it opened, one of the largest factories in the world. In the interwar era, its fame spread throughout the industrializing world as a model for the systematization of mass production; considered so paradigmatic, in fact, that the term "Fordism" was widely used, even outside the United States to describe this strategy of production (Hughes 1989).

In both panels, the gray, metal body of the assembly line snakes like a living thing back and forth across the huge expanse of the mural. Workers bend and twist in rhythm with this mechanical beast. Like the crazed factory worker in Charlie Chaplin's 1936 film, Modern Times, one can imagine them unable to shake off its cadence even outside the factory gates. What Rivera's images do not make apparent is that these mechanized men have also entered into one of the great Faustian bargains of modernity. In exchange for submitting to the dictates of mechanization, they received the then extraordinary wage of $5 a day, enabling them to purchase bountiful, low priced, mass-produced consumer

goods that such technological innovation made possible. Along with millions of other Americans, they might, in fact, someday purchase an automobile. But for assembly line workers, the price was more than simply $500 at the dealer's. Killing speed, mind-numbing repetition, subjugation to the dehumanizing logic of the assembly line constituted the trade-off for participation in the market economy.

Workers' enslavement to the rhythm of the assembly line and the dictates of monopoly capitalism is certainly an essential and distinctive characteristic of this particular work/technology relationship. But it is a vision that severely limits workers' own agency. Historians have shown that even on the assembly line, men and women carved out space for themselves and defined the meaning of their work in ways that defied their bosses and the logic of the machine (Meyer 2001). It is also clear that there were real limits even to Ford's ingenuity in the application of mechanization techniques. In the nooks and crannies of the Rouge (and the background of Rivera's mural), women still sewed upholstery piece by piece while machinists and other craftsmen made the machines that made the cars.

And were we to follow the automobiles as they jerked off the chain and moved out past the gates of the factory, the full complexity of the relationship between technology and wage labor would become even more apparent. Even in the 20$^{th}$ century, not all work or perhaps even most work fit the mass production paradigm. New technologies brought with them new needs for workers that were not tied to the mechanics of production and old ways of making and doing things persisted because it was neither economically nor technically possible to mechanize them. Much as

capitalists (and sometimes consumers) might wish for total control, all the historical evidence suggests that mechanization was and is an uneven and unpredictable process.

"The mechanic will gyp you," automobile owners have been warning each other since the dawn of automobility. Their warning carried with it not only the bitter taste of experience but also a middle class anxiety about being dependent upon the technical knowledge of working class men to keep their machines on the road. If some mechanics might take advantage of their customers, others could use that knowledge to improvise solutions to mechanical problems unimagined by the automobile's designers and producers. If computer diagnostics and modular parts now threaten to undermine the mechanic's autonomy, for the first one hundred years of this technology's existence, a screwdriver, wrench set, and a good ear could suffice to put many machines back on the road. Occasionally, as in the work of the rural Vermont mechanic described by Douglas Harper, such mechanics might even improve upon the ideas of the original designers (Harper 1987).

Automobile mechanic was a new job in the 20th century that evolved alongside America's dependence upon a complex machine that needed regular maintenance and frequent repairs. Henry Ford might have been able to create the means to produce an inexpensive automobile, but he could not have designed one that could be used without the intervention of this other group of workers. Nor would he necessarily have considered that to be necessary. After all, early twentieth century America was full of machines that required maintenance and repair (Borg 1999). A host of other workers also used automobiles and automobility to earn a daily wage in ways that increased rather than lessened their independence. Teamsters, ubiquitous in urbanizing America, gradually

found themselves liberated from the challenges of maintaining and managing horses. Like chauffeurs, taxi, and bus drivers, they parlayed the skill of driving into a myriad of other livelihoods. In the same way, the introduction of other new technologies, most recently computers, has resulted in many different kinds of work, not all of which involved mindless, repetitive enslavement to machines and their capitalist owners.

If we were to follow the workers rather than their products off the floor of the Rouge, we might discover something else. Workers are also consumers and consumption is a means throughout which people in industrialized societies decide how work will be done, who will do the work, and what it will be worth in the market place. For instance, the hard earned dollars of the assembly line worker might be used to purchase a washing machine or it might be used to pay someone else to do the laundry. The consequences of these technological choices rippled out across the American landscape, transforming how and where work is done for everyone from housewives to farmers to line workers at the Rouge.

It is important to recognize however, that while industrialization may have changed how all kinds of work were done, wage laborers' relationship to technological change differed from that of housewives and farmers in some very fundamental ways. First of all, the primary purpose of most production technologies (such as looms or stamping presses or assembly lines) is to create wealth for capitalists by adding value to the labor of workers. Tools and machines are prostheses that make workers stronger, faster, and more accurate than they would be working with their bare hands. Or, more chillingly, the worker becomes prosthesis of the machine, a "hand" facilitating its work.

Ultimately, the process is what matters, not the needs or desires of the individual worker who conducts it.

While all users of technology make choices about how it will be used, in the process of reshaping the technology itself, workers' choices are often circumscribed by the power relationships of wage labor. Workers may exercise some choice about the type of employment sought, but once in a job, most can make only minor changes to the technologies they use. This is particularly true of the machine operatives and assembly line workers. In the former case, because they do not own the machines they use but must adapt themselves to the machine. In the latter case, it is because they control only a tiny part of a process which is severely circumscribed in time and space by the rhythm and organization of a larger process. This lack of control is, of course, less true about workers who use tools and those who engage in processes outside the regimes of mass production.

Workers' relative powerlessness in shaping the technologies they use has had profound historical consequences. Mindless and powerful, the new machines that became more and more a part of workers' lives with industrialization, tore the unsuspecting limb from limb or more slowly twisted and crippled bodies forced to adapt to their imperatives. In linking productive technologies into a system, assembly lines forced workers into a kind of time and physical discipline that defied nature. The alienation produced by such lock-step discipline surpassed even the familiar tedium of stepping behind a plow or hemming sheets and tablecloths. Mechanization not only requires workers to work *with* machines that are not always of their choosing, but also to work *like* a machine.

Technological knowledge also takes on distinctive characteristics in the context of wage labor. In this setting, it is almost always equated with "skill." Skill implies not only abstract knowledge about a particular technology or process, but also the ability to manipulate or use it successfully. For instance, the knowledge base of a skilled automobile mechanic is different than that of an automotive engineer because the engineer primarily needs a theoretical knowledge of how cars work. On the other hand, theoretical knowledge does the mechanic no good if he or she can't fix a specific car. Skilled workers tend to be difficult to replace because substitutes cannot be rapidly trained. Both formal training and tacit knowledge—a "knack" with technology—constitute skill. Historians have noted that in American history, workers' claims about who has skill and how it is acquired is often defined by divisions within the working class based on race, ethnicity, and gender (Milkman 1987). White men in relatively unmechanized trades have often claimed a monopoly. It also turns out that when historians have looked at the actual content of work, the claim to be skilled is only partly based in workers' technological knowledge. Skill, to a certain extent, is in the eyes of the beholder (Mohun 1996).

**Mechanization and 19th Century Industrialization**

The assembly line at River Rouge is the progeny of a long lineage of industrial workplaces. It shares with them characteristics going back to the first years of the Industrial Revolution. Even the earliest 18th century textile mills gathered workers in one place, divided up work processes between increasingly specialized machines and workers, and used mechanization to replace traditional skills and animal power (Landes 1961). In the majority of these workplaces, more and more workers became machine

operatives—"hands"—whose relationship to technology involved tending automated looms and spinning machines, filling in gaps where machine makers could not find the mechanical means to tie together broken threads, load fresh bobbins, or adjust for differences in organic materials.

Without doubt, even these tasks required a certain kind of skill—the knack of setting up a machine, of listening for a sound that meant something was not working correctly—but this was not the kind of skill that took years of practice to acquire. Nor was it the kind of skill that craft guilds felt compelled to protect. For these reasons, machine operatives often came from the social groups with the least access to the lengthy training process of apprenticeships and with the least power to command high wages: women, recent immigrants, and, in the 20th century, African Americans. In the United States, manufacturers were particularly drawn to women because they would work for lower wages and seemed, at least initially, to be only transient members of proletanized labor. They also rationalized their choices by arguing that women were naturally more tolerant of the tedious repetition that characterized such jobs and incapable of the kind of independent decision-making that characterized more skilled (and highly paid) forms of work.

Conventions of assuming some industrial jobs would always be done by men and others by women ("sexual division of labor") both derived from and contradicted the patterns established in household and preindustrial labor. Technological knowledge acquired by women in the home such as sewing or ironing could help provide a pathway to industrial employment. But other jobs were regendered in the process of being industrialized. In textile mills, women tended looms but men operated the mules—

machines that drew out thread. This is despite the fact that in cottage industry, men had often been the weavers and women the spinners. Machine manufacturers even built these newly developed social conventions into the size and shape of devices workers would operate. Most women, for example, were not tall enough to comfortably operate the mules because machine builders assumed a male worker.

Throughout much of the 19th century, only a minority of industrial wageworkers shared the operative's relationship to technology. And even where mechanization was utilized, it extended just to discrete parts of a process that could be done by a single individual on a stationary machine. Factory floors swarmed with workers carrying raw materials, tools and parts, and finished goods from machine to machine, storeroom to workroom. Crafty mechanics and manufacturers gradually figured out ways to make the parts of complicated devices like sewing machines and bicycles so that they could be fitted together with a minimum of adjustment from randomly chosen parts. But the actual assembly process still took place on something very much like the workman's bench under the guidance of a generalist who understood how the entire object should fit together.

Outside the brick walls of factory buildings more and more people also found themselves drawn into wage labor. Their interactions with technology, new and old, varied widely. In the lofts and tenement rooms of Boston, New York, and Philadelphia women took the sewing skills learned at their mothers' knees and earned a living stitching together sailors' shifts and men's shirts with a needle and thread. This kind of work bridged the pre-industrial with the industrial, unpaid domestic "women's work" with the market economy. After the introduction of the sewing machine in the1840s,

some saved their pennies and bought a machine to speed the process while many others moved to the lofts of small-time jobbers. Even while the home gradually ceased to be a site of productive labor for the middle and upper classes, working class people churned out an extraordinary variety of goods for the consumer market using little more than their fingers and a few simple tools. Artificial flowers, boxes, matches, fur and feather pulling were among the many activities that went on in the cramped quarters of their tenement rooms.

Other workers interacted with the newest and most sophisticated technologies of their age but in fundamentally different ways than their brothers, sisters, and cousins who toiled in factories. Railroads, for instance, provided employment to more than 400,000 Americans in 1880 (Licht 1983, 33). While the backbreaking labor of loading cars and laying track must have seemed utterly familiar to tired men with long histories as day laborers, the technology of railroads provided a strikingly new kind of work environment for other employees. The work of engineers, firemen, brakeman, and car-couplers brought them into daily contact with the most powerful machines that most 19$^{th}$ century Americans would see in their lifetimes. Unlike the steam engines that drove more and more factories, they operated in public for all to see, tearing violently across the landscape. It is no wonder that little boys of that era dreamed of growing up to be engineers and grown-ups shuddered at the potential destructive power of the same technology.

Railroad work also differed from other kinds of wage labor because it involved a technological system that operated across time in space in an era in which most technology was specific and local. Workers had to learn to think in a new way about how

their actions: a switch thrown incorrectly, a locomotive repaired badly, could affect strangers hundreds or even thousands of miles away. By 1877, they had learned the lessons of time-space transcending technologies well enough to create the first national strike, spread along the rail lines from its origins in West Virginia.

As machines became larger, more powerful, and more often the locus of work, accidents also became more frequent and more severe. The grim toll of railroad fatalities is particularly illustrative of callousness with which many 19th century capitalists made choices about the design and deployment of workplace technology. Worker fatalities on railroads averaged 3.14 per thousand workers (Aldrich 1997, 15). Since railroad employment included relatively low risk jobs such as taking tickets and cleaning cars, the percentages within the most dangerous job categories were substantially higher. Such numbers did not even take into account non-fatal injuries.

Railroad company executives resisted adopting technologies like air brakes, automatic coupling, and engine stoking despite the widespread concurrence that these devices that would make railroad labor safer and easier for workers. They reasoned that it was cheaper to pay an occasional death benefit to the widow of worker crushed between cars than to expend large amounts of capital to renovate the tens of thousands of railroad cars already in use. This began to change substantially only with the intervention of the Federal Government through the passage of the Safety Appliance Act in 1893 (Aldrich 1997, 172). As a consequence of this peculiar form of technological conservativism, bystanders observing the passage of this quintessentially modern machine through the landscape might still catch sight of brakemen skittering along the tops of cars and struggling to turn the manual brakes up into that decade (or even later on

some freight lines). Other trainmen displayed their profession's stigmata of missing fingers, hands and feet — some of the lesser consequence of standing between two railroad cars in order to couple them together. The loss of limbs was so common among railroad workers in the 19th century that worker magazines ran advertisements for prostheses and employers looked to hire workers who had already lost fingers with the idea that they would be more careful than their undamaged fellows.

This kind of involvement with large, dangerous, charismatic technologies—particularly work involving large objects or processes involving iron and steel—was a masculine domain. The work itself might be dirty, repetitious, and bone breaking but it was also a source of fierce pride for the workers who participated in it. Association with such technologies was a source of cultural power. Male workers did their utmost to gender these technologies and the processes involved in making and using them male. In many occupations, they not only excluded women, but also defended their territory against the incursion of African American men and men who belonged to ethnic groups that seemed, in the ever-changing schema of American racial categories to be less than white—Italians, Irish, Eastern European Jews. They made their claim by utilizing and creating a set of cultural ideas about the gendered meaning of work and gendered technological competence that remain powerfully embedded in American culture. No woman drove a locomotive for an American railroad until 1969, more than twenty-five years after the introduction of diesel engines put an end to any last claims about the significance of physical strength for such a job. A half-century earlier, the identification between masculinity and railroading was so powerful that the Pennsylvania Railroad,

then America's largest railroad company, employed men even in the kinds of clerical positions that were gendered female in most other businesses.

Nowhere was the identification between gender, race, technology, and prestige more obvious than in the culture of machine shops. Machinists controlled a technological skill key to the process of industrialization: they knew how to construct machinery with the control and precision that made it possible to mechanize production. Carefully measuring and setting their machines, they peeled away layers of metal to make everything from mechanized looms to the huge steam engines that drove the workings of an increasing number of factories. Any error and pistons would stick, gears fail to mesh, and the worker's knowledge built into the machine would manifest itself as an ill-wrought piece of goods. It is little wonder that these men considered themselves the aristocracy of labor, that they held their heads up high as the headed to work in their ties and bowler hats, that they commanded high wages and defied their employer's efforts to control their pace of work or shop floor culture.

**Scale, Scope, and Systematization, 1880-1920**

The late 19th century marked another watershed in the changing relationship between workers and technology in the workplace. Jobs like machinist, locomotive engineer, and artificial flower maker survived virtually unchanged well into the twentieth century, but became less and less the norm in industrial production. In part, the change came through the continually mounting pace of mechanization. A growing number of inventors and innovators bent their minds to creating machines to do everything from folding cardboard boxes to stirring molten steel. Increasing scale also played a role.

Larger factories led to more and more minute divisions of labor. Economies of scale demanded the adoption of enormous, complex machines.

This technological culture also gave rise to a self-created group of systematizers who self-consciously applied themselves to the process of "rationalizing" the workplace. Like their predecessors, part of their aim was explicitly economic: to lower the price of finished goods by reducing labor costs and making production more efficient. But rationalization also equated with shifting more control over work processes from workers into the domain of managers. By the 1910s and 1920s, this set of ideas and practices had evolved into something resembling an ideology, sometimes referred to as the "gospel of efficiency." It brought a kind of factory-logic out from behind factory walls and into all kinds of work, paid and unpaid.

The efficiency movement is often identified with Frederick Winslow Taylor (1856-1915) and his followers, proselytizers of a mixed bag of rationalizing techniques they called "scientific management." But the origins of this wave of rationalization and its eventual manifestation in technologies like the assembly line are more widespread. Historians have found their roots not in *productive* industries like textile manufacture, but in *processing* industries like steel manufacturing and meat processing (Biggs 1996). They point out that these two types of industries provide different kinds of challenges to rationalizers. In productive industries, each step of the processes must be carried out correctly or the results will show in the end product. Production involves many more types of skilled workers than processing. In processing, much of the work involved simply moving materials through each step of the process. In 19$^{th}$ century iron and steel manufacturing, for instance, the most skilled workers were the puddlers who judged the

quality and readiness of molten metal in the smelter. Experience and careful judgment was also required in preparing the beds for casting and in a few other tasks, but the vast majority of steel workers provided the strength of their backs and the flexibility of human arms and legs. It was these less skilled workers who were the first target of factory rationalizers.

The great innovation of this first generation of systematizers was to use mechanical means to move work from place to place-- conveyor belts, chain drives, etc. Without question, such innovations saved a great deal of backbreaking labor. But in the meatpacking industry, the other implications for workers became immediately apparent. Where once individual butchers had considered each animal carcass as distinctive, shaped by nature in ways that required individual consideration in the process of dismemberment, meatpacking workers now focused only on a single part of the animal. Eight or more hours a day they repeatedly removed the same leg, stripped out the same viscera, sectioned virtually the same portion of meat. On the chain drive, the carcass then passed onward as another one rapidly took its place. Division of labor eliminated the lengthy training traditional butchers underwent to understand the complex anatomy of cattle, making it possible to hire cheaper and replaceable workers. Bringing the carcasses to workers mechanically eliminated some of the hard physical labor of moving large pieces of meat around. This "disassembly line" historians have argued, is the direct predecessor of Henry Ford's production assembly line (Hounshell 1984).

Taylor's role in the process of rethinking industrial labor was as much cultural and material. He and his followers turned a set of practical techniques for improving manufacturing into an ideology, a set of beliefs about how all of society could and should

be organized. Taylor claimed that any process could be analyzed and systematized using his techniques. The "human factor" as it later came to be called would be treated analytically as part of a mechanical system. In a particularly telling statement he asserted, "In the past, the man must be first; in the future, the system will first" (Kanigel 1997)

Taylor's system was complex, involving a variety of often-sensible changes to the disorganized, ad hoc organization of workplaces. But he is best remembered and was most controversial in his own time for the introduction of "time motion study." This technique purportedly allowed experts with stopwatches to analyze the movements of workers carrying out a particular process. This information was used to establish the "one best way" to do a job and a standard pace at which the job should be carried out. Once the method and pace had been established, workers could be retrained to work more quickly and penalized if they did not through the use of piece rates. Trying to get management control over the pace of work was nothing new in American industry, but Taylor also made a radical claim: this system would benefit both employers and workers. Workers would learn how to work more efficiently and would therefore earn more money. Production would increase resulting in bigger profits for employers (Kanigel 1997).

Significantly, Taylor's claims about the origins of his system did not begin with watching workers on a factory floor assembling consumer goods. In his own telling, it began with observing a manual laborer employed to load pigs of iron onto a railroad car in a Philadelphia area steel mill. "Schmidt," as he was called in Taylor's accounts, had somehow found the means to lift and carry the pigs more easily than his fellow workers.

Taylor broke down and analyzed each of Schmidt's simple movements and then improved upon them. He offered Schmidt a financial incentive to carry out his work according to Taylor's instructions and had soon increased his pace. Schmidt was soon toting 47 *tons* of iron each day under Taylor's tutelage and careful scrutiny.

After Taylor set up shop as a consultant to industry in 1893, time-motion study became a new locus of conflict between workers and employers. Workers resented the incursion of outsiders who claimed to be able to understand the essential character of their work with only cursory examination. They also recognized that, in practice, the piece rates set on the basis of such studies were set in such a way that the profits from added productivity would largely go into the pockets of employers. And they recognized that such close scrutiny gave foremen and forewomen the power to stop practices such as soldiering, taking unauthorized breaks, and making informal agreements about the pace of work.

Initially, capitalists' efforts to use time-motion study to improve efficiency and gain shop floor control took place quietly, behind the gates of individual factories. But in 1910, a strike at the U.S. Government's Watertown Arsenal led to a Congressional Hearing, which put the labor implications of Taylorism on trial. Molders in the arsenal's foundry had walked out in protest of the presence of an efficiency expert trying to establish appropriate times and therefore piece rates for their work. They claimed that the expert lacked enough specific knowledge to be able to fairly say how long any given job would take. In 1916, two of the Taylorists' most distinctive tools, time-motion studies and their particular methods of setting wage rates, were banned from government contractors' workplaces for the next thirty-three years (Aiken 1985 [1960] 234-5).

Ford's assembly line combined these two ways of thinking about rationalizing production (bring the work to worker, treat the worker as a machine, as part of a system). Without doubt, these techniques made it much cheaper to manufacture many kinds of goods. But assembly line work also offered employers unprecedented control over the pace and character of work. Previously, employers had largely relied on surveillance, piece rates, and the tyranny of the factory clock to keep workers churning out goods. The assembly line much more effectively imprisoned workers in time and space. Like the meatpacking industry's disassembly line that had partly inspired it, the chain drive and its subsidiary conveyors and belts brought the work to the worker. No more getting up to get materials or to sharpen tools or to take finished products away. No more soldiering because the line set the pace of work. In some cases, the "hand" did not even seem to need his or her legs anymore except to clock in at the beginning of the shift. Nor did he or she have any sense of the complete logic of the object being assembled.

It should be pointed out that neither the technology of the assembly line nor the efforts to rationalize work was inherently anti-worker. Systematizers often claimed that greater efficiency would ultimately benefit everyone by leading to greater production, higher profits, and the elimination of unnecessary work. Workers themselves also recognized that many 19$^{th}$ century workplaces were badly organized and frustratingly inefficient. They also resented the sometimes-capricious judgment of all-powerful foremen. They welcomed efforts to improve production and to eliminate unnecessary work. Industrialization had, in fact, involved a long history of workers themselves contributing to the improvement of machines and processes, but in practice, new

production and management techniques were mostly put in place by employers to control workers and increase profits.

Henry Ford became a hero in his own age for the innovations he oversaw. But capitalists in wide variety of other industries could only dream about intensive mechanization and systematization. It was not possible to simply wave a magic wand and create a machine to replace proud, expensive craft workers. For others, the dream was futile despite the existence of viable technology. For instance, batch producers in small shops turning out small amounts of goods found new machinery uneconomical and cumbersome. It was cheaper, if more exasperating, to stay with simpler tools and more expensive, independent workers (Scranton 1997).

Other products simply did not lend themselves to mechanization or assembly line techniques. Ford's efforts to apply mass production methods to make ships for the First World War proved an expensive failure. The size and complexity of large vessels simply did not lend itself to his methods. In a completely different way, commercial laundry owners found ironing machines and other devices could help them increase the scale of their factories and eliminate the most expensive workers. But progress came with a cost. Their "raw materials" –shirts, tablecloths, and undergarments—could not be standardized. All machine processing involves a certain amount of destruction and waste, particularly if some materials are more delicate than others. This kind of waste was not acceptable to customers who wanted their heirloom napkins and favorite shirtwaists back, clean and intact (Mohun 1999).

As capitalist enterprises have grown in size and complexity, more and more workers found themselves employed not to piece together a material product, but rather

to help operate the information technologies that coordinated companies employing hundreds of thousands of employees often spread over great distances. Others, particularly women, took on the growing number of clerical jobs in businesses that primarily dealt in information such as banks and insurance companies.

Historians have pointed out that as early as the 1840s, railroad companies used paperwork to control far flung employees such as stationmasters who collected money for the company. But the so-called "great merger movement" of the late 1890s is a watershed in the establishment of a large number of truly huge, bureaucratized corporations. Some of the largest of these companies were banks and insurance companies. They did not produce a material product at all. Instead, they dealt in information. Early 20th century statistics from the Metropolitan Life Insurance Company provide a dizzying testament to the amount of human labor needed to manage information in the age before computers. The filing system alone took up two floors of the company's New York headquarters. Sixty-one employees spent their days keeping track of twenty million insurance applications, 700,000 accounting books, and half-a million death certificates. In the same building, women organized into huge typing pools bent over rows of typewriters churning out the endless reams of correspondence and paperwork needed to coordinate this massive enterprise. In 1915, one writer estimated that 1,170 typewriters were in use in the Metropolitan building (Zunz 1990, 114-115).

In an earlier period, a small number of male clerks had toiled to keep the ledgers of manufacturers and financial institutions. This job was widely seen as a stepping-stone to a management position, a way to "learn the company." As companies grew larger and the need for paperwork increased far beyond the capacity of the company to promote

clerks, clerical work became feminized. Mid-19th century male clerks had conducted their work using technologies that pre-dated industrialization: bound ledger books and quill pens. The ability to write a "fine hand" was a marketable skill that ambitious young men worked hard to acquire. Feminization of clerical work coincided with the introduction of a variety of office machines that, like their industrial counterparts, were intended to speed up and systematize the passage of information through offices (Davis 1982). The introduction of the typewriter was particularly significant. One of the clerk's jobs was to write letters and create documents on behalf of his employer. However, the personal character of handwriting and the interpretation inherent in creating that correspondence meant that he was a visible intermediary in the process. Letters churned out by a typing pool lacked any such personal dimension. Secretaries could even compose letters or documents for their employers and then have their intellectual labor rendered completely invisible once the letter was typed up and signed by someone else.

The feminization of office work was clearly driven by the economics of female labor. Women also sought out these jobs because they were cleaner and carried more status in the marriage market than factory work while men avoided them because they did not pay well and offered little hope of promotion. Despite the obvious economics of sexual division of labor, employers and manufacturers of office machinery went to great lengths to justify the technological dimensions of these jobs on gendered grounds. Using the typewriter, they argued, is very much like playing the piano (an activity that was also gendered female in Victorian America). Other office technologies also helped employers regender office work. The adding machine and time clock contributed to the development of a new, largely female office job—the comptometer—an employee who

not only added up hours worked for a payroll office, but also compiled statistics on work hours and productivity for efficiency experts (Strom 1992).

**Consumption, Work, and Urbanization**

The changing spatial character of work in late 19th century America also had profound consequences in workers' relationship to technology. Early factories had often been situated in rural settings, in villages perched on the banks of fast running streams and rivers. The first generations of industrial workers slipped easily back and forth between wage labor and subsistence agriculture. Late 19th century wage labor was increasingly based in cities or in situations in which workers were utterly dependent on the market for the necessities of everyday life. Moreover, the technologies they used at work and in their homes bore less and less resemblance to each other.

This distancing between home and work and growing dependence on the market place was part of a larger historical phenomenon. Historians have pointed out that the rapid expansion of the industrialization of production in the late-19th century coincided with widespread changes in habits of consumption. In effect, this marked an extraordinary transformation in where and how work was done. Almost all Americans increasingly bought what they once would have made. While the wealthier classes had always paid other people to do things for them, industrialization physically and economically separated producers and consumers. Early 19th century housewives had often work alongside their servants or "helps" preparing food or making clothes or other household goods. Servants remained a fact of middle and upper class life until World War II but industrialization changed their roles and the roles of their employers. As more and more people purchased the shoes, shirts, bread, and soap their grandparent had

fashioned at home, the household became a center of consumption rather than production. Middle class women gradually became household managers. Servants (except, perhaps the cook) filled non-productive roles such as household cleaning and maintenance, nursing and child-minding, running errands and making household purchases. And men's unpaid household labor almost completely disappeared from urban and suburban households until the emergence of a mid-20th century emergence of the culture of male home improvement hobbies.

The great labor conflicts of the late 19th and first half of the 20th centuries were partly fueled by this emergence of a new kind of consumer culture and the growing distance between producers and consumers. Higher wages were central to workers' demands commensurate with what was termed an "American Standard of Living." In these discussions, workers' defined themselves as citizen consumers. They argued that society owed them more than bare subsistence—a Malthusian existence. Meat as well as bread, houses, automobiles, and eventually washing machines were their due (Glickman 1997). This set of rights also imagined a division between male work and female consumption and unpaid household labor. Men would be paid a "living wage" so that their wives and daughters could stay out of the labor market. Demands for shorter work hours also accompanied the commodification of leisure and the disappearance (particularly of men's) productive labor out of the household. Coney Island, the corner saloon, and sales floor of urban department store all beckoned on a Saturday afternoon. Most employers were slow to realize that their workers could also be their customers, that higher wages might result in greater sales. For producers of raw materials like steel, the connection did indeed seem tenuous, but for producers of consumer goods, like Henry

Ford, an employee parking lot full of Model T's was testament to the hidden economic logic of the five-dollar day.

In turn, the distancing of production from consumption meant the middle and upper classes also had less and less of a sense of personal responsibility towards the invisible legions that sewed their clothing, packaged their crackers and candy, and assembled their automobiles. By the early 20th century, progressive reformers had begun trying to rekindle that connection, sometimes by using the objects themselves to evoke the lives of invisible workers. Middle class members of the Consumers' League, for example, led a series of efforts to convince female consumers to buy only products made under conditions beneficial to workers. A 1928 campaign, for example, called attention to the unsanitary and unpleasant conditions in which women workers hand-dipped chocolates. It is a testament to the distance between these workers and consumers, that candy purchasers responded not by demanding better conditions for workers, but by switching to machine-made confections presumably made in more sanitary conditions (Cooper 1998).

An older, pre-industrial technological regime offered few options in doing the most basic kinds of day-to-day work. For instance, in the preparation of food, one could cook a meal one's self or pay someone else to do it, use ingredients very close to their natural state. The rapid technological transformation of both paid and unpaid work provided consumers with a wide range of choices in how such work might be done and by whom. The late 20th century consumer can make a meal from the same kinds of raw materials as his or her 18th century predecessor or microwave a prepared dinner or open and heat a can or buy already prepared food that might or might not be delivered to the

home. Each choice involves different technologies and different kinds of labor, for instance, different modes of farming (factory or organic? local or international?), workers to prepare and deliver it (who makes frozen entrees and how?). In effect, consumption becomes an act of deciding how, where, and by whom work will by done.

Historically, these choices have been driven by a wide variety of factors. Some forms of work performed domestically carry powerful emotional meanings. They are, particularly for women in the roles of housewife and mother, labors of love and therefore worth keeping within the home. Until very recently, food preparation seemed to fall into this category (Cowan 1983). Other tasks have moved in and out of the home depending upon the technologies available both commercially and domestically. For instance, with the introduction of paper dress patterns in the late 19th century, many women who had paid dressmakers to make their clothes began to do the work themselves. The introduction of looser fitting styles, more amenable to mass production, and standardized sizes in the interwar years shifted the balance towards factory made garments (Gamber 1997).

Most historians have focused their attention on middle class consumers. But workers are also consumers. They also make choices about where work will be done. For instance, early 20th century reformers lamented the tendency of working class women to buy baked goods and deli food rather than preparing inexpensive stews and breads at home. Their assumption that homemade was better ignored the domestic technologies and time constraints with which workers struggled. Tiny stoves in hot tenement rooms fueled by expensive fuel made the prospect of hours of cooking very unattractive. Cooking techniques and knowledge of ingredients gained in rural areas often oceans

away from American neighborhoods also did not necessarily translate well, leaving women with a deficit of skills with which to cope with this new urban environment. It is no wonder they chose to pay someone else to do the work.

**Science-based Technologies, Transportation and Communication**

As America entered the 20th century, work was also transformed by two other factors: the proliferation of science-based technologies and the role of new transportation and communications technologies in delocalizing the connection between production and consumption. 18th and 19th century factory production largely focused on making familiar objects and substances using new methods: cloth, steel, gunpowder, etc. Novelties tended to be mechanical devices, cherry pitters, bicycles, steam engines, that were understandable from visual inspection. Beginning in the late 19th century, more and more workers found themselves not only using novel technologies as tools in their jobs but making or maintaining or operating technologies that had never before existed anywhere in the world. Many of these technologies had originally been created by scientists or other technical specialists in research and development laboratories of large corporations. They were often based on new discoveries in electricity and chemistry and were difficult to comprehend and reproduce by those without technical training. For workers who first spun nylon or assembled computers, technology also becomes black boxed in a whole new way.

If 20th century industrialization and technological change created a variety of jobs that had never before existed in the world, it also transformed some of the most ancient and seemingly immutable kinds of work. For instance, nursing has long been a job associated with the most basic activities of feeding and caring for persons too sick to care

for themselves, has become more and more a profession of managing complex medical technologies in the context of hospitals. Nurses traditionally came to know the bodies and needs of their patients through conversation, physical touching, and observation. As nursing began to professionalize after the American civil war, this distinction was formalized into a set of protocols that distinguished the labor of doctors and nurses. Nurses were enjoined from using tools or invasive techniques to observe or treat patients. However, the introduction of a succession of new medical technologies: more and more injectable medications, intravenous feeding, and a variety of monitoring technologies challenged those protocols. Doctors wanted patients treated and observed using these technologies but did not want to be present every time a needle was inserted or a reading taken. The history of nursing in the 20th century, therefore, has been characterized by a constant set of negotiations over who will use which technologies and what that usage will mean in terms of prestige, professionalization, and relationships with patients (Sandelowski 2000).

To take a very different example, agriculture is one of the oldest of all human technology-intensive forms of work. In the last four centuries, agriculture has undergone a whole series of technological transformations each of which required different types of workers and different kinds of knowledge. However, 20th century changes have perhaps been the most profound because they originated in the science laboratories of universities and in corporate boardrooms.

The industrialization of farm work followed some of the same patterns already described in this essay. The use of a growing variety of gas-powered machinery from Fordson tractors to combines made it possible to carry out farming on a larger and larger

scale. Agricultural scientists in land grant universities also tackled the two most labor intensive parts of growing crops: weed and pest control and harvesting. The introduction of a broad range of new chemicals, including DDT and 2-4-D after World War II enabled farmers to spray rather than sending large numbers of workers through fields to pick off insects and hoe weeds (Daniel 2000). Scientists also treated plants themselves as technologies, designing square tomatoes that could be harvested mechanically and hybrid corn that could not be manipulated genetically by farmers themselves (Fitzgerald 1990). Consequentially, farmers found themselves deskilled and farm workers found themselves displaced by machinery.

In the same way that late 19th century industrialization changed the landscape and with it social and economic relationships by concentrating production in large cities, 20th century changes in agriculture have changed the land and social relations upon it. In the 1950s, the adoption of chemicals and machines gradually put an end to racially based system of sharecropping and tenant farming that had characterized Southern agriculture since the end of the Civil War. Large landowners no longer needed the labor system that had replaced slavery to work their land (Daniel 2000). In the Midwest, chemically based agriculture and sophisticated harvesting machinery has virtually eliminated the system of itinerant labor and huge work crews that once characterized farm life. Raising wheat is now largely a solitary endeavor carried out in the air-conditioned cab of a combine.

Fears of Automation

Beginning in the 1930s, mechanization and industrialization led to a widespread public debate about not only the dehumanizing of work but also the possibility that too much technological ingenuity could lead to widespread unemployment. Are we

"inventing ourselves out of jobs?" commentators asked (Bix 2000). The impact of the Great Depression had called into question the assertion by Ford, Taylor, and other systematizers that more efficient production would lead to cheaper products which would lead to more consumption and, in turn, more jobs to make those products.

The so-called "manpower" shortages of the Second World War temporarily silenced such worries, but they reappeared in the post-war era along with the first ripples of what would later be called de-industrialization. Kurt Vonnegut's dark 1952 novel Player Piano imagined a world in which engineers had automated industry to the point that no workers were needed at all. IQ and aptitude tests determined whether young people would be trained as engineers or give make-work employment in the army or the "reeks and wrecks"—public works crews. Automation was justified in Taylorist terms: human workers were lazy, incompetent, and prone to error. In Vonnegut's fictional world, engineers had bypassed the necessity of figuring out ways to make a human being act like a machine. They had simply eliminated the human beings (Vonnegut 1952)

Vonnegut's distopian vision was based in part on his own experience working at General Electric in Schenectady, New York during a period in which the company was working on techniques for automating machine tools (Noble 1984, 166). As suggested earlier, the job of machinist had long stood as the quintessential exemplar of skilled, male labor. Postwar engineers hoped to turn the process of cutting complex parts out of metal into something that could be done with the push of a button by collecting the machinist's knowledge on a tape and later computer program (Noble 1984).

Not just novelists worried about automation and unemployment. A 1955 Congressional Hearing on "automation and technological change" interviewed a parade

of witnesses about the costs and benefits of new technologies. Advocates claimed that the lower cost of goods and the creation of new kinds of jobs maintaining and supporting the new machinery more than made up for job losses. Others were not so sure. Labor leader Walter Reuther expressed his concern about the fate of older and more specialized workers. By the early 1960s, technological unemployment had become a fact of life for more and more workers and a hot political issue. President Kennedy went so far as to ask the Department of Labor to create an Office of Automation and Manpower to track statistics and set up programs to retrain displaced workers. Critics could point to Detroit where a 12 percent unemployment rate co-existed with enormous gains in automobile production. In 1958, for example General Motors announced they planned to increase production 25 percent but only hire 5 percent more workers (Bix 2000, 247-250, 254, 256).

In historical perspective, postwar fixations on automation represent a partial misunderstanding of the impact of technological change on wage labor in America. Such discussions still assumed that automation was the primary solution to the rising cost of American labor. The had not counted on the power of new communications and transportation technologies to make it feasible to carry on manufacturing without substantial automation in the developing world where labor costs were much lower. Capitalists who went abroad found workers who were not only willing to work for less but who also had skills acquired from other parts of their lives that had largely disappeared from American culture because of the impact of consumer culture. Women in Korea, and Thailand, and Mexico were already skilled sewers because they made their families' clothes rather than purchasing them.

## Conclusion

Productive labor has not disappeared out of the United States. Across the country, workers still assemble cars and package food and make a thousand variations on the ubiquitous consumer products we take for granted. And other workers still engage in work that could be characterized as pre-industrial (although it would be difficult to find an example of work that has not been changed technologically by industrialization). As summer approaches, road crews set out their orange cones and stand, shovels in hand, by the side of the highways, ready to shovel the dirt that cannot be moved by machines. In workshops and studios, potters, luthiers, cabinetmakers and other craftspeople turn out handmade objects one at a time.

In the last few decades, much has been made of the impact of one particular technology, the computer, on work. A little bit of historical perspective may in fact be useful in shedding light on this phenomenon. As with the automobile with which this essay began, there is no single kind of computer work. Forms of labor related to this technology are extraordinarily diverse. Like automobiles, computers are mass-produced objects made for a consumer marketplace. In factories across the world, impoverished women assemble microprocessors. Like their predecessors who dipped chocolates (or made hats or assembled televisions), many cannot afford to buy what they make. Unlike the candy makers, many also would not know how use the product they help put together. Computers are a very 20$^{th}$ century kind of technology in this sense. Elsewhere, very different kinds of workers write code, repair computers, or enter data (replacing the file clerks that once climbed ladders to file and retrieve information).

Perhaps more striking is the way computers have redefined the physical nature of work. More and more American workers, like their counterparts in other industrialized countries, use a computer keyboard or a touch screen as prosthesis between their own bodies and the thing they are making or doing. Even in the Rouge, still standing, but a shadow of its former grandeur, many autoworkers do not make direct physical contact with the cars they are building. Where Diego Rivera to portray the same spaces now, they would be relatively empty of people. The sinewy rhythm of men's bodies bending to their tools is more and more being replaced by workers standing at the side of the line, monitoring a series of robots. 19th century utopians such as Edward Bellamy imagined a future in which technology would free workers from toil, giving them leisure time to improve their minds and enjoy pleasure outside the workplace. Mid-century critics of automation worried about the spread of technological employment. As it turns out, the number of hours worked by the average American has increased over the last decade and unemployment levels have hovered at record lows. Technological change has not resulted in less *time* spent working. Instead, wage labor has ceased to be synonymous with hard physical work. Even many industrial workers no longer expect to wear out their bodies in the course of doing their jobs. If technology is indeed socially constructed, this is striking choice to have made, undoubtedly with unforeseen consequences.

Bibliography

Aiken, H.G.J., Scientific Management in Action: Taylorism at Watertown Arsenal, 1908-1915 (Princeton: Princeton University Press, 1985 [1960]).

Aldrich, M., Safety First: Technology, Labor, and Business in the Building of American Work Safety, 1870-1939 (Baltimore: Johns Hopkins University Press, 1997)

Biggs, L., The Rational Factory: Architecture, Technology, and Work in America's Age of Mass Production (Baltimore: Johns Hopkins University Press, 1996)

Bix, A.S., Inventing Ourselves Out of Jobs? America's Debate over Technological Unemployment, 1921-1981 (Baltimore: Johns Hopkins University Press, 2000)

Borg, K., "The 'Chauffeur Problem' in the Early Auto Era: Structuration Theory and the Users of Technology," Technology and Culture 40 (October 1999): 797-832

Cooper, G., "Love, War, and Chocolate: Gender and the American Candy Industry, 1890-1930," in His and Hers: Gender, Consumption and Technology, Roger Horowitz and Arwen Mohun, eds. (Charlottesville: University of Virginia Press, 1998) 67-94

Cowan, R.S., More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave (New York: Basic Books, 1983)

Daniel, P., Lost Revolutions: The South in the 1950s (Chapel Hill: University of North Carolina Press, 2000).

Davis, M., A Woman's Place is at the Typewriter: Office Work and Office Workers, 1890-1940 (Philadelphia: Temple University Press, 1982).

Downs, L.B., Diego Rivera: The Detroit Industry Murals (Detroit: Detroit Institute of the Arts, 1999)

Fitzgerald, D., The Business of Breeding: Hybrid Corn in Illinois, 1890-1940 (Ithaca: Cornell University Press, 1990).

Gamber, W., The Female Economy: The Millinery and Dressmaking Trades, 1860-1930 (Urbana: University of Illinois, 1997)

Glickman, L.B., A Living Wage: American Workers and the Making of Consumer Society (Ithaca: Cornell University Press, 1997).

Harper, D., Working Knowledge: Skill and Community in a Small Shop (Chicago: University of Chicago Press, 1987)

Hounshell, D., From American System to Mass Production: The Development of Manufacturing Technology in the United States (Baltimore: Johns Hopkins University Press, 1984)

Hughes, T.P., American Genesis: A Century of Invention and Technological Enthusiasm (New York: Viking, 1989)

Landes, D.S., The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present (Cambridge: Cambridge University Press, 1969)

Licht, W., Working for the Railroad: The Organization of Work in the Nineteenth Century (Princeton: Princeton University Press, 1983)

Meyer, S., "Work, Play, and Power: Masculine Culture on the Automotive Shop Floor, 1930-1960," in Boys and their Toys? Masculinity, Class, and Technology in America, Roger Horowitz, ed. (New York: Routledge, 2001) 13-32

Milkman, R., Gender at Work: The Dynamics of Job Segregation by Sex during World War II (Urbana: University of Illinois, 1987)

Mohun, A.P., "Why Mrs. Harrison Never Learned to Iron: Gender Skill, and Mechanization in the American Steam Laundry Industry," Gender and History 8 (August 1996): 231-251.

Noble, D., Forces of Production: A Social History of Industrial Automation (New York and Oxford: Oxford University Press, 1984).

Sandelowski, M., Devices and Desires: Gender, Technology, and American Nursing (Chapel Hill: University of North Carolina Press, 2000)

Scranton, P., Endless Novelty: Specialty Production and American Industrialization, 1865-1925 (Princeton: Princeton University Press, 1997).

Strom, S.H., Beyond the Typewriter: Gender, Class, and the Origins of Modern American Office Work, 1900-1930 (Urbana: University of Illinois Press, 1992)

Vonnegut, K., Player Piano (New York: Dell, 1952).

Zunz, O., Making America Corporate, 1870-1920 (Chicago: University of Chicago Press, 1990)