SHIFT HAPPENS

ESSAYS ON TECHNOLOGY

GENE WILBURN

MARION TURNER WILBURN

SHIFT HAPPENS

Essays On Technology

Gene Wilburn
Marion Turner Wilburn

2020

Contents

CONTENTS

CONTENTS

Introduction

Any sufficiently advanced technology is indistinguishable from magic

— Arthur C. Clarke

Technologies shape us and our environment. They affect how we think about the world and our place in it. Beginning with stone tools, technology has shifted humankind's ideas, perceptions, and abilities.

Over most of the 14,000-year rise of human civilization, beginning around 12,000 BCE, the pace of technological change had been slow enough for people to adjust gradually to its impact. More recently, however, the pace of change has increased exponentially.

Shift Happens is a collection of essays that chronicle the introduction and spread of technologies that have shifted and reshaped our lives during the past century. With examples drawn principally from North America, the authors review the impact of new technologies from the perspective of two individuals who have lived through most of this time of immense change.

Starting with the introduction of electricity and the rise of radio and TV, the essays turn to personal computers, the Internet, World

Wide Web, streaming audio and video, artificial intelligence, and quantum computing.

The authors, Gene Wilburn and Marion Turner Wilburn, are retired information specialists whose careers included managing IT projects and establishing websites for their institutions. Both authors have written extensively and taught courses on information technology. *Shift Happens* reflects their personal experiences with the technologies of our era.

Note: The use of "I" in the essays denotes Gene's memories. Marion's memories are identified by her name to avoid confusion.

    — Port Credit, Ontario, Canada, June 2020

Electricity: The Spark of Modernity

Electricity is really just organized lightning

— George Carlin

Life in the Dark Ages

Try to imagine a world without electricity, electric lights, or power tools. Curiously, I experienced this in my early years. As a toddler in the late 1940s, I lived with my Swedish grandparents on their homestead farm in northern Minnesota, adjacent to the Manitoba border. With no electricity, our main fuel came from a woodpile set well away from the house. It was a comfortable, warm, home but without modern conveniences. My mother and grandmother cooked on a wood-burning, cast-iron stove with a reservoir at the side that heated water for dishes, laundry, and bathing.

For entertainment, my grandfather, who knew a little English, read children's books to me, while my uncle played guitar and sang harmony with my mother. Occasionally someone performed a piece or two on the pump organ. At night my mother read to me by the flickering glow of a kerosene lamp, which she would carefully wick down when I fell asleep. Although this was the 1940s, we were living in the equivalent of the 1900s.

The Grid

Although Thomas Edison created the first commercially practical light bulb in 1879, for most people, especially those in rural areas, electricity didn't arrive until much later. It first came to towns and cities, then gradually spread to the countryside in what was called "rural electrification." For some remote areas, electricity didn't arrive until the early 1950s.

The Canadian Niagara Falls hydroelectric generating station, built in 1906, began the spread of electrical power in Ontario. To this day, to the confusion of many, the "hydro bill" is not a water bill, but an electric bill. A similar spread of electricity occurred in the United States. During the Great Depression of the 1930s, President F. D. Roosevelt supported the Tennessee Valley Authority (TVA) initiative, which provided hydroelectric power to many states. Where dams were not feasible, provinces and states used fossil fuels to power electric generating stations.

Electricity changed our mental landscape. Night no longer had to be dark and dangerous — it could be fun. Lights lit up the landscape. We began to stroll under flashing movie marquees, to watch in wonder as the town's Christmas tree lights were turned on, and to eat hotdogs at a night baseball game.

Home environments changed. Reading by candle light and cooking on a wood stove were left behind with the introduction of electrical appliances. With the flick of a switch or turn of a dial, ranges and ovens were ready for food preparation. Refrigerators kept food fresher for longer and leftovers could be stored for more than a day. Frozen foods became a staple of life, and grocery shopping shifted to a weekly event. Although life became easier, the expectation of cooking more varied and exciting meals added a new and different kind of pressure on homemakers.

Work environments also changed. Ford Motor's assembly line was only possible through the use of electricity. Many craftsmen, who had worked on their own using an extensive skill set, became line workers, focused on a single, repetitive task, bearing little relationship to the whole. With the loss of independence came higher wages and greater job security.

Cities changed. New inventions, such as elevators and escalators, allowed buildings to be built higher and higher, changing the visual landscape. Soon electrical wires powering trams, electric buses, and subways, created a tangled web overhead, some of which survive in places like San Francisco, Toronto, Boston, and Montreal.

Although electricity brought many benefits, it also brought unanticipated, denied, or ignored downsides. Fossil-fuel generating stations are hard on the environment, releasing tonnes of CO_2 gas into the atmosphere. As newer sources of power become available, fossil-fuel stations are being phased out. Canada introduced its controversial CANDU nuclear reactors for "cleaner" power generation in the 1960s. In the early 2000s, more environmentally-friendly technologies, such as wind turbines and solar power, began dotting the landscape.

Despite its environmental complications, electricity is the bedrock technology of our time.

Transportation: The Great Escape

Everything in life is somewhere else, and you get there in a car

— E.B. White

Cars and Highways: A New Mobility

One of my first childhood memories is an automobile ride from Richmond, California, to nearby San Francisco. As we drove across the San Francisco-Oakland Bay Bridge, the car climbed higher and higher. When I saw the water so far below, I panicked. Uncle Pete, in an attempt to distract me, suggested I watch for sharks in the water. It didn't work. It was the first of my many experiences with vertigo.

Somewhat later, I rode in my grandfather's Model A Ford over dirt and gravel roads in northern Minnesota, as we made our weekly trip to nearby Ross to sell cream from the farm. There were four or five other cars parked in the lot, but an equal number of horses and buggies. The automobile, in 1948, was just beginning to make inroads into the isolated farming community.

The rise of the automobile for general use is one of the pivotal events of the early 20th century. Henry Ford's new Ford Motor

Company introduced an automobile that was reliable yet affordable: the Model T — affectionately dubbed the "Tin Lizzy." The Model T was in production from 1908 to 1927, by which time Ford had sold 15 million cars, more than all its competitors combined.

Before the automobile, it was necessary to live near your work. Having a car meant you could choose where to live. You could move away from the congested city and drive to work. Cars meant freedom, mobility, and independence — you could come and go as you pleased.

Family trips and Sunday drives became the norm. Marion's family loved their day trips through the Niagara Peninsula to take in the spring blossoms. My family of eight, piled into our new station wagon and embarked on a two-day drive to my grandparents' farm in northern Minnesota. Large family reunions and quick short trips to escape the city became commonplace. To support these changes, an entirely new transportation infrastructure had to be built. It reshaped our landscape.

Changed Landscape

The local impact of the automobile was profound. As the number of cars overtook the number of horse-drawn buggies, parking meters replaced watering-troughs, the smell of automobile exhaust replaced the smell of horse manure, and the sound of honking horns and squealing brakes replaced that of rumbling cart-wheels and horses clopping on the pavement. With increased traffic came traffic lights, multiple-lane and one-way streets. Auto repair shops employed a new specialist, the automobile mechanic, and offered gas pumps for refueling your car.

Parking lots for existing local businesses, schools, and churches were squeezed into any available space, including back alleys. City

streets became less pedestrian friendly, traffic snarls more common, and the "rush hour" was born. Sprawling suburban shopping malls, with their massive parking lots, took business away from town centres. New homes featured one, two and eventually three-car garages as cars joined the family. The pace of life became faster as noise and air pollution grew.

The demand for improved and extended roadways turned highway construction into a major industry. In the United States, Interstate Route 66 connected Chicago to Los Angeles, while in Canada, the Trans-Canada Highway (Route Transcanadienne) spanned 7,821 kilometers (4,860 miles) from Newfoundland in the east to British Columbia in the west, making it one of the longest highways in the world. These major, multi-lane routes, coupled with existing shipping routes, transformed our access to manufactured goods and produce. We could now readily enjoy tropical fruits in the middle of winter, and buy fabrics and furnishings from world-wide sources.

New service industries also arose. Motels and their adjacent restaurants sprang up along the highways offering tired drivers overnight accommodation. They also supplied that absolute necessity — the "pit-stop" bathroom. Drive-in fast eateries served customers in their cars with the aid of carhops on roller skates who took and delivered orders. Drive-in movie theatres meant families with young children could enjoy an inexpensive night out without disturbing or distracting others. Some churches even offered drive-in services via a car-mounted speaker. Convenience became "king."

Romance of the Road

More than anything else, the automobile turned dreams into reality. The romance of the road gripped the imagination. Families could head out to the cottage, the lakes, the mountains, the prairies, or the

deserts. Fishermen, campers, photographers, hikers, and sightseers could drive to out-of-the-way places seldom dreamt of before the automobile. And if life was hard in the east, you could head west and start afresh. Above all, you could be "on the road" — a state of mind captured in Jack Kerouac's novel *On The Road* and Gordon Lightfoot's song, "Carefree Highway."

Style, Comfort, and Power

> *The car has become an article of dress without which we feel uncertain, unclad, and incomplete in the urban compound*
>
> — Marshall McLuhan

As automobiles multiplied, so did automobile manufacturers. By the 1950s, cars were no longer just black and utilitarian, but colourful and fashionably designed. Ford, General Motors, American Motors, Chrysler Motors, and Studebaker introduced big "muscle cars" powered by gas-guzzling V-8 engines. At thirteen, Marion practiced driving her family's 1957 Mercury sedan on the back roads of cottage country. The car was so large, that even though she sat on a cushion, her only view of the road was through, rather than over, the steering wheel.

The annual automobile show was the highlight of the year. Family trips to the show were filled with excitement and strongly held opinions on the new looks: tail fins, two-tone paint jobs, shiny chrome, sleeker lines, four headlights instead of two, AM/FM radios, and many styles of two-door and four-door sedans. It was the age when you "drove your Chevy to the levee." Your status as a male was reflected by your car, or lack of one. Young men often drove souped-up jalopies while business executives drove Cadillacs and Lincolns. Sensible family men drove middle-level sedans

and station wagons. Automobile advertisers featured scantily clad young women posing with the latest cars to entice new male buyers.

As oil supplies in North America dwindled, the price of gasoline rose and many drivers purchased smaller, imported cars with better gas mileage and lower maintenance costs. Volkswagen Beetles became popular among budget-strapped college students. There were times, at college, when I looked ruefully over a sea of VW Beetles trying to locate mine, when the only distinguishing feature was colour. The new appetite for economy cars caught the North American auto industry flat-footed. Imported Hondas, Toyotas, Mazdas, and Datsuns (Nissans) flooded the market and drained sales from the domestic gas hogs.

The 1973 OPEC Oil Crisis drove a nail into the coffin of the muscle car market. They became too costly to maintain and consumers lost their desire for them. North American manufacturers began to offer downsized models, like the Ford Pinto and AMC Gremlin. Economy and safety features became the watchword of the day.

Nevertheless, as cars multiplied, so did accidents. Damage to cars and injuries to passengers sometimes resulted in loss of life. Automobile safety became a major issue. Despite widespread initial resistance to their use, safety belts were introduced and proved so effective they became mandatory. Airbags were soon added for additional crash protection. Laws were passed to reduce drinking and driving.

Smog: The Ugly Dragon

Along with freedom and adventure came air pollution. The Los Angeles area in particular, with its heavy traffic and extensive freeway system, experienced severe smog conditions as early as the 1950s.

Weather-related thermal inversions frequently trapped emissions close to the ground, intensifying the bad air quality. Over time, all major cities routinely experienced smog that obscured the sky and frequently smelled noxious. Air Quality Index readings appeared in weather reports with warnings that those with breathing problems should stay indoors. Over time local pollution became global pollution. Climate scientists have identified CO_2 emissions from vehicle traffic as one of the principal contributors to global climate change. As a result, efforts are underway to use greener alternatives to fossil fuels.

The North American automobile industry has introduced electric-powered vehicles, such as the Tesla 3 and Chevrolet BOLT. Volkswagen is developing an electric version of its once-popular minibus, and Volvo is gradually phasing out all gas-powered vehicles. As improved battery technology extends the mileage per charge, people will increasingly accept these as their vehicles of choice.

Despite urban congestion, traffic jams, fatal accidents, and harmful emissions, the automobile has developed a firm and lasting hold on the North American psyche. It has created such a ubiquitous shift in our lives it's impossible to imagine a world without cars, buses, trucks and vans. Plus, as some have pointed out, you're a different person when you drive. For many car owners, driving clears the mind and refreshes the spirit. For parents, driving has soothed many a newborn to sleep.

Automotive vehicles are here to stay. They're a must for getting to and from work and to suburban shopping malls, community centres, hockey practice and dance lessons. Trucks and vans are essential for transporting the vast range of products supporting modern life. It's only a question of which engines will power tomorrow's vehicles: gasoline, electric, hydrogen, or some type of hybrid.

Air Travel: Up, Up, and Away

> *Oh! I have slipped the surly bonds of earth / And danced the skies on laughter-silvered wings*
>
> — John Gillespie Magee, Jr.

From the legend of Icarus on, humans have dreamt of "slipping the surly bonds of earth" to fly free as a bird. As early as the 15th century, Leonardo da Vinci designed flying machines that included a helicopter-like device. With the development of aircraft, modern people can fly through the heavens like the legends of Greek myth.

The first commercially successful flying machines were the lighter-than-air Graf Zeppelin dirigibles which offered trans-Atlantic flight. Excitement turned to horror in 1937, when 36 passengers died as the *Hindenburg* went up in flames while attempting to land in New Jersey. This marked the demise of the dirigible as a viable means of flight. From that point onward, airplanes became the most accepted method of air travel. The first successful commercial passenger-carrying airplane was the propeller-driven Douglas DC-3. For those who could afford it, air travel became the desirable way to travel long distances, a status it still holds today and into the foreseeable future.

Airplanes were first used with weapons in World War I. Aerial dogfights were glamourized in films or fantasied in comic strips such as Snoopy and the Red Baron. Unlike films or comic strips, however, the reality was grim. The once clear skies were now filled with killing machines. During World War II, military bombers rained destruction first on Britain and then on Germany with nightly bombing raids that wreaked havoc on the cities, killing innocent civilians. Despite their destruction, nothing had the global impact of the atom bombs detonated over Hiroshima and Nagasaki. Our sense of safety would never be the same again.

After the Second World War, commercial jet airliners, like the Boeing 707, shrank travel time once again. They also shifted our concept of travel. International tourism blossomed as greater numbers of North Americans holidayed in Europe and beyond, visiting ancient cities, enjoying different cultures, and tasting new foods. At the same time, Europeans and Asians came to North America. But these holidays were often so short and jam packed, the publishing industry began offering travel guides such as *Europe on 5 Dollars a Day* and humorous films such as *If It's Tuesday, This Must Be Belgium* and comedic love stories like *Roman Holiday*. Our own love story began when we first met at a youth hostel in Bergen, Norway.

Travel and tourism was now a major business. For many years, air travel was somewhat luxurious. The cost of a flight included free baggage storage, in-flight meals served on porcelain dishes accompanied by stainless steel utensils, drinks, and snacks. But as the cost to build, maintain, and fuel airplanes rose, commercial airlines shifted from customer comfort to fuel savings and low-cost flights. Airport taxes, baggage fees, reheated meals served in plastic trays and eaten with plastic utensils are now the norm. On the cheapest flights, you are offered a bag of peanuts or pretzels and a Coke, Sprite or Dr. Pepper. The combination of barebones in-flight services, plus self-serve ticket counters and crowded airports, has done much to destroy the mystique of flying. What would have been magical in the past has become banal as air travel has become a challenging experience for many. Flying has lost most of its cachet.

And yet . . . when you lean back in your seat, feel the power of the engines surge, and see the world below you drop away, you're still charged with an adrenaline-spiked sense of adventure. It's what to do during the rest of the flight that remains a challenge.

Telephone: From Socket to Pocket

One ringy-dingy {snort}, two ringy dingy {snort} . . .
Hello, is this the person to whom I'm speaking?

— Lily Tomlin, telephone switchboard operator on *Rowan and Martin Laugh-In*

The invention of the telephone forever altered our means of communication. Centuries of letter writing gave way to real-time voice conversations. The question of who invented the telephone remains disputed, but, by most accounts, Alexander Graham Bell was the primary inventor. Ironically, Bell himself refused to have a telephone in his study, feeling it was an intrusion on his real work as a scientist.

Despite Bell's reluctance to use his own invention, the telephone's popularity spread rapidly. As with other technologies it required a new infrastructure. The earliest callers contacted a local exchange by hand cranking a "magneto" generator, attached to the side of their wall-mounted phones, and asked for a connection. The operator then connected a switchboard cable to the socket of the requested number. As demand increased, the newly formed Bell Telephone company built thousands of local exchanges, staffed by operators sitting in front of massive grids of connecting plugs and sockets. Paralleling the switchboard grid, our streets became lined

with telephone poles and criss-crossing wires. Cities and suburbs were dotted with public telephone booths where, for a dime, anyone could make a local call. The booths also provided a convenient place for television's Clark Kent to change from his business suit to his caped Superman costume to fly after dastardly criminals.

Over time, human operators and manually connected circuitry were replaced by automated telephone exchanges where callers listened for a dial tone and dialled the desired number themselves. For a long while, the iconic black rotary-dial telephone was the only offering available. Eventually, push-button, pulse-tone phones displaced the rotary units. To broaden their market, Bell introduced designer phones in a variety of shapes and colours. The 1959 "Princess" phone, aimed at teenage girls, became a "must have" possession. Eventually, homes needed multiple outlets and handsets, or even a separate number on a second line. Phones also moved outdoors to porches and patios with the introduction of the portable cordless phone.

Long-distance calls soon connected family and friends who chatted as if they were in the same room. Small businesses used telephones to stay in touch with customers and suppliers. Large businesses relied so extensively on telephone communication, they frequently set up their own internal switchboards. International telephone calls became a reality when the first trans-Atlantic telephone cable was completed in 1956. The telephone conference call eventually allowed business professionals to participate in meetings with colleagues from all points of the globe, sometimes to the chagrin of those who worked in different time-zones.

In the wake of the 1962 Cuban Missile Crisis, which threatened nuclear war, the "Washington-Moscow hotline" phone was put in place so the United States and Soviet Union could communicate instantly with one another to prevent misunderstandings or misinterpretations of troop and naval movements.

For ordinary users, hotlines were far removed from their daily reality. Stay-at-home moms used the phone to maintain friendships and participate in social circles. Teens talked to one another for hours, ostensibly about their "homework." College students called home to request more funds from mater and pater.

Walking the Talk

It had long been a dream to free telephony from the tyranny of cables. In the 1960s TV comedy show *Get Smart,* agent Maxwell Smart used his secret rotary-dial shoe phone to wirelessly call headquarters. The dream was realized in 1973, when researchers at Motorola placed the first cellphone call from a handheld experimental unit. Later, in the 1993 TV show *The X Files,* Mulder and Scully stay in touch using similar Motorola cellphones.

Cellphones were an instant hit. Soon, people were chatting everywhere on their phones. While walking down a busy street in Toronto, I was startled to hear the well dressed man next to me volubly talking to an invisible companion. I thought only street people did that. But then I noticed his earbud and the cable to his cellphone. It shifted my perception of normal behaviour on the street. In Toronto, growing complaints about unrelenting, elevated noise levels among commuter-train cellphone users resulted in the creation of a rush hour "quiet zone" in the upper level of double decker cars, where cellphone calls were not permitted.

Over time, cellphone technology passed through several "generations." The first generation (1G) cellphones were analog, and were used strictly for voice. 2G added the ability to send and receive data in the form of text messages. 3G and 4G phones improved the speed of data exchange by incorporating Internet-compatible TCP/IP packets for communications. By 5G, every aspect of sending and receiving was digital and faster than previous generations.

Cellphones had also shrunk so much in size they easily fit in a pocket or purse, ready to go anywhere. It was definitely a case of "Honey, I Shrunk the Phone" rather than "Honey, I Shrunk the Kids."

The Smartphone

Apple Inc.'s introduction of the iPhone in 2007, radically shifted our perception of what a cellphone could be. Apple CEO Steven Jobs asked his engineers to integrate the various touchscreen devices of the day, including the cellphone, compact camera, and MP3 player. The result was an earthquake invention with tremors still being felt today. The iPhone became the hottest technology in the marketplace — the all-in-one computing, browsing, telephony, and photographic device now known generically as the "smartphone."

Apple encouraged software developers to create "apps" that users could access via their iPhone. Soon, there were apps for email, Safari, Google Maps, Facebook, Twitter, Skype, YouTube, Spotify, Apple Music, Netflix, and even Internet-connected office apps such as Pages, Numbers, Microsoft Office, and Google Docs.

Apple's competitors dived into the technology and major vendors, such as Samsung, Nokia, LG, Motorola, Lenovo, and Google, developed smartphones of their own and encouraged developers to make their iOS apps available for all Android-based smartphones. The race was on. People flocked to smartphone technology like bees to nectar, fundamentally shifting telephone use. Soon, Bluetooth earbuds, with long lobes, adorned users' ears like ancient Egyptian jewelry.

The smartphone's grip on people's habits is now so complete, that smartphone use has become smartphone dependency. Instant ac-

cess to Internet data, addictive social-media apps such as Facebook, Twitter, email, text messages, and streaming media, have transformed the social landscape. When you look around today, you see people using smartphones everywhere — walking down sidewalks, driving their cars (hopefully with hands-free devices) and even when gathering at the family dinner table. As a result, some families have declared the dinner table a phone-free zone in order to revive family conversations.

In all, the smartphone has become the most widespread and successful technology of the 21st century. Its impact has yet to be fully understood, though it has been appreciated by billions of users worldwide. As the Virginia Slims cigarette ad once said, "You've come a long way, baby."

Radio: The Tribal Drum

*Then radio came in. For the first time people didn't
have to leave their homes to be entertained*

— Kliph Nesteroff

The introduction of the radio in the early 20th century created a profound shift from the written to the spoken word. It supplemented, and, for many listeners, surpassed print technology for news, information, and entertainment. Radio had more immediacy than newspapers. Everyone in the family could gather around to listen to events such as King Edward VIII's abdication speech, Franklin D. Roosevelt's "Fireside Chats," and Winston Churchill's exhortations to the British people during the bombing of Britain. By the 1930s and 40s radio featured timely news and weather reports, numerous comedy and drama series, telephone interviews and call-in talk shows. It is a small wonder that Marshall McLuhan, Canadian media guru, called radio the modern "tribal drum."

By the early 1950s, beautifully finished, wood cabinet standalone or table-top radios became the centerpiece of the living room. Ours was a Zenith floor model with a large round illuminated dial for tuning in stations, and a very large 14-inch speaker. The depth of the speaker's bass tones gave voices a special gravitas. We listened to everything from live broadcasts of symphonies to Friday night

fights and radio series such as *The Lone Ranger, Fibber McGee and Molly, The Jack Benny Show, The Shadow, Superman, The Grand Ole Opry,* and *Don Messer and His Islanders.*

Not long after, smaller shelf radios allowed homemakers to listen to the news, weather, and pop music while working in their kitchens. The newly invented bedroom clock-radio, designed to wake you up in the morning with music or news, eased us into the start of the day.

Portables: Batteries Included

In the late 1950s, one of the first commercial applications of "space-age technology" was the portable, transistorized AM radio. Listened to via a single monaural earbud or the radio's tiny speaker, it was small enough to fit in a shirt pocket. Its portability shifted radio listening from the living room, kitchen, and bedroom, to a personal listening space you could take with you everywhere — a forerunner of the Walkman, iPod, and smartphone.

At the time, most World Series baseball games were still played in daylight hours. Young fans brought their transistor radios to school to surreptitiously listen to the games. Because many teachers weren't yet conversant with the technology, a few students got away with stating, when questioned, that the earbuds in their ears were hearing aids, until the science teacher spotted them and put an end to that caper. In fairness, the pocket transistor radio *did* resemble the bulky, transistorized hearing aids of the day.

FM: Smooth and Easy

Although FM radio was first demonstrated in the 1930s, it wasn't widely available until the late 1950s. Broadcasting on a higher radio frequency than AM, FM provided a cleaner, static-free, signal.

28

Before the days of stereo, FM receivers became coveted components in single-speaker, HiFi (High Fidelity) sound systems. FM was much appreciated by audiophiles.

FM radio programming offered classical, opera, and warm, relaxing music, at a time when the brash new sounds of rock-and-roll were filling AM radio airwaves. FM radio hosts spoke in hushed, cool, and reverential tones. Even the commercials adopted this soft, soothing sound.

In 1961, FM radio stations first broadcasted in stereo. At the same time, the music industry introduced stereo LP (long-play, 33 1/3 rpm) albums. Two years later, stereo FM became an option in automobiles. Soon AM/FM radios became standard equipment in all vehicles. By the late 60s, the same youth culture that celebrated Woodstock and the Summer of Love, started "underground" FM radio stations to play psychedelic rock music.

Ham and CB: Getting Personal

"CQ, CQ, CQ" for "I seek you." Individual amateur radio operators use this code to greet the airwaves when they want to strike up a random conversation with another operator. For several decades, amateur, or "ham," radio was one of the hottest hobbies around the world. The word *ham* is derived from the pejorative phrase *ham-fisted,* which described how poorly amateurs keyed Morse code compared to professional telegraph operators. Over time, the name acquired a positive connotation, and amateur radio operators now use it proudly.

Ham radio is, above all things, personal broadcasting — a kind of specialized "people's radio." To become an operator, you must pass an exam on amateur radio regulations and radio theory, at which point you are assigned a "call number," such as K0DYO, and

are required to identify yourself any time you get on the air. Once licensed, ham operators can initiate and take part in two-way conversations using either Morse code or voice. Many of them enjoy the sub-hobby of "DXing" in which they try to reach increasingly distant contacts. The farther away, the greater the bragging rights.

Today there are approximately three million amateur radio operators worldwide. Ham operators often assist in emergency conditions, such as hurricanes, floods, or tornadoes, when normal communication links are down, using battery-powered transmitters to put victims in touch with their families.

CB (Citizen's Band), another form of personal radio, uses a restricted number of frequencies, designed for short-distance communication. Unlike Ham operators, CB operators are not licensed and are therefore at liberty to invent their own identification "handles" or nicknames. Handles were usually creative and colourful, such as "First Mama" (Betty Ford). Mel Blanc, a well known voice actor, used his characters "Bugs" and "Daffy" to delight children in the LA area on his CB rig. CB also inspired movies such as *Smokey and the Bandit, Breaker! Breaker!,* and *Convoy.*

CB soared in popularity with truckers and other travellers in the 1970s and 80s. During the oil crisis, when gasoline was rationed, long-haul truckers informed others of available gas supplies, along with alerts on the location of speed traps. They also kept themselves awake during long hauls by chatting with other drivers.

Although CB radio attained huge popularity, it, like ham radio, diminished in usage with the advent of smartphones and the Internet. For a brief while CB radio transformed how ordinary people thought about radio communication. It provided an opportunity for many to shift from simply listening to actively participating. For many, the Internet will never fully replace the fun and excitement of operating your own radio rig.

Radio Today: Still Crazy After All TheseYears

Mainstream AM and FM radio stations are still thriving. Radio serves as a major source of up-to-date traffic, news, weather reports, and sports broadcasts. Talk shows, from sports chats to political discussions, thrive on audience participation. Radio is also one of the few places to offer local interest stories, author interviews, and user requests during music shows.

Many radio stations now simultaneously broadcast to the Internet for listening via the Web, reaching listeners throughout the world. Despite competition from television and other sources of entertainment, radio still supports a large number of devoted listeners and hard-core fans.

Television: The Fascination Box

Every time you think television has hit its lowest ebb, a new program comes along to make you wonder where you thought the ebb was

— Art Buchwald

It's easy for us, the authors, to be nostalgic about 1950s and 60s TV shows because we spent our childhoods there. The medium was still young and new, and the family radio sat neglected as we all gathered together, glued to snowy, black-and-white images of Jackie Gleason in *The Honeymooners,* and Lucille Ball in *I Love Lucy.* We were spellbound as we watched the coronation of Queen Elizabeth II. Saturdays meant kids' shows in the morning and the *Baseball Game of the Week* in the afternoon. In the evening, we kids left the room as the adults watched, and actually seemed to enjoy, *The Lawrence Welk Show.* Sunday nights were devoted to the *Ed Sullivan Show* that amazingly featured Elvis Presley and the Beatles. TV had its seasons, and while watching summer reruns of the previous season, we eagerly anticipated the new fall lineup.

After the 50s and before the Internet, people spent most of their free time in front of the TV. In many households, Swanson's frozen TV dinners shifted meals to the living room. Homemakers scheduled their activities around their favourite daytime soap operas.

Sporting events such as *Hockey Night in Canada,* the Stanley Cup playoffs, and the World Series, brought family and friends together for home parties. Kids' love of cartoons meant moms had a built-in babysitter. After the kids were in bed, mom and dad watched late-night talk shows hosted by Johnny Carson, Steve Allen, Dick Cavett, and others on their bedroom TV.

But the medium's programming drew criticism from the more high-minded as being badly written and stereotyped. Educators rued TV's lack of educational material. But entertainment was, and still is, king. Given how awful some shows are, TV as a medium got a rap for being culturally downscale. Despite being labelled "the idiot box" and "the boob tube," it has remained immensely popular.

B&W to Colour

Like the movie *The Wizard of Oz:*, television started out in black-and-white, then suddenly shifted into glorious Technicolor. Colour lit up our screens as we watched nature shows, travelogues, dramas, sports, and the world news. One of our favourite colour-TV shows was *Walt Disney Presents,* which, on Sunday evenings, broadcast animations and adventure stories from *Fantasia* to *Davy Crockett.*

Even more than radio, TV shrunk the world. We watched both glorious and inglorious major events like royal weddings, hurricane disasters, and the daily horrors of the Vietnam war. Events didn't seem real until we'd witnessed them on "the Box" in full colour.

Channels Galore

Although for audiences, television was entertainment, for broadcast networks it was big business. "Bums on seats," representing the number of viewers tuned in, drove the industry. Audience

rating systems, like Nielsens in the U.S., determined the ultimate fate of shows, including which time slot they were given, and how many seasons they would last. The higher the Nielsen rating, the more advertising dollars a show brought in. Pausing for a "word from our sponsors" was the norm for every mainstream television show and advertising attached itself to television like barnacles to a ship. Some ads, then and now, were clever and entertaining. But most were visual and aural annoyances that you did your best to ignore. The "commercial break" became a good time to raid the fridge, which, for many, was their main form of exercise.

In its first few decades, television had a normative effect on popular culture. People watched the same shows, creating a shared basis for chit-chat with co-workers around the water cooler or friends on the phone. Favourite newscasters like Walter Cronkite, Peter Jennings, and Knowlton Nash added an avuncular, trusted presence to the national news. It took many years before females and people of different ethnicities were accepted as reporters and anchors with equal status.

Despite TV's popularity, some users found its offerings lacking in variety or educational value. At the same time, producers with more unique programming ideas found it tough to crack the fortresses of the major networks. When UHF was added to the broadcasting spectrum, the number of channels increased from 12 to 51. Not only were there more innovative stations to watch, there were now commercial-free educational networks such as PBS-TV in the U.S. and TVOntario in Canada. These brought us shows like *Sesame Street, The Agenda with Steve Paikin,* Ken Burns *Civil War,* and *Masterpiece Theatre.*

Cable TV brought about the greatest boost in programming variety. For many, this fee-based, antenna-free form of television was piped into users' homes via coaxial cable. Viewers were attracted to its clearer reception and its specialty offerings such as the History Channel, Discovery Channel, Food Channel, sports channels,

and 24-hour news channels like CNN, that offered more to viewers with special interests. Cable became highly popular and soon spawned a competitor in the form of DSL (digital subscriber line) TV, delivered to the home by telephone companies such as Bell Canada. Despite the number of channels, you can still hear the complaint, "There is nothing to watch on TV."

Satellite TV

In 1949, Arthur C. Clarke, a well-known science fiction writer, envisioned the concept of beaming TV signals up to stationary-orbit satellites which beamed them back down to a far distant location. Given that there were as yet no satellites in the sky, it was remarkably prescient.

Clarke's vision became a reality and the world shrunk again, as satellites began broadcasting political and sports events. We could now watch live broadcasts of uprisings in Uganda, tennis at Wimbledon, World Cup Championship football playoffs, not to mention the "Thrilla in Manilla" — the heavyweight boxing championship fight between Joe Frazier and Muhammad Ali.

Over time, our visual landscape changed again, as satellite dishes "decorated" homes and apartment buildings. Satellite TV, with programming similar to Cable TV, became the latest link in the chain of viewing, reaching remote areas such as settlements in the far north of Canada, and rural areas in North America where cable and over-the-air broadcasts did not reach.

CRT to Flat Screen

The first TV sets took up a lot of living room space. Behind the viewing screen sat a large CRT (cathode ray tube) that included a

"gun" that literally fired electrons onto the back of the screen. The larger the screen, the larger the CRT and the larger the enclosure.

In the 1990s and 2000s, digital LEDs (light emitting diodes) replaced CRTs by embedding thousands of transistors into the viewing screens. TV screens and computer monitors were now slim and trim. As the price of the technology dropped and production increased, homeowners began buying 40-inch, 60-inch, and even larger sets. Wall-mounted units became common in living rooms taking up a fraction of the space they once required. Big screen TVs also found a happy home in pubs and sports bars.

At the opposite extreme, flat screens became small and personal. Every PC, tablet computer, and smartphone, with its ability to display television broadcasts, allowed watchers the option to enjoy television anywhere.

Television Today: Fragmentation

While cable and DSL TV continue to be popular, some customers have cut monthly charges by purchasing indoor antennas that deliver free HD (High Definition) digital broadcasts. Others have completely "cut the cable" and waded into the flood of subscription-based Internet streaming services, such as Netflix, HBO Online, Hulu, Hoopla, Kanopy, BritBox, and Amazon Prime.

These services offer commercial-free original content, foreign films and TV, and "oldies but goodies." They have also shifted our viewing habits. Instead of waiting a week for the next episode of our favourite show, we can now hunker down for a marathon viewing of one or more full seasons of *The Crown, Shetland,* and *Friends.* Streaming services and *binge watching,* satisfy our unquenchable desire for instant gratification, continuous novelty, and freedom of choice.

Music: Platters, Discs, and Streaming

Without music, life would be a mistake
— Friedrich Nietzsche

Mankind is a musical species. From earliest times, religious and secular songs and tunes have filled the air wherever people have gathered. It had long been a dream to capture music and play it back. Recording first occurred in the late 19th century in forms that included direct transfer to wax cylinders, piano rolls, and record platters. By the 1930s, magnetic recording tape had been invented. The question became one of which technology would deliver music to the masses, and, for a long while, records proved the most popular.

By the end of the 1940s, the commonest record format was the 78 rpm, two-sided disc that could hold just over three minutes of music per side. In the early 1950s, the smaller and lighter weight 45 rpm disc was introduced. It enjoyed spectacular success during the early days of rock music, and the 45 rpm "single" (with side B) sold heavily to adoring teens. The girls at my school carried specially designed boxes of 45s to school to play on the classroom record player during lunch and recess. There were many popular singers, but the king of the 45 was Elvis Presley. "Playlists," as we would call them today, were created by stacking selected 45s

39

on a tall spindle where each would drop down to be played after the previous one. Elvis might be followed by Bobby Darin, Little Richard, the Coasters, the Everly Brothers, and even Pat Boone.

LPs and Tapes

In addition to the 45s, the new 33 1/3 rpm LP (long-playing) record format came to market. The LP could play up to 30 minutes per side offering buyers twelve or more songs. The superior quality of vinyl LPs created a new type of listener — the audiophile. Because their musical tastes tended toward classical, jazz, stage and film soundtracks, and opera, they built the best single-speaker HiFi systems available. In 1957, stereophonic LPs hit the market. This prompted audiophiles to scale up their systems to include a new stereo cartridge, a stereo amplifier, and *two* good speakers rather than just one.

To show off the potential of the new stereo technology, demo LPs featured exaggerated left-to-right and right-to-left sound effects, such as trains and ambulances going by. It gave the listener the illusion of being there in a kind of aural "virtual reality." Stereo changed recording techniques, and music began to be recorded with a minimum of two microphones rather than just one. This aural expansion of music caught on immediately, and soon recording artists were releasing albums in stereo. In 1959, RCA released Rodgers & Hammerstein's *South Pacific* in "Living Stereo," bringing the movie experience into the living room.

To listen to stereo, you had to purchase new gear or update your existing equipment. Thus began an upgrade cycle driven by the desire for the latest electronics — a cycle that has continued to this day.

In addition to records, music recordings became available on 8-track, 1/4-inch, and 1/8-inch tape. Truckers were avid users of 8-

track systems picking up new tapes at truck stops along their routes. Audiophiles regularly used 1/4-inch reel-to-reel tape to dupe their LPs, saving wear on the original discs. In 1979, Sony introduced the 1/8-inch cassette tape along with the first cassette player, the Sony Walkman. The Walkman allowed you to take along your favourite music wherever you went. It became almost *de rigueur* for joggers to strap on a Walkman before a run. The Walkman, and its competitors, soon incorporated AM/FM radio into their units, making them even more attractive to listeners.

CDs

The CD (Compact Disc) was jointly developed by Phillips and Sony in the early 1980s. CDs differed from both LPs and cassettes in that they were a totally digital format, free of the hiss of tape and the scratches and pops of LPs. Some audiophiles were aghast at the lack of warmth and presence in early CDs but the general public loved the "pure" sound.

By the 1990s, CDs became the de facto standard for packaging music. LP and cassette recordings gradually disappeared from music stores. Major recording artists released their back catalogues on CD and many music lovers replaced their favourite worn LPs with CDs. When Sony introduced the popular Discman, it replaced the Walkman on the belt and pouches of joggers. CD sales exploded.

At the same time, the computer industry adapted the CD form factor, spawning a number of digital formats. The CD-ROM and its variants were used to store data. The DVD (Digital Video Disc) and its variants could store not only data but also store high-definition video with CD quality sound tracks. Later the BD (Blu-ray disc) further improved video quality.

MP3s

Because CD audio tracks are very large digital files, to fit more of them on a computer hard disk, the music industry introduced a new compressed format called MP3 (MPEG audio layer-3), but the shrinkage came at a cost. The MP3 was a "lossy" format, meaning it achieved its compactness through the partial discarding of data. Many listeners scarcely hear the difference between MP3s and CDs, but audiophiles find the difference painfully noticeable.

Nevertheless, the MP3 prevailed. The format was highly practical. Music listeners could "rip" the tracks of a CD, saving them as MP3s to play back on their computers using audio software. They could also copy them to the small, newly introduced solid-state, portable MP3 players. Joggers and others who desired music on the go, soon switched from the Sony Walkman and Discman, to portable MP3 players.

The best known of the MP3 players was the Apple iPod, which came in various sleek models, colours, and sizes. Easily fitting into a shirt pocket or purse, these units were very popular with pedestrians, drivers, railway commuters, and students. People began using them at the office to listen to their private music while working.

Before long, computer programs, such as Plex and Kodi, allowed listeners to wirelessly broadcast MP3 music from their computers to media players such as Roku or Apple TV. This proved so convenient that people began ripping their entire CD collection. Instead of getting up to change discs on their CD player, listeners could now select music from any album via their TV remote. They also became their own DJs as they created personal playlists.

The music industry soon rolled out a game changer that transformed listening forever — streaming music.

Streaming Services

By 2020, streaming music services had captured the mindset of a huge number of listeners. For a monthly subscription fee, Google Play Music, Apple Music and Spotify, offered unlimited access to their entire music catalogue. This was a win-win situation for sellers and buyers alike. However, music store sales dropped so much, many of them were forced out of business.

For independent musicians — those not on major labels — earning a living has become even tougher than ever. The earnings from streaming sales are less than those from CDs. This discourages new talent from getting into music — a setback that has not been resolved.

Vinyl's Revenge

In an unanticipated reaction to the somewhat compromised sound of digital music, the vinyl LP has made a surprising and spectacular comeback. Aided by noise-reduction audio system components, the once annoying distractions from pops and scratches have all but disappeared while the warmth and depth of the analog originals has been retained.

Eschewing CDs and MP3s, audiophiles have brought the vinyl LP out of retirement. Reissues of many music classic recordings share space with new releases, offering everything from Beethoven's symphonies to the latest pop stars. Local record stores, selling new and used vinyl recordings, are once again flourishing, while audiophiles are once again fussing with LP discs.

The bottom line is that people love music and are listening as never before. Listeners seeking convenience and availability cherish the

streaming services, while audiophiles seeking ultimate audio quality continue to grow their collection of vinyl LPs. Everyone, it seems, has found the music format they prefer — at least until an, as yet unimagined, format appears.

Big Bangs: Fission, Fusion, and Furore

For they have sown the wind, and they shall reap the whirlwind

— *Hosea,* 9:7

Of all the technologies of the mid- to late-20th century, none has created a more devastating impact than the atom bomb. In the fall of 1945, the U.S. detonated atomic fission bombs over two cities in Japan, Hiroshima and Nagasaki, killing 200,000 or more civilians. "The Bomb" ended the war in the Pacific and ushered in a new era. Its brilliant flash and mushroom cloud effectively annihilated mankind's long childhood and cast a shadow over its future. For the first time in history, humans were faced with the potential for being bombed into oblivion.

However, few people were immediately aware of the profound shift that had occurred. Paradigm shifts take time to filter through to the collective consciousness and war-weary citizens simply wanted to pick up the pieces and start life anew. In the economic boom that followed the war, citizens migrated to the cities and the burgeoning suburbs, to partake in post-war prosperity. For many, it was the North American Dream: a steady job, a house of your own, several children, a stay-at-home mom, a shiny new automobile, and church on Sundays. It was a time of optimism and accelerated materialism. People acquired electricity, appliances, station

45

wagons, houses, telephones, record players, radios, and television sets.

But postwar euphoria did not last. While splitting the atom was an astonishing scientific achievement, confirming Einstein's famous equation, *e=mc²,* it led to the development of the newer and more devastating hydrogen bomb that unleashed far greater force and destruction. The atom bomb had acquired a big brother and it didn't belong to the U.S. alone.

A new post-war power, the Soviet Union, as well as England and France, also acquired the hydrogen bomb. As the U.S. and France blew up Pacific atolls like ducks in a shooting gallery, the U.S.S.R. rearranged parts of Siberia with nuclear blasts. The future didn't seem as safe as it had been. The Cold War had begun.

At the height of the Cuban Missile Crisis in 1962, many of us were terrified that a worldwide nuclear war was imminent. To prepare citizens, towns and cities sounded sirens during mock nuclear attack exercises. Students were instructed to sit under their desks, though no one ever explained how this would save their lives. Radio stations ceased broadcasting, leaving only the U.S. government CONELRAD emergency radio channels broadcasting on AM frequencies 640 and 1240, identified on radio dials of the day by two small triangles.

There was palpable fear in the air — a gnawing sense that this was *it:* we had come to the end of civilization. Movies like Neville Shute's *On the Beach* portrayed a bleak scenario of inevitable doom. Many people built and stocked bomb shelters in their backyards. The U.S. Strategic Air Command carved a huge facility in the Idaho mountains designed to protect chief military and civilian personnel and to launch strategic nuclear bombers. Meanwhile, the Canadian government, under John Diefenbaker, built a Canadian Forces underground facility (colloquially known as the *Diefenbunker*). Now a somewhat quaint museum, its original intent was in deadly earnest.

As a result of the Cold War and atmospheric nuclear testing, radioactive isotopes spread across the planet, high in the atmosphere. Alarming reports filtered in that strontium-90, which came down with the rain, was appearing in the dairy milk fed to children. This was poignantly captured in the gentle protest song, "What Have They Done to the Rain?" by San Francisco grandmother and folksinger Malvina Reynolds. To prevent the release of radioactive particles into the atmosphere, the military switched to nuclear testing deep within the earth.

In 1953, in an effort to shift perception from fear to acceptance, U.S. President Dwight D. Eisenhower delivered an "Atoms for Peace" address to the United Nations General Assembly. Eisenhower championed the peaceful use of the atom to give mankind unlimited power to grow and expand. The icon of the atom became synonymous with progress. Despite some citizen opposition, the U.S. and Canada built nuclear reactors. However, nuclear power plant disasters, such as Three Mile Island, Chernobyl, and Fukushima, once again raised and spread public distrust of atomic energy. Whatever the eventual outcome of "atoms for peace," the mushroom-cloud image of destruction hangs over atomic energy like one of Scrooge's ghosts

The detonation of nuclear bombs spawned ripple effects that are felt to this day. The threat of nuclear annihilation shifted postwar positivity to an underlying uncertainty and even a lingering existential dread. Concerned citizens formed coalitions like the CND (Campaign for Nuclear Disarmament) whose "Ban the Bomb" symbol has become the universally-recognized "peace symbol." Nuclear protestors staged rallies in England in the late 50s and early 60s, and the movement subsequently spread to Europe, Japan, Australia, and North America. In 1961, brought together by Women Strike for Peace, 50,000 women marched in protest in 60 U.S. cities. The effectiveness of these marches in attracting the attention of the press and legislators clearly influenced the later 1960s

Civil Rights marches and "Youth Culture" demonstrations against the Vietnam War.

The Ban the Bomb movement created an expectation that citizen voices could and should be heard. Today's protests and rallies against fossil-fuel pollution and climate change are direct descendents of that movement. As Bob Dylan expressed it, "The times they are a-changin'." We have indeed reaped the whirlwind.

It's no exaggeration to say that our modern era started with a bang, whose after effects continue to reverberate.

Satellites: Eyes in the Sky

Beep ... Beep ... Beep ... Beep ... Beep ...
— Sputnik I, 1957

On October 4th, 1957, the Soviet Union put Sputnik I, the first man-made satellite, into earth orbit — an event which stunned the world and launched the Space Age.

This clarion achievement also started a "space race" in which the Soviets quickly pulled ahead of the Americans. The Soviets soon launched Laika, a dog, into orbit and in 1961, cosmonaut Yuri Gargarin became the first human launched into orbit.

The Americans soon caught up by launching their own satellites and, in 1962, putting astronaut John Glenn into orbit. In 1969, millions watched their TVs in awe, as astronaut Neil Armstrong put his foot on the moon's surface and spoke his now famous words, "That's one small step for [a] man, one giant leap for mankind."

Space Program: Byproducts

The U.S. Space program, administered by NASA (National Aeronautics and Space Administration), used many "space-age" technologies, such as the transistor, while inventing a few of its own.

As direct spinoffs from NASA technology we have memory foam, freeze-dried food, emergency "space blankets," DustBusters, cochlear implants, LASIK eye treatments, and digital photographic image sensors. Contrary to common belief, NASA did not invent Tang, Velcro, or Teflon, though it used them.

After the Cold War, the U.S. and Russia shared their technological knowledge which enabled the creation of ISS (the International Space Station). ISS serves as a microgravity and space environment research laboratory for conducting experiments in astrobiology, astronomy, meteorology, physics, botany, and other fields. Canada contributed the invaluable Canadarm to the space station. This large, remote-controlled, robotic "Shuttle Remote Manipulator System" is a giant "grabber" used to deploy, maneuver, and capture payloads. It is also used to inspect the space station itself.

GPS Satellites

GPS (Global Positioning Systems) is satellite technology merged with computer technology. In contrast to most earlier satellites, GPS satellites orbit the earth in a "fixed" position overhead. The GPS system in your car or on your smartphone can triangulate on three of them at a time, using trigonometry to calculate your position on the ground to within 30 centimeters (11.8 inches) of accuracy. Today's drivers generally rely on GPS to map out the best route to their desired destination. After you key in a location, a robotic co-pilot issues driving instructions, while displaying a real-time map on the vehicle's computer console. On the western prairies some farmers use robotic farm machinery, guided by overhead GPS satellites, to till their land. GPS is one of the most widely used gifts of the space age.

Astronomical Satellites

When I was a kid interested in space, the largest telescope on the planet was the 200-inch Hale Telescope located in the Mount Palomar Observatory in southern California. Some of its black-and-white photographic images of space were so stunning they were reproduced in daily newspapers for reader enjoyment and wonder. As earth telescopes merged with computer technology, optical telescopes like the Hale became obsolescent. New more powerful and specialized instruments were developed that could peer deeper into space.

Although telescopes are best situated on high mountaintops where the atmosphere is thinnest, astronomers dreamed of placing their instruments in space, well above the earth's atmosphere. The dream was realized when astronomical satellites were parked in Earth orbit, allowing researchers to peer into the infrared and ultraviolet spectra to detect extremely distant x-rays and gamma rays. The most famous of these instruments is the optical Hubble Space Telescope, launched in 1990. Its clear, colourized images of distant galaxies and nebulae are now our most iconic images of the cosmos.

Remote Sensing Satellites

While the military have long used surveillance satellites for espionage, in more recent times, remote sensing has become a boon to several scientific disciplines. Satellite-mounted thermal and infrared sensors can penetrate the earth to a meter in depth, revealing outlines and patterns of soil, vegetation, geology, and man-made structures not easily visible at ground level. This has led archaeologists to discover new Mayan ruins in the jungles of Central and South America, as well as lost settlements, tombs, and pyramids in

Egypt's Nile Delta. Geologists use satellite radar sensors to map features on the seafloor, while climate scientists map weather patterns and track the effects of global climate change.

The ability to view earth from space has shifted our understanding of the planet's complex patterns and events. Despite their sophistication, every satellite currently in orbit still pays homage to the original "beep ... beep ... beep" of Sputnik I.

Lasers, Microwaves, and Ultrasound

Focus like a laser, not a flashlight

— Michael Jordan

In the 20th century, engineers combined laser beams, microwaves, and ultrasound with electronics. The resulting products and services have reshaped our technological infrastructure.

Lasers

The first functional lasers were built in the early 1960s. While not as elegant as the Jedi-knight light sabers of the *Star Wars* movies, laser beams are one of the champions of modern technology, used in everything from weaponry to eye surgery.

The theoretical foundation of the laser first appeared in Alfred Einstein's 1917 paper, "On the Quantum Theory of Radiation" — or, if this were subtitled in a *Bullwinkle* cartoon episode, "I've Seen the Light!" A *laser* ("light amplification by stimulated emission of radiation") uses an *optical amplifier* or *lasing medium* to excite the atoms of certain gases which causes the atoms to emit energy in the form of light. The light is then filtered to achieve *coherence*

that results in a tight beam with very little spread. Today the term *laser* broadly includes visible-light lasers, infrared lasers, ultraviolet lasers, X-ray lasers, and gamma-ray lasers.

The functional uses of the laser beam are widespread. Its cutting, cauterizing, and hardening capabilities are used in medicine, metallurgy, automobile manufacturing and the garment industry. Reflected laser beams are used by surveyors, builders, and the military to measure distance with extreme accuracy. Businesses of all kinds now scan barcodes to manage inventories. At home, we use the laser read-write capabilities with our CD, DVD, and other discs as well as our laser printers. And, finally, lasers are used to entertain us with anything from large-scale laser light displays to small-scale laser pointers. Who hasn't enjoyed watching a cat chase the moving red dot.

Although unassuming and largely invisible, lasers have quietly embedded themselves in our lives.

Microwaves

Microwaves are situated above radio waves and below infrared waves in the electromagnetic spectrum. Microwave technologies are used for both data communication and for heating.

Microwave astronomers study microwave emissions from the most distant parts of the universe. The CMB (Cosmic Microwave Background) provides information on the state of the universe in the first moments after the Big Bang. On a more earthly scale, microwaves are incorporated into air traffic control systems and police radar guns used to check for speeders.

Microwaves are used extensively in personal electronics. Bluetooth keyboards and earbuds employ microwave signals to commu-

nicate with computers and smartphones. WiFi technology uses microwaves to wirelessly connect smartphones, laptops, and tablets to the Internet, allowing us to roam untethered.

The heating power of microwaves gained tremendous popularity with the advent of microwave ovens. The process of exposing food to concentrated electromagnetic radiation, known as *dielectric heating,* causes the excitation of molecules in the food itself, producing thermal energy. Cooking without a heat source like fire or electrical heat seemed eerily impossible when microwave ovens first appeared in the late 1970s. For some while most people had only a vague understanding of how they worked. At an educational conference in the early 1980s, Marion encountered her first microwave oven. To her astonishment, a colleague explained that microwaves "cooked the food from the inside out." Cooks today use microwave ovens as comfortably as stoves.

Invisible microwaves are now part of our everyday life. Today we connect wirelessly to the Internet or "nuke" a bag of popcorn without giving it a second thought.

Ultrasounds

Ultrasounds are sound wave frequencies inaudible to most humans. Animals such as bats and porpoises use ultrasound for locating prey and obstacles. Once scientists and engineers harnessed ultrasound, they had a non-invasive way to detect, measure and view objects.

Ultrasound recording devices were first used to detect invisible flaws in industrial products and structures such as ships. Many companies now use it to inspect their equipment during maintenance cycles, thereby avoiding costly and disruptive equipment failures.

In the late 1950s Glasgow hospitals were the first to pioneer the use of medical ultrasound, also called *sonography*. For the first time, physicians could see images of soft tissues, such as the heart, lungs, and liver, to look for swelling or infection. Obstetricians could also observe the prenatal development of babies. In the mid 1980s, a pregnant Marion had an ultrasound taken. When asked for a copy of the image, the astonished technician admitted he couldn't produce one. She came home saying the hospitals were missing a money-making opportunity. It's now standard to produce the images which are treasured by parents and their families.

Compared to what we could "see" previously, ultrasound technology has extended our ability to see inside objects and bodies. Laser, microwave, and ultrasound technologies have enhanced and extended our sensory universe.

DNA: A Game Changer

> *I'm fascinated by the idea that genetics is digital. A gene is a long sequence of coded letters, like computer information. Modern biology is becoming very much a branch of information technology*

— Richard Dawkins

Although DNA (deoxyribonucleic acid) was discovered in 1869, it wasn't until 1943 that its crucial role in passing gene traits from one generation to the next was finally understood. When in 1953, James Watson and Francis Crick discovered the double-helix structure of DNA, the stage was set to deepen our knowledge of DNA and inheritance and to set us on a path toward DNA manipulation.

This has led to the development of two distinct genetic engineering technologies. GMO stands for "genetic modification of organisms." Also called "transgenic" modification, it works by inserting genetic material from one species into another. The other is "gene editing," which manipulates the traits expressed in a single genome. These have resulted in processes like artificial insemination, *in vitro* fertilization, and cloning (identical reproduction of a cell or organism).

Progress in genetic modification has come quickly. In 1974, the first genetically modified organism, a mouse, was created; in 1983

the first plant was produced; in 1994 the first commercialized GMO food, the Flavr tomato, appeared; in 2003 the GMO GloFish became the first commercialized animal; in 2015 the AquAdvantage salmon became the first GMO animal to received approval for food use. Although controversial, genetic engineering is just beginning.

Plants and Animals

Gene editing technologies like CRISPR, which operates like genetic "scissors," were first targeted at plants, such as corn, soy, alfalfa, and cotton, by introducing new traits that do not naturally occur. For example, certain crops are being DNA enhanced so they can grow in normally inhospitable salty ground. Efforts to save the world's banana crops involve inserting pepper genes into bananas to make them less susceptible to encroaching diseases. In most cases, gene editing is intended to enhance a crop's resistance to pests, diseases, and chemical treatments, such as herbicides, and to reduce spoilage rates. In addition, gene-editing capabilities are being used to improve the nutritional profile, taste and other qualities of soy, peas, and other fruits and vegetables. However, growers and distributors of these products face the uncertainty of worldwide regulatory practices. Europe's regulatory systems for gene-edited crops are stricter than those in North America.

Compared to plant genetics, gene editing in animals is more complex. Even so, researchers at the University of Missouri have successfully used gene editing on pigs to make them more resistant to porcine respiratory and reproductive syndrome (PRRSV). At the University of California at Davis, gene-edited cattle were successfully able to pass on a polled (hornless) trait to their offspring. This method of dehorning cattle is significantly more humane than the techniques currently used by cattle producers, who want to prevent their livestock from injuring workers and each other. Genetic engineering is a sensitive and contentious issue for many. While some

critics have philosophical and religious issues with the use of the technology, others object on the basis of environmental or health concerns. The debate is fiery and scientific research is at times contradictory. But the use of biotechnology in our fight against possible famine as the world's food supply becomes threatened by climate change may prove critical to our survival.

Humans

In 1990, the Human Genome Project, an international, cooperative science research endeavour, started with the goal of mapping the complete human genome — the sum total of a human's DNA. It was successfully completed thirteen years later, in 2003. The mapping of the human genome is considered one of the highest achievements, so far, of 21st-century science.

During its development, the project attracted a commercial competitor launched by American researcher Craig Venter and his firm Celera Genomics. The Celera approach was making faster progress than the Human Genome Project, partly because it had access to the Human Genome Project's data in addition to its own research, and Celera announced that they intended to patent the human genome once they'd mapped it. The mapping became a race between publicly funded researchers and big business. Billions of dollars were at stake.

In March 2000, U.S. President Clinton announced that the genome sequence could not be patented, and should be made freely available to every researcher and member of the human race. The statement sent Celera's stock plummeting. The biotechnology sector lost about $50 billion in market capitalization in two days. It was one of the rare times when the good of the people bested the interests of corporate greed.

Family Connections

Genealogists were among the first people to use at-home DNA testing kits from companies such as 23 and Me, Ancestry, and MyHeritage. From your saliva sample, the companies extracted selected genes needed to identify "blood" relatives. For this to work, they built a database whereby members could link their DNA results to someone in their online family tree. The company software would then search for matches. Those who wished to "fish in many ponds" had to upload their data results to GEDMatch, a genetic genealogy website that works by comparing the results from multiple DNA testing companies.

While initially genealogists used their matches to prove their known ancestry, some, like Marion, took on the role of "genetic genealogists" as they began to help adoptees, orphans, and others identify their birth parents. But once frequently "hidden" secrets are in the open, ethical questions arise. Who has the right to know and/or share this information? Should adoptees be allowed to contact birth parents? There are no easy answers to these questions.

In 2018, the genealogy community was shocked to learn that police had compared a DNA profile in CODIS (Combined DNA Index System) against GEDMatch profiles to identify and arrest the infamous "Golden State Killer," the suspected perpetrator of a series of murders and sexual assaults in the 1970s and 80s. No one on GEDMatch had consented to police surveillance of their data. Reaction was swift. Many withdrew their profiles and all DNA companies rewrote their privacy statements and altered their business practices. Despite the ongoing debate on this use of DNA, under specific conditions police continue to work with genetic genealogists to solve cold cases.

Molecular Medicine

Researchers are building a knowledge base that identifies genetic variations and/or mutations and their relation to specific diseases and conditions. Using this knowledge, medical practitioners and pharmaceutical researchers are finding new ways to diagnose and treat gene-specific diseases, such as sickle cell anemia. Molecular analysis is also becoming an essential tool for uncovering an individual's predisposition to various illnesses, such as breast cancer, cystic fibrosis, and liver disease. Precision or "personalized" medical diagnoses based on an individual's medical DNA profile may eventually become as common as blood tests, ultrasound, x-rays, and MRIs are today.

Gene therapy is the next step in molecular medicine. If a mutated gene causes a necessary protein to be faulty or missing, gene therapy may be able to introduce a normal copy of the gene to restore the function of the protein.

Put bluntly, genetic engineering tinkers with the stuff of life. Some see scientists as playing God. When a Chinese genetic engineer altered the DNA in human babies, he was so universally and roundly condemned, that even the government of China had to admit a line had been crossed. Many fear that individuals, companies, or governments may use lab-created diseases as "biological weapons" for terrorism or war.

Reconstructing the Past

Genetic engineering also holds the promise of one day being able to resurrect extinct species. This was fancifully portrayed in Michael Crighton's novel and subsequent block-buster movie *Jurassic Park,* in which dinosaur DNA was extracted from dinosaur blood preserved in mosquitoes fossilized in amber. In the movie,

an entire cast of dinos were recreated this way. As blatantly unrealistic as this is, there is an element of truth in the concept. The recent discovery of a well-preserved baby mammoth in the permafrost of Siberia yielded a good sample of the creature's DNA, and scientists speculate that the mammoth could probably be resurrected. Genetic cloning has also proven possible, as demonstrated by Dolly the sheep. Human cloning, as seen in the TV series *Orphan Black,* lies within the realm of possibility.

DNA analysis has also had an impact on the study of prehistory. Using DNA from early human remains, archaeologists have tentatively mapped out the migration patterns of prehistoric *Homo sapiens.* It has also ascertained that early *sapiens* interbred with Neanderthals and Denisovans, two other species of early humans.

As we understand more about DNA and can actually manipulate life itself, it is incumbent upon us to use this knowledge wisely. There will be a temptation to improve the human body through genetic manipulation, beyond simply repairing genetic damage. What would the societal, financial, and medical consequences be if we were able to produce children who are demonstrably smarter, or more athletically or musically gifted, or to significantly extend our lifespan? We need to think carefully about the wisdom of creating a designer strain of "bespoke" human beings.

Personal Computers: Power to the People

Moore's Law: The number of transistors on a chip doubles every 24 months

— Gordon Moore

Transistors: Silicon Valves

Until the mid 1950s, vacuum tubes, or "valves," amplified and controlled the flow of electronic circuits in radios and TVs. They also powered the famous 27-ton ENIAC (Electronic Numerical Integrator and Computer) built with 20,000 tubes, 7,200 crystal diodes, 1,500 relays, 70,000 resistors, 10,000 capacitors, and approximately 5,000,000 hand-soldered joints. The rumour was that whenever it was turned on, lights in Philadelphia dimmed.

As important as vacuum tube technology was, it was soon replaced by the simple, tiny transistor. Its small size — four or five could be clustered on a 25-cent coin — made it ideal for creating electronic components that were smaller, tougher, and ran cooler.

Later, the transistor shrunk further in size until dozens, hundreds, and even thousands could fit onto another new technology, the printed-circuit board. Printed circuits replaced the point-to-point

wiring of earlier electronics, making devices more robust and re-liable. Soon, a broad range of analog electronics — televisions, radios, stereos, and tape decks — went "solid state," meaning they abandoned vacuum tubes in favour of transistors.

Transistors eventually became so miniaturized they could be in-corporated onto CPU (Central Processing Unit) computer chips by the thousands, millions, then billions. In just over 60 years, I have gone from being thrilled by my 3-transistor pocket radio to being relatively blasé about my billion-transistor Macbook Air — as Kurt Vonnegut says, "and so it goes."

The transistor became the foundation of contemporary digital elec-tronics and paved the way to the personal computer revolution.

Electronic Calculators

In the 1970s, the fabulously popular electronic calculator became the first widely used personal computing device. The basic "four banger" calculator, using the newly released 2300-transistor Intel 4004 (4-bit) microchip, could add, subtract, multiply, and divide.

Teachers used them to calculate grades, small contractors used them to estimate job costs, and everyone used them to calculate tax returns. Specialty calculators, with financial functions such as ROI (Return On Investment), became a "must have" in the busi-ness community. Pocket and purse calculators became so common-place, small, and cheap they were used as giveaways. *Macleans* magazine, in Canada, sent them out as gifts to new subscribers.

The "scientific calculator" changed the way scientists and engi-neers solved mathematical problems. In addition to the basic arith-metic functions of the four-banger, these sophisticated calculators included algebraic, trigonometric, and logarithmic functions. They

completely deposed the slide rule as the mathematical instrument of choice. Further, several of these calculators, manufactured by HP (Hewlett-Packard) and TI (Texas Instruments), enabled users to write and store programs, making them the first programmable personal computing devices.

In 1979, at Toronto's Royal Ontario Museum, the science curators held an informal "scientific calculator bake-off," where they demonstrated their problem-solving applications, such as calculating statistics on the measurements of bat skeletons, or determining crystal structures. A mineraologist, Dr. Joseph Mandarino, demonstrated the 250-line TI calculator program that had replaced his previous program that ran on a University of Toronto mainframe.

We had crossed a divide — slide rules and analog technologies on one side, digital devices on the other. Once we crossed the digital divide, there was no going back.

DIY Microcomputers

Although large mainframe computer systems had been around since the 1940s, their use was limited to computer specialists in the military, big business, and universities. The introduction of 8-bit microprocessor chips changed all that.

These 8-bit chips caught the attention of electronics hobbyists. Early experimenters tinkered in basements and garages assembling processors, capacitors, and resistors onto "breadboards," as they built the first primitive but functional "microcomputers." More enterprising entrepreneurs soon developed and sold "digital computer kits" from their homes. Assemble-it-yourself models, such as the Altair 8800, were highly coveted by a growing base of computer enthusiasts. When Harvard students Bill Gates and Paul Allen read about the Altair, in the January 1975 issue of *Popular Electronics,*

they immediately foresaw a new business opportunity. The price of computer hardware was dropping to the point where selling software to run on them could become a profitable venture. With the sale of their BASIC computer language software for use on the Altair, Microsoft Corporation was born.

Kit owners soon formed local computer clubs to demonstrate their new "micros" and software games and applications they had written. As a result of attending a meeting of the Homebrew Computer Club in Menlo Park, California, Steve Wozniac was inspired to design and build the Apple I computer.

Consumer Microcomputers

In the late 1970s and early 80s, ready-to-use 8-bit microcomputers such as the Commodore PET, Radio Shack TRS-80, and Apple II were purchased by a new set of users — "early adopters." They were attracted to the ready-to-go software for word processing, spreadsheet calculations, and database creation.

Marion and I first saw microcomputers in action at a monthly meeting of the Toronto chapter of SLA (Special Libraries Association) in late March 1981. The presenters for the evening demonstrated how they used their computers. One panelist created computer music using a MIDI (Musical Instrument Digital Interface) connection. Another showed a program for tracking bicycle-riding statistics he had written using the BASIC programming language.

The star of the panel was a Toronto lawyer who demonstrated two hot new programs, WordStar, an impressive word processor, and VisiCalc, the first spreadsheet program. But he generated the most excitement when he connected a modem to a telephone line, and accessed two large commercial databases: Nexus for news and Lexus for legal research. Earlier in the day, U.S. President Ronald

Regan had been shot. To our sheer astonishment, he accessed the AP (Associated Press) newswire feed which had up-to-the-minute news about the President's condition. As we left the meeting we looked at each other and said, "We have to get one of those."

We put aside our plans to purchase a VCR for recording television programs and bought a microcomputer instead. A Radio Shack TRS-80 Model III, along with a telephone-coupled 110 bps (bits per second) modem took place of honour in our home office. Although the setup was clunky and limited by modern standards, we were hooked.

Aside from word processing, spreadsheet, and database programs, software wasn't plentiful in the early days. As a result, many early adopters wrote programs in BASIC and assembly language, which they shared with other users via BBSs (Bulletin Board Systems). Toronto had several free dial-up BBSs: *Magic* for Apple, *TPUG* for Commodore PET, *Connection-80* for TRS-80, and *RBBS* for CP/M. These offered games, educational exercises, and computing utilities. In 1981, we set up and ran *InfoPort,* a BBS where library professionals shared ideas and sought help about using microcomputers in libraries. The BBS helped all of us keep up with rapidly changing developments in the microcomputer world.

It was a magical time. Computer clubs quickly formed to support like-minded individuals, who were excited about the technology and eager to learn more. Experienced enthusiasts soon offered free microcomputer orientation sessions at schools, on sidewalks and in shopping malls. They explained how microcomputers worked, demonstrated hardware and software, and answered questions.

As interest in microcomputers grew and more people purchased them, large scale BBS systems appeared. CompuServe, a fee-based, North-American-wide BBS, offered broader and more advanced services to the ever-growing base of computer users, whatever brand they owned. It offered full-featured topical discussion

forums such as, SFLIT (Science Fiction Literature) overseen by Robert J. Sawyer, a Toronto-based science fiction writer and personal computing pioneer, who later won the coveted Nebula and Hugo awards for his writing.

In addition to discussion forums, CompuServe also offered email at a time before Internet mail was widely available. It implemented an email gateway so CS users could connect with Internet mail users. CompuServe was later joined by rivals Prodigy and AOL (America Online). It was AOL's famous spoken alert that became the romantic comedy title, *You've Got Mail,* starring Tom Hanks and Meg Ryan.

Business Microcomputers

Due to the popularity of VisiCalc, WordStar, and dBase II, businesses introduced microcomputers into the office. However, early machines were largely incompatible with one another. Each brand had its own operating system and unique way of storing data. Floppy disks created on one system were unreadable on another system, creating a serious problem for data exchange.

This situation continued until 1983, when IBM released its new 16-bit IBM PC (Personal Computer). It addressed more internal memory than an 8-bit machine, allowing users to create much larger documents and spreadsheets. The PC ran MS-DOS (Microsoft Disk Operating System), which enabled users to run the new Lotus 1-2-3, WordPerfect, and dBase III Plus 16-bit applications. This gave institutions, businesses and individuals the very things they were looking for: powerful office software plus data interchangeability — in other words, *standardization.* The use of IBM PCs soared in office settings, while the less-expensive, earlier 8-bit microcomputers remained popular with home users.

Computer Publications

Amid this maelstrom of microcomputer development and deployment, one thing stood out: the need for more technical and tutorial information. Enter the computer magazines, which, in their heyday, included *Byte, Infoworld, Creative Computing, InfoAge, Computing Canada, The Computer Paper, Compute!, PC Magazine,* and *MacWorld.* The *Toronto Star* newspaper even created a weekly section, *Fast Forward,* devoted to computing. I enjoyed writing reviews, columns, and how-to articles for several of these publications.

A new branch of the publishing industry was also born. Hundreds of massively large books soon appeared on specific software packages, programming languages, and on how to use your computer. Each book had to be revised and updated frequently to keep up with the rapidly changing and evolving microcomputer industry. Between magazines, books, workshops and co-worker support, many people became highly adept at using PCs.

Computer Programming

While off-the-shelf software was readily available for PC users, there were still many who wanted to experience the challenge of writing their own programs. Using the BASIC language that came with their PCs, computer enthusiasts wrote their first program, instructing the computer to display "Hello World!" on the screen. Many elementary students used LOGO, an educational computer language, to create geometric shapes using "turtle graphics." It was a fun introduction to sequential logic which was often followed by the teaching of BASIC.

From a techie perspective, the PC was a brilliant "learning lab" for understanding the inner workings of a PC and for mastering

programming languages. Although BASIC was a good starter language, it was slow and didn't enforce the structured programming needed for complex, sophisticated applications. Programmers switched to PC-based compiled languages like Turbo Pascal, C, and C++.

Programming languages are to a techie what a word processor is to a writer or a spreadsheet is to a businessman — a blank canvas on which to create something unique, useful, and perhaps even elegant.

Obstacles: Vocabulary and Keyboards

Perhaps the most daunting challenge for most new computer users was the technical vocabulary. People who had never operated anything more complex than a microwave oven were now required to understand words and phrases like: *floppy disk, hard disk, operating system, boot, reboot, shutdown, RAM, ROM, peripheral, serial port, printer port, modem, CPU, input, output, dot-matrix, daisy-wheel, monitor, keyboard, mouse, bits, bytes, binary, ASCII,* and occasionally, *crash and burn.* Later came vocabulary like *Zip drives, servers* and *network adapters.* Today's vocabulary would add *USB, stick-disk, Bluetooth, WiFi, Hotspot, IP address, cloud storage,* and many more.

The second most daunting challenge was the keyboard. Non-typists were faced with a dilemma. Interaction with the computer required keying in DOS commands like *dir, cd, mkdir, rmdir, del, copy,* and *attrib.* Some people turned to software like *Mavis Beacon Teaches Typing* while others devised a hunt-and-peck method of their own.

Users who wanted computing to be simpler and easier were about to get a huge break with the development of the GUI (Graphical User Interface).

Graphical User Interface

In 1984, Apple introduced the Macintosh computer in a squat box that featured a stunning black-and-white graphical user interface. Billed as "the computer for the rest of us," it featured drag-and-drop ease of use and it oozed creativity. Software developers fell in love with it and soon developed sophisticated programs such as Adobe Photoshop and Illustrator.

Microsoft, inspired by the Macintosh, created a GUI-based operating system for PCs called Windows. But, compared to the Mac, Windows 1 and 2 looked like hastily built lab experiments. However, with the release of Windows 3, MS-DOS users jumped on the bandwagon and no longer suffered Mac envy. (To the best of our knowledge, no Mac user has ever experienced Windows envy.)

The graphical interface totally changed the way most users worked with their computers. WYSIWYG (What You See Is What You Get) became the new norm. Because the GUI presented a much friendlier interface, people, formerly overwhelmed by the new technology, were now able to hop on board.

The Macintosh galvanized the electronic publishing industry with Aldus Pagemaker and Quark Express, desktop publishing programs used to professionally typeset everything from flyers to full-length books. Windows later caught up and, for some while, DTP (desktop publishing) became a significant cottage industry for freelancers.

Over time, the PC market simultaneously both grew and shrunk. Apple Macintosh and Microsoft Windows PCs became the sole survivors of the personal computing world. Gone were the Altairs, Ataris, Commodores, Osbornes, Kaypros, Sinclairs, and TRS-80s. Even MS-DOS was largely left behind. Artists, designers, and musicians gravitated toward the Mac while business and professional

users gravitated toward Windows. By the late 1980s, computer buyer options were much the same as today: MacOS or Windows. But the computer industry is never static, and in the early 90s, a cheeky new operating system called *Linux* arrived on the scene.

Linux and Open Source

> *The Linux philosophy is 'Laugh in the face of danger'.*
> *Oops. Wrong One. 'Do it yourself'. Yes, that's it!*

— Linus Torvalds

It had been the dream of many computer techies to get Unix, a highly regarded minicomputer operating system, to work on a PC. In 1991, their dreams were partially realized when Linus Torvalds, a computer science student at the University of Helsinki, announced that he had created the kernel ("car engine") of a functional Unix clone. He asked for volunteers to help him test and grow it, and they did. That's the "kernel" of the story.

The rest of the story comes from elsewhere. Another group of individuals, who were also attempting to bring Unix to the PC, formed the FSF (Free Software Foundation). They had already created a rich set of free, Unix-compatible programs called the GNU Utilities (Gnu's Not Unix). They also formulated the GNU GPL (General Public License). This guaranteed programmers the right to run, share, and even modify the source code of GPL'd software.

Torvalds elected to put a GPL license on his kernel, which his assistants named "Linux," in his honour. Paired with the GNU utilities, the Linux operating system was launched into the world. Later, another software project called X11, provided a graphical user interface for Linux. What astonished people was that Linux worked so incredibly well and that everything was free.

This kind of international collaboration on the development of free software came to be known as "open source." Other major open-source projects included: LibreOffice, Apache, PostgreSQL, the Mozilla (Firefox) Internet browser, the Gimp photo editor, the La-TeX typesetting system, and hundreds of other programs. Open source offered a DIY (do it yourself) approach to computing that released users from the continuous expense and licensing restrictions of proprietary software.

Although Linux still runs as a distant third behind Windows and MacOS in terms of desktop and laptop operating systems, it is the number one choice for running Internet web and database servers. Programmers flocked to Linux, which offered nearly every programming language available and a legion of excellent programming editors. For many users, it put the "fun" back into computing.

Although Linux is mainly used by techies, the reality is we all rely on it. Many smartphones run on Android (a Linux derivative). It's also deeply embedded in automobile electronic systems and home appliances. Your new high-tech fridge is likely to be running Linux, and your Internet router, definitely. Microsoft (which once referred to Linux as a "cancer") now embraces it and frequently works on projects with the open source community. In an ironic twist, Microsoft has incorporated Linux into Windows 10, via its new WSL (Windows Subsystem for Linux) feature.

Linux and other open-source projects introduced a new model for software development. It was, and still is, entirely an Internet-based phenomenon and, to many, a breath of fresh air.

Internet and The World Wide Web

I've heard internet addiction is now an official mental disorder and you can go to rehab for it. I'm only going if there's WiFi

— Anonymous

The Internet is the most seismic technological innovation of our era. It has shifted humanity from the Industrial Revolution to the Information Revolution. The "Net," along with its offspring, the World Wide Web, is both a supercharged communications medium and home to countless "virtual" communities. While its future is unknown, its origins are clear.

Inception and Development

The Internet began as a military-funded project. What we now call the Internet started as a quest to connect the mainframes and minicomputers used by a consortium of U.S. military sites, universities and research institutes. It was called ARPANET (Advanced Research Projects Agency Network) and was funded by DARPA (Defense Advanced Research Projects Agency).

ARPANET consortium members sought to adopt a standardized, robust series of technical protocols that everyone could accept and implement. After testing various proposals for reliable connectivity, the project adopted the Ethernet TCP/IP protocol invented at Xerox Parc in Palo Alto, California. This early networking was referred to as "internetting," from which we derive the word *Internet.* Soon a series of additional protocols were adopted to facilitate file transfer and communication over the network.

FTP (File Transfer Protocol) established a reliable method for transferring files, from one computer to another anywhere on the network. SMTP (Simple Mail Transfer Protocol) defined a standardized framework for *email.* Later, IRC (Internet Relay Chat) allowed users to join live "chat room" channels. In 1979, Usenet (Users Network) introduced BBS-style "newsgroups" or discussion forums. Users could post, reply to, and follow forums by subscribing to their "news feeds." Topics ranged from the technical and scientific to sports, culture, and hobbies.

In the mid 1960s, Ted Nelson envisioned a concept he dubbed *hypertext* — a means of enabling readers to jump seamlessly back and forth within and between linked documents. When Apple introduced its Macintosh HyperCard application, Nelson's concept came to life. By pointing and clicking on a word or phrase, Mac users could navigate through HyperCard "stacks" to fluidly access a network of ideas and topics. In 1991, The University of Minnesota developed and pioneered a text-based, menu driven hypertext protocol called *Gopher.* Users could create, distribute, search, and retrieve their research documents — a precursor to today's web pages.

PC and Mac users, who connected to the Internet, were faced with a massive learning curve as they scrambled to use email, FTP, IRC, Usenet newsgroups, and Gopher services. Everything was moving toward an explosive flash point.

In 1989, British scientist Tim Berners-Lee of the CERN Institute, in Switzerland, created the World Wide Web. The WWW, as it is often abbreviated, was originally designed as a means to quickly share research among particle physicists. Key to this development was the implementation of HTTP (HyperText Transfer Protocol) and HTML (HyperText Markup Language) for building websites. Whereas Gopher was limited to static, text documents, the Web, as the WWW was also called, was rich in multimedia documents that included photographs, graphics, audio, and video.

In 1991, Berners-Lee created the first web browser for use by CERN members. It was soon released to the general public, but it only ran on NeXT computers, which few people owned. In 1993, the NCSA (National Center for Supercomputing Applications) at the University of Illinois released "Mosaic", a browser that ran on Unix based systems. Once Mosaic was ported to Microsoft Windows and Macintosh, the World Wide Web was thrown open to ordinary users, with the result that proprietary services like CompuServe, Prodigy, and AOL became obsolete. Mosaic and Netscape Navigator became the "killer apps" of the mid-1990s. The WWW unleashed a torrent of creativity as individuals, as well as organizations, began building their own websites.

Accessing the Web

Up to this point, most of us used our PCs for gaming, word processing, and number crunching. The Web changed all that. It brought information to our fingertips and the world to our PCs. But to access this "Brave New World," we needed to purchase a telephone modem and get an account with an ISP (Internet Service Provider).

ISPs, such as Interlog.com, IO.org, and Bell Sympatico, in Toronto, offered dial-up access which transferred Internet data at speeds up to 56Kb/s (kilobits per second). Initially a modem connected one

person using one PC to the Internet, but soon other family members wanted their own PCs and access to the Net. At the same time, due to the increase in the number of websites, the growing amount of graphical content, and the expanding array of services, web browsing became slower and slower on dial-up modems. To alleviate this problem, cable and telephone providers offered PC users high-speed cable and DSL broadband connectivity, and WiFi routers. With the advent of WiFi wireless connectivity, everyone in the household who had their own computer or, eventually, laptop, tablet, or smartphone, could access the Internet simultaneously at speeds up to 1Gb/s (gigabits per second) and higher.

Searching the Web

The ever-growing, tangled web of information on the Internet quickly overwhelmed even the most enthusiastic user. To help ameliorate this situation, software engineers deployed "bots," automated software robots, that crawled through public websites, collecting data and links, and organized the results into searchable databases.

Search sites, such as Archie, Webcrawler, Lycos, Magellan, Infoseek, Yahoo!, and AltaVista sprang up, offering libraries of links to website content. To find information of interest, users chose either to enter search terms or browse through a broad listing of subjects. While word searches produced more "hits," they also produced more "noise" — poor and often irrelevant results. In 1998, Google was the first search engine to address this issue when it introduced computer algorithms to rank sites in order of probable relevance.

Today's Google and Bing make searching almost effortless. They correct our typos, offer a list of suggested search phrases, and provide amazingly accurate results.

Web Interaction and Creativity

As the web moved from being a passive information portal to an active, creative environment, users posted reviews, comments, and feedback, and engaged in community building, publishing, and education. Our individual and collective imaginations soared.

Communication

Before the Web, email had traditionally been the backbone of Internet communication. It allowed private communication among colleagues, friends, and family. It was an Internet success story from the beginning, quickly replacing "snail mail" (postal mail) for most Internet users.

Email had also been successful for group mailings. This was particularly true of a specialized type of email service called a *listserver* or *mailing list*. These group-oriented services were either broadcast only or interactive. To participate, you signed up using your email account.

Some mailing lists have been active for years. The *OED Online Word of the Day* (*Oxford English Dictionary*) set up for word lovers, broadcasts the "word of the day," with full definitions, pronunciation, etymology, and historical citations. *Maplepost,* which I helped set up for the Canadian folk/roots music industry, allows members to post gig announcements, information on new releases, radio folk-show playlists, and news of interest. Both are still going strong after 20 plus years.

Since the advent of the Web, methods of communication have mushroomed. People can now "talk" to one another using text messaging, private messaging, and audio/video "apps" (software

applications). To save time, computer techies, in frustration, often replied to new users with "RTFM" (Read The ... Manual). Early web users relied on commonly known initialisms such as, LOL (Laugh Out Loud), TTFN (Ta Ta For Now), and BTW (By the Way). Soon texters developed a whole new vocabulary, largely meaningless to those less savvy, including examples such as TL;DR (Too Long; Didn't Read), IDK (I Don't Know), and JK (Just Kidding). To further simplify typing, users often use lowercase only. (Uppercase only is considered gauche.)

If you are so inclined, try to interpret the following: jtm but srsly imho what u oh was tmi. This resource should help: "The Ultimate List of Social Media Acronyms and Abbreviations" (see Futher Reading).

Over time, text messaging expanded to include multimedia content. Along with the inclusion of photos, etc., came "emojis," picture icons of happy faces, sad faces, hearts, and other symbols. They were used to disambiguate nuances of emotional meaning and intent often misconstrued by text alone. But mostly, they were used for fun. The current "fun things" are "Bitmojis," user-created digital cartoon images of ourselves.

The ease and speed of staying in touch by texting has shortened our attention spans and promoted a shift in social etiquette. For those who prefer face-to-face communication, the "heads-down" addiction of texters to their phones, is very disconcerting, particularly at dinner tables and in restaurants.

PM (private messaging) works like a cross between email and text messaging. Anyone using a service, such as Facebook Messenger and Apple Messages, can directly contact another member without knowing their email address without leaving the service. The downside of private messaging is that it doesn't allow users to organize them into categories in the way that email does, but for quick communications its convenience is compelling.

Beyond email and text messaging, new video conferencing services have come to the Web. Businesses, organizations, and individuals can easily participate in meetings, chats, webinars, and family gatherings. Use of services like Zoom, Skype, Facetime, and Messenger Rooms has exploded during the Covid-19 pandemic as employees work from home, and grandchildren "visit" grandparents.

Communities

The Net is brilliant for connecting users with special interests. In your local neighbourhood you may not find anyone interested in distressing furniture, creating digital art, raising an autistic child, or restoring antique cars, but get on the Net and you'll find others who are. With billions of users, it's a given that people with interests similar to your own are "out there" somewhere.

This became evident to me many years ago when I stumbled onto Rangefinderforum.com. Photographers from around the world posted their thoughts and biases about rangefinder film cameras, including every model from low-end Soviet-era FEDs and Kievs to high-end Leicas. Even though I now use digital cameras, I'm still in touch with many of my RFF friends. The Web creates unexpected and long-lasting friendships with people we may never meet in person.

Discussion forums like RFF were an early form of "social media" — Internet sites that encourage and facilitate communications for loosely organized groups of people or "friends." Teenagers, in particular, were the earliest adopters of social media sites like MySpace and Facebook. Adults too have discovered social media and often use it to exchange banter and information with friends and colleagues.

In recent years, corporate-dominated social media sites, such as Facebook and Twitter, have developed into billion-dollar businesses. Politicians, sports figures, and movie stars, have attracted vast followings. Twitter is also used as a source of fast-breaking news. Perhaps the most infamous tweeter was a President of the United States.

Education

Colleges and universities were among the first educational institutions to offer their courses online. Students read or listened to lectures, uploaded assignments, took exams, regularly participated in class discussions, and periodically met with their tutor or instructor all online. Athabasca University (athabascau.ca), Canada's open, online university, offers certified online degrees for both undergraduate and graduate work.

Providers like Coursera, now work with 200+ universities and businesses, offer streaming on-demand video lectures in subjects like business, computer science, data science, language learning, and more. "Anytime, anywhere" education offers remote, self-paced learning enabling those who cannot, or would prefer not, to attend classes in person, to gain a diploma or degree. This past year I audited a credit course in "History of the English Language" at Cape Breton University. Auditing students engaged with full-time students in the weekly online discussions about the assigned readings. The professor frequently cited auditing students' questions or comments during his lectures. It was a convenient way to brush up on one of my favourite subjects and engage with like-minded individuals. Marion participated in a non-credit "DNA Decoded" course offered by McMaster University to further her understanding of genetic genealogy.

Webinars, short for web-based seminars, are presentations, lectures, workshops or seminars transmitted over the web using video

conferencing software. Webinars are interactive, enabling a presenter to give, receive and discuss information in real time. Webinar conferences allow thousands of cyber-attendees to follow the live proceedings from their home or office. Recorded conference sessions are also posted online for a limited time period, allowing those who couldn't view the proceedings in real time to catch up later.

Digital Publishing

The Web democratized publishing. Individuals now had their tools to reach their own audiences.

"Bloggers" used Web logs or "blogs," to post personal essays, poetry, fiction, memories, life stories, and humour. Certain bloggers, who attracted millions of followers, became known as *influencers* as they became celebrated "citizen critics" of movies, TV, fashion, and food. Blogs sparked the exchange of ideas as well as fierce debates.

"Podcasters" used audio broadcasting software to address followers on their views on subjects like writing, personal health and well being, politics, and business trends. As with blogs, there was a podcast for every interest.

"Vloggers" used video sharing software to post short videos on their websites or social media accounts. The advent of YouTube and Vimeo, shifted video watching to public channels. Users with specialized knowledge and skills began to produce tutorials on everything from science, history, math, music and art, to cooking, computer programming, plumbing, or how to prepare and serve a proper English tea. The age of self-directed learning had come into its own.

Instagram, Flickr, and Smugmug, photo hosting services, expanded the concept of "gallery space." Both professional and amateur photographers now posted thousands of their images for viewers to "follow" and comment on. Families no longer made duplicate prints of their images or spent hours assembling photo albums. They now curated their photos online.

The Web has also revolutionized publishing, allowing individuals to share their insights and creativity without going through traditional book, journal, or magazine publishers. CreateSpace, Smashwords, Blurb, SELF-e, and other online services allow writers to self-publish using the Web for sales and distribution. Self-publishing has lost its stigma.

Wiki, a collaborative online publishing system, has sparked the development of "mini" encyclopedias by communities of knowledgeable volunteers. *Wikipedia,* the largest and best known Wiki, is a general encyclopedia so vast and up to date, it essentially ended the era of printed encyclopedias. Even the *Encyclopaedia Britannica* is now only available online.

Web Commerce

As a colleague of mine liked to say, "Did you think the Internet was free?"

E-commerce, or conducting electronic commercial transactions on the Internet, has dramatically shifted the way most businesses operate. Many of our familiar bricks-and-mortar stores have created a web presence. Buyers visit their websites to examine virtual inventories of goods and services, compare prices and place orders which can be picked up or delivered to their homes.

One such business is Amazon, founded by Jeff Bezos in Bellevue, Washington, in 1994. The company initially began as a "virtual" bookstore where buyers could browse and purchase print or

electronic books (ebooks). Amazon's virtual inventory was more exhaustive and extensive than even those of the largest bricks-and-mortar stores. In a smart move, they also created the Kindle, a dedicated ebook reading device loved by many. Building on its success, Amazon soon evolved into an Internet "general store," where you could shop for anything from electronics, software, and video games, to clothing, furniture, toys, and even mustache wax.

The ebook format has also allowed the electronic publication of out-of-print, no longer copyrighted materials. Project Gutenberg (gutenberg.org) offers thousands of these classic and obscure books as free downloads. Traditional publishers have released hundreds of out-of-print titles from their back catalogues.

Electronic publishing has shifted the way many of us purchase and read books and magazines. However, there are those who still prefer the physical experience of holding books, smelling the ink, and flipping the pages. But for those of us addicted to the convenience and ease of electronic publications, public libraries now offer ebooks, audiobooks, and e-magazines. Best of all, these items are automatically "returned," eliminating late-return fines.

With e-commerce comes online advertising — a necessary and lucrative marketing tool for most businesses and services. It is the single-most effective way to target audiences. Advertisers buy information collected on your search and viewing habits as well as the information you provide on your social media profiles, such as your age, sex, location, and interests. As data mining and machine learning techniques have improved, the ads you receive are becoming uncannily appropriate. For example, I had the experience of checking on the price of a camera one day and receiving ads for similar cameras on Facebook the next day.

Companies see this as a form of logical, useful, but benign customer surveillance. Users increasingly think otherwise. The EU

(European Union) has identified some data mining practices as being in violation of user privacy and has introduced stricter data protection and online privacy laws. North America has yet to address these issues with legislation.

In truth, if you use the Web, you are being tracked. Loss of some privacy appears to be the cost of free online access.

Cloud Storage

Nothing is more devastating to computer users than a hard-disk crash that wipes out all their data. For this reason, savvy users regularly back up their work to a separate hard disk. But even that does not protect your information from flood, fire, theft, or disk failure. To alleviate the data loss problem, the Internet industry has made it easy for users to back up their information to the "Cloud."

The term "cloud" is misleading. It sounds like an ethereal Internet "service in the sky" that magically lets you store and retrieve your information as needed. In reality, the "cloud" is simply offsite computer storage on someone else's hard disks. Cloud computing has become feasible through a combination of extremely large hard disk capacity and Internet broadband connectivity.

Services such as iCloud, Dropbox, and Google Drive make cloud storage particularly attractive because they employ the best IT management practices — redundant disk arrays, hardened physical plant facilities with emergency backup power, intrusion detection safeguards, strong firewalls, and a vigilant 24/7 dedicated staff. When you consider the professional expertise behind the scenes, cloud computing offers file storage management that most users couldn't easily replicate in their homes.

Internet: The Good, The Bad, and The Ugly

We are all now connected by the internet, like neurons in a giant brain

— Stephen Hawking

The Good

The Internet has revolutionized almost every aspect of our lives. We use email, messaging, and video conferencing and other social media for business and personal communications. A Google or Bing search can find a needle in the haystack of web information. GPS systems have largely replaced printed maps. Realtime services like Waze provide up-to-the-minute details on traffic flow, alternative routes, the current weather, and where to find carpools.

Nearly every place of business has a website, if only to provide their location, hours, and contact information. Online shopping has replaced the old Sears and Canadian Tire catalogues. Online delivery services, like Uber Eats or GrubHub, will pick up and deliver dinner from your favourite restaurants. Grocery stores offer online shopping and home delivery. Shopping isn't what it used to be.

The Bad

Call it the "oh-no second." You know — the interval between clicking the Send button on a private e-mail and realizing you just cc'd the entire universe

— Dan Tyan

Leaked private messages, photos, and videos can go viral in the blink of an eye, removing your "public" mask. Family, friends, and colleagues may suddenly become aware of a "different" you. Potential employers can also check beyond your "resume self" to see your "Internet self," revealed by binge-drinking photos, rants, and off-colour or politically-incorrect humour. Humiliating yourself and others is now easier than ever before.

In addition to the mostly minor embarrassments of ordinary individuals, the Net is rife with the scandals of the rich and famous. The mistakes, cheating, lies, and deceptions of well-known figures in all walks of life are frequently exposed by reputable journalists and genuinely concerned citizens, as well as by yellow journalists, scandal mongers, and political enemies. This often results in someone being fired, sued, or mortally embarrassed.

Most of the Internet and World Wide Web has been created by people wearing white hats — the "good guys" — but, as the story of Eden suggests, there's a serpent in the garden. The black hats, or "bad guys," have infiltrated the Net, creating an underworld of questionable and illegal activity.

Scams are now prevalent on the Web. Most Internet users are familiar with email "phishing" scams which attempt to lure you to open a "fake" website that contains a trap. While you are reading the site, the site is reading you. The quality of phishing has improved to the point that fake sites can appear to be a genuine site. For example, if you live in Canada, you may receive an email, apparently from the CRA (Canada Revenue Agency). When you click on the link in the message, you are connected to a perfectly reconstructed version of the real site, which states that you owe money and provides instructions for immediate payment. The money does not go to the government.

Whether you are aware of it or not, you are part of one or more "information bubbles." These bubbles are inadvertently created by

computer algorithms that track your "likes" and browsing history. Based on the data collected, you are presented with interesting-sounding news and postings. Before long you end up "bubbled." If your political leanings are to the left, you see mostly liberal content. If your leanings are to the right, you see mainly conservative material. In both cases, you end up living in a virtual gated information community. The bias is subtle and not recognized by most users.

These bubbles set the stage for exploitation. It's possible for unscrupulous individuals, or nations, to create phony accounts that can flood a particular bubble with disinformation and deceit — "fake news." The irony is that in an attempt to provide a customized user experience, the resultant bubbles make us vulnerable, as the 2016 U.S. presidential election powerfully demonstrated.

"Hackers" create malware — software designed to break into a computer system to collect personal information or destroy files. "Spam bots," a type of malware, are sometimes inserted into web-connected home appliances such as computers, printers, routers, refrigerators and doorbells, from whence they send out unsolicited email and phishing attacks. "Ransomware," a specific type of malware, disables a system, then asks for a ransom to be paid in e-currency to restore the system to normal. At the time of this writing, a major South African public utility was disabled by ransomware, and it has happened elsewhere.

All this has led to the development of antivirus and intruder detection software. Major browsers like Chrome and Firefox give you the choice to opt-in only for cookies on trusted websites or to prevent tracking by all sites. Specialty web browsers, such as DuckDuckGo and Brave, automatically turn off all tracking and wipe out any cookies left in your computer. There is no easy way to stay on top of web surveillance activities, but it's a good bet there is little about you that someone can't find. The bottom line is that you shouldn't put any information about yourself on the Web

that you don't want to be shared widely. If you don't want your life to be an open book, discretion is the watchword.

Like driving a car safely, we must educate ourselves on how to use the Internet carefully, developing strategies to avoid the dangers.

The Ugly

> *Beyond the confines of most people's online lives, there is a vast other internet out there*
>
> — Andy Becket

There exists an invisible underbelly to the Web known as the "dark web," a seedy, online alt-web that is only accessible through specialized software. It is the place of child pornography, the sale of illicit drugs, firearms, and stolen credit card numbers, and the recruitment of hit men and terrorists. These are Internet neighbourhoods you wouldn't want to drive through, much less visit.

Like life, the Internet and the Web follows the 80/20 rule. The 80% good is marred by the 20% bad or ugly.

Internet Everywhere

> *The Internet is the first thing that humanity has built that humanity doesn't understand, the largest experiment in anarchy that we have ever had*
>
> — Eric Schmidt

What began as a consortium of "internetted" research facilities and, later, a method of communication among particle physicists at

CERN, has transformed into the Internet and World Wide Web as we know it today. It has expanded our understanding of communities, our opportunities for learning, and our ability to communicate.

The greatest joy of the web lies in its intellectual and entertainment content. Smartphones bring that content to our fingertips wherever we go. The Internet is like an appendage to our minds. Many of us would be at a distinct loss without it, even if we don't fully understand it.

Into the Future

> *It's tough to make predictions, especially about the future*
>
> — Yogi Berra

Artificial Intelligence

AI (Artificial Intelligence) is the current "big thing" in computing — even though some programmers are adamant that AI doesn't really exist. It's a disputed term and some prefer the simpler term "machine learning." Nonetheless, "AI" is widely used in the industry to describe a number of types of computer systems, and we'll follow industry usage, gingerly.

AI is a branch of computer programming used in such diverse applications as data mining, facial recognition, machine learning, language translation, and real-time decision-making systems, like industrial robotics and self-driving automobiles. AI is essentially a sophisticated sequence of computer algorithms, or instructions, that can learn from data and then use that learning in problem solving.

AI attracts headlines partly because it is exciting, leading-edge technology, and partly because it's spooky and not well understood

by the general public. Our gut feelings about AI tend toward the spooky because we've been conditioned by generations of science fiction films in which computers or robots become prescient and take over, like "HAL 9000" in the movie *2001: A Space Odyssey*. Added to this are a number of tech industry insiders, such as Elon Musk and Bill Gates, who have warned us about the dangers of AI and the future of mankind. It's enough to give anyone AI anxiety.

And yet, when we see AI at work, it seems relatively benign. The AI software in our automobiles is revolutionary and welcome. Cars now have convenience factors such as fob detection and automatic windshield wipers. More important are safety factors such as proximity detection, pre-emptive braking, and lane-drift alerts.

The fruits of AI research are already well established. OCR (Optical Character Recognition), used for transcribing and digitizing print, is a form of AI we now take for granted. Our use of voice recognition via Siri or Alexa has become commonplace and is improving constantly. Voice dictation, or speech to digital text, is amazingly accurate. Gmail regularly anticipates what I'm about to write, and offers suggestions that are uncannily useful.

AI algorithms are used for spam filtering, search engine querying, image recognition, weather prediction, and real-time computer translations from one language to another. Algorithms for image recognition have improved to the point where Facebook can often recognize friends in your photos.

On a professional level, AI is assisting medical researchers in their search for new treatments for diseases. Combined with DNA analysis, AI is also helping historians in the enormously challenging job of assembling and translating the Dead Sea Scrolls. AI has improved the accuracy of weather predictions [believe it or not] and in analyzing and correlating climate change data from around the globe. It is also used to track and model the spread and impact of

the Covid-19 virus. In lab after lab, some form of AI is being used in research.

The most common AI algorithms are probability engines that calculate the odds of something being true or not. Netflix provides a simple example. As you begin rating shows you've watched, an algorithm learns your preferences. By comparing yours with those of others, Netflix identifies and ranks new shows you might enjoy. Using similar AI algorithms, Amazon identifies items you might want to purchase and Spotify suggests music you might like to hear.

AI Anxiety

Despite its benefits, AI makes many people edgy. For instance, the use of video surveillance and security cameras on streets and in shops is increasing. Facial recognition is routinely used by police and intelligence agencies to identify individuals. The government of China uses highly sophisticated facial recognition systems for everything from preventing toilet paper theft from public washrooms to identifying participants in political protests. Recently, demonstrators in Hong Kong added foil and other attachments to their faces to prevent being identified by AI algorithms. While we're not quite at a "Big Brother" state, things are leaning in that direction.

Elsewhere, the use of AI robotics in manufacturing has significantly impacted many economies. While it has reduced production costs, it has simultaneously eliminated millions of blue-collar jobs. Even some white collar jobs are becoming redundant. Microsoft recently cancelled its contracts with freelance writers, replacing them with AI software.

One of the things AI is especially good at is data mining, and for this purpose, various companies and even governments want your

data. This could lead to an extensive loss of privacy for individuals, with no guarantee how the data might be used. On the other hand, it could help planners understand their constituencies better, and it could conceivably provide police forces with useful data for solving crimes. It's not inconceivable that AI could be added to the already extensive camera surveillance in the streets to identify suspicious activity in real time and immediately alert authorities. Such measures might make cities safer, but there is also the potential for creating a police state in which governments exert strong control over their citizens.

One burning question remains: could AI algorithms become self aware? At this point, it's speculation, and even if AI ever did become prescient, there's nothing to suggest it would be malevolent. Instead, it's just as likely that it could become an intimate servant and protector — a kind of digital "Jeeves" tuned to your individual needs.

Quantum: Qubits For Sale Or Rent

Quantum machines promise to outstrip even the most capable of today's, and tomorrow's, supercomputers

— Martin Giles

Quantum computing uses certain phenomena from quantum mechanics, such as "superimposition" and "entanglement," to perform operations on data. To say the least, it's a specialized field and non-intuitive to people outside the discipline.

Even the way quantum computing stores data is different from traditional computing storage methods. Whereas the basic unit of classical computing is the binary digit, or *bit,* represented by 1 or 0, the basic unit of quantum computing is the quantum bit, or

qubit. A qubit's state can be 1 or 0, or both simultaneously. Quantum computing can perform certain types of calculations far more quickly than classical computing, especially in the area of encrypting and decrypting data. It can crack many encryption schemes in milliseconds. Alan Turning would have loved it at Bletchley Park.

Quantum computing is a field rich in experimentation and speculation, but meager in the delivery of practical applications — so far. Nevertheless, research continues, and there is a general consensus among quantum computing researchers that it will, at some point, be transformative.

What is interesting about quantum computing from a layperson's point of view is that it's a technology being born in plain view. IBM, a major player in the development of quantum computing, is making successive releases of its quantum computers available to its customers. Microsoft and Google are engaged in similar research. When this reaches maturity, there will initially be a shortage of qualified programmers. Quantum computing could make a brilliant choice for a STEM student contemplating a promising career working with the computational aspects of "quantum entanglement," "coherence," and "decoherence."

Gaming: Living on the Edge

> *To make an embarrassing admission, I like video games.*
> *That's what got me into software engineering when I*
> *was a kid. I wanted to make money so I could buy a*
> *better computer to play better video games*
>
> — Elon Musk

When we, the authors, were growing up in the 1950s and 60s, board games were highly popular: *Clue, Monopoly,* and *Uncle*

Wiggily, as well as traditional board games like parcheesi, checkers and chess, or card games like poker, euchre, or solitaire. Video games had not yet been envisioned.

In contrast, our son, who was born in the 1980s, grew up on Nintendo, Sega, and computer games like *Zork, King's Quest, Dark Castle, Commander Keen, Myst, Doom, Quake, Wolfenstein 3D,* and subsequent PC and Mac games. In our home, we had a series of gaming consoles. He started with the Nintendo NES featuring Mario, Luigi, and Princess collecting gold coins amid bouncy music and catchy sound effects. Later came a Microsoft Xbox and a Sony Playstation, followed even later by streaming game services such as Steam.

At one time, just a few short years ago, PC gamers hauled their bulky desktop computers to the back rooms of gaming stores where LAN (local area network) parties were held. Gamers plugged into the network via an Ethernet cable and played against each other. Today they, and millions of others, play games across the Internet. Unless you're a gamer, you might not be aware that today's gaming industry rivals Hollywood in terms of gross profits. According to data released by the Entertainment Software Association, the U.S. video gaming industry generated a record $43.4 billion in revenue in 2018, up 18 percent from 2017.

Gaming hardware and software live at the bleeding edge of computer technology. Gaming engines, the software that drives the games, are chock full of AI, underlying everything from the trajectory of objects in real time, like firearms, missiles, and automobiles, to creating realistic scenes in which wind blows through animated leaves on trees. When a new technology comes along, like VR (Virtual Reality) goggles, it quickly finds a home in computer games where it enhances 3D realism. Hence, games are voracious devourers of computer memory, CPU and graphics processor cycles, and Internet bandwidth. They also demand the highest resolution that monitors can deliver. The mantra "better … faster

. . . cheaper," used to describe the computer industry in general, applies especially to gaming.

For the vast gaming community, fast computing hardware combined with AI and elaborate stories and characters, has forever changed the concept of what gaming is and can be. At some point gaming may even tap the potential of quantum computing. There has been a complete shift from the board games of our youth to today's sophisticated computer games.

Augmented Reality

> *I think that a significant portion of the population of developed countries, and eventually all countries, will have AR experiences every day, almost like eating three meals a day. It will become that much a part of you*
>
> — Tim Cook

AR (Augmented Reality) already exists and is poised to become a major technological assistant when it matures. AR is a method of superimposing computer information onto reality itself. For instance, some building inspectors use AR glasses to check on the location of wiring, plumbing, and ducts that are behind walls and in ceilings. Similarly, some archaeologists are using AR devices to view reconstructed levels of the original site to aid in placing finds in their proper context.

In everyday use, AR glasses can scan faces as you walk down the street and, using facial recognition, display the names of the people they recognize. Perfect for when you greet a long-lost acquaintance or neighbour who lives down the street, and can't quite recall their name. At the same time, your smart glasses can take still pictures or videos of what you're looking at, storing the images or videos on your smartphone.

Let's take a not-so-imaginary future scenario: you're a North American, and you've planned a vacation in Europe. Just before you leave, you download the latest "European Tour" package for your wearable smart glasses, which contain either clear or prescription lenses. The glasses work in conjunction with information stored on your smartphone.

Once in Rome, when you look at the Coliseum, you blink your eyes twice and, in addition to seeing the structure you are looking at, you also see the site reconstructed in its original glory. Blink three times, or give a voice command to Alexa or Siri to listen to a narrated history of the Coliseum. Your smart glasses will have become your personal tour guide.

And that's just the start. They can provide you with up-to-date floor plans of museums, such as the Louvre, guide you to the art you most want to see, and then help you find a café afterward where you can rest your tired feet and enjoy an espresso and croissant. They can also help you find a place to stay that meets your designated criteria for price and location.

Although this may sound futuristic, it's far from being science fiction. These tools already exist in one form or another and, in fact, Google offered glasses of this sort called Google Glass, a product discontinued in 2013 due to lack of sales. They were relatively expensive and people found them a little unnerving and intrusive. Nonetheless, in 2019, Google introduced a sleeker and improved second generation of Google Glass aimed at its business customers. Other vendors are also testing AR glasses prototypes.

Needless to say, there are privacy issues to be resolved and it may take awhile for AR to reach the level of sophistication posited in the travel scenario. However, if there's one thing we've learned about technological change, it's never wise to underestimate it. Who'd have believed, even forty years ago, that people would one day be carrying a compact, sophisticated personal computer — a

smartphone — in their pockets and purses. The computer revolution continues unabated and we can expect more of the unexpected. As Alan Turing once said, "Machines take me by surprise with great frequency."

Afterword: Covid-19 Pandemic

The threat from piranhas and quicksand may have been exaggerated when we were kids, but we really underestimated cooties

— Internet Meme

Societies around the world ground to a halt early in 2020 due to a pandemic caused by a mutated coronavirus strain, SARS-CoV-2 or Covid-19. It appears to have first broken out in the city of Wuhan, China. It came at a bad time of year as travellers within and beyond China arrived to celebrate the Chinese New Year. The virus spread rapidly within Wuhan infecting individuals of all ages with respiratory disease. Hospitals were overwhelmed and the city went into lockdown as death rates soared, especially among the elderly.

The WHO (World Health Organization) alarmed by how quickly the virus spread, tracked its progress around the world and urged nations to try to contain it. This did not happen. Because the threat was initially dismissed or downplayed, the virus soon reached pandemic status. Travellers flying between countries spread the virus rapidly from country to country. In addition to China, the virus hit hard in Italy, Spain, Iran, and the UK. The U.S., due to its slow and uncoordinated response, had the worst infection and death rate

of all countries. Around the world, borders were closed, trade dropped off, and supplies ran short as panicked individuals bought out all the toilet paper and disinfectants available on store shelves. Even bread-baking yeast disappeared. Worse yet, medical facilities quickly ran desperately short of PPE (personal protection equipment) and ventilators.

Lockdowns were declared. Schools were closed, professional sports suspended, and concerts cancelled. Most non-essential businesses, such as restaurants, gyms, and hair salons closed. Businesses that remained open, encouraged employees to work from home, using the Internet. Stock markets fell and governments scrambled to provide financial aid for the unemployed. Voluntary self isolation was called for, and gatherings of more than five people were banned. Grocery store pickup and home delivery services were swamped and the number of shoppers inside stores was metered. Social distancing became the norm. Frontline medical workers and hospitals were overwhelmed with critically ill patients and many medical personnel themselves caught the contagion, sometimes with fatal consequences.

We were putting the finishing touches on the manuscript of this book during the Covid-19 pandemic and, at the time of writing, are still in the midst of it. As might be expected, we have been fascinated by the ways technology has been involved in one of the most unusual events of our lifetime. Several things stand out.

Transportation Infrastructure

In the course of this book we have frequently touched on the infrastructure that builds up around technological innovations. The Covid-19 crisis demonstrated the vital importance of these infrastructures. Roads and highways, for example, are essential to our supply chain for food and material goods. We may shop via the

Internet, but delivery usually involves a vehicle. Although individuals have been driving less, supply trucks and delivery vans have continued to bring us the necessities of life

We know that the large amount of air pollution produced by the internal combustion engines in cars and other vehicles, has been a significant contributor to climate change. When people in large numbers stopped driving to and from work and back, the skies cleared and the air smelled fresh. It underscored how urgent it is for the automobile industry to segue to electric motors to cut down on the use of fossil fuels. This will be one of the great shifts in automotive technology when it reaches widespread acceptance.

Communication Technologies

We are lucky that the Internet infrastructure was in place. If the coronavirus had struck even 15 years earlier, work and study from home would have been impossible for the majority of people who may not have even owned a computer. Access to current information on the crisis would have been limited. Today the internet is our lifeline to information. It's where we've found the latest information on the virus, its spread, and how to protect ourselves and our families during the pandemic. Millions of us learned the proper way to wash our hands as well as many ingenious ways to disinfect mail, shipping cartons, door handles, and food. Dormant sewing machines were brought out of storage and were soon busy making homemade masks.

Families and friends used voice, text, private messages, email, and video to check on each other and be "together." It's been a time of creativity on the web. Performing artists, whose gigs were cancelled, streamed live "concerts" for fans to enjoy. Actors, like Patrick Stewart of *Star Trek* fame, posted readings of poetry and

fiction. Friends used services like Zoom and Skype to schedule virtual coffee klatches.

Streaming services like Netflix, Amazon Prime, and BritBox experienced so much usage, they reduced video quality to save bandwidth, so the Internet wouldn't become overloaded by stay-at-home viewers.

Work-at-home arrangements ramped up significantly and introduced many employers and employees to the concept for the first time. It remains to be seen if working from remote will become more common in the post-pandemic period.

With schools being closed, teachers and professors of necessity have learned how to deliver education via the Internet. Online courses have surged in numbers and online learning will undoubtedly figure large in future educational planning and delivery.

In addition to learning to communicate through a mask, Canadian shoppers using pickup services to their cars are tapping their credit cards on scanners attached to the end of hockey sticks to ensure that the employee is maintaining the requisite six-feet of distance from the driver.

Internet Misinformation

The Internet's dark side became apparent during the Covid crisis. Conspiracy theorists quickly circulated inaccurate stories about the origin of the virus itself. One of the favourites was that the virus was created in a microbiology lab in Wuhan, China, despite DNA evidence that suggests the virus evolved naturally in bats. Another widespread theory is that the virus was caused by 5G Internet technology, a theory with no credibility but widespread belief.

Various snake-oil salesmen pitched their unproven cures and protections on the Net. Sadly, even a U.S. President promoted an unproven panacea in the form of an antimalarial drug.

Denial of the invisible threat was the first reaction of many officials, who, at the start, suggested that there was nothing to worry about and encouraged life to go on as normal. In a phenomenon unique to the United States, far right-wing extremists denied the potency of the virus and tried to convince their followers that the horrors of emergency wards in New York City were "fake news." This misinformation compounded the difficulty for U.S. health officials to educate citizens and shift behaviour. They are still fighting the battle as many demand the removal of lockdown and a return to business as "normal."

Personal Health Technologies

Between lockdown and social distancing, Covid stress is impacting our physical and mental health. Devices such as smart watches can help maintain and improve our health. They can monitor vital signs such as blood pressure, heart rate, and sleep quality in real time. When used while walking or running they can log your distance and count your steps. More importantly, for seniors, some have a "fall detection" feature that is programmed to activate if the watch senses the wearer has had a possible fall. The watch asks if you're okay and, depending on your reply, dials for help. In an emergency it can provide GPS information on your location.

Contact Tracing

Contact tracing is the process used to alert individuals that they have been in close contact with someone who has tested positive

for the virus. Health officials then notify these people that they are at risk and may need to be tested or even quarantined. It has been suggested that smartphone technology could assist with this onerous task. Apple and Google have worked together and are prepared to put contact tracing software directly into their operating systems during the duration of the Covid-19 crisis, if and when governments request this. Privacy issues are being addressed by anonymizing the data. This contact tracing scheme has been designed as a secondary safety net to supplement widespread medical testing for the virus.

Face masks

The populations in countries such as Hong Kong, Singapore, and South Korea, hard hit by the 2003 SARS epidemic, already had a culture of wearing face masks, even to prevent the spread of colds. The rest of the world was caught flat-footed. With a worldwide shortage of N95 (hospital strength) masks, manufacturers like 3M Corporation have ramped up production to meet the demand from front line workers in medical, fire, and police departments. Once health officials began recommending that citizens wear masks, dozens of articles on how to make them appeared on the Web.

DNA Technology to the Rescue

The authors, themselves confined to their home, will conclude with an obvious prediction: the world will return, if not to "normal," at least to "functional." DNA analysis has ascertained that the novel coronavirus is somewhat slow to mutate. The only safe way out of the crisis, with minimal loss of life, is through the development of a vaccine. Eventually there may be annual Covid vaccinations, similar to annual flu vaccinations.

Final Thoughts

One cannot help but see this as one of history's great dividing lines: *before* Covid-19, and *after.* Our hearts go out to all who have lost loved ones to the virus and our admiration goes out to all of those who provided essential services during the crisis, often at risk to themselves — they are unheralded heroes of our time.

About the Authors

Gene Wilburn is a Canadian writer and photographer with a life-long love of science and technology. A retired IT professional, he worked for many years as IT Manager at the Royal Ontario Museum in Toronto. He has contributed articles to a wide range of computing publications. An amateur folksinger, he wrote the book *Northern Journey: A Guide to Canadian Folk Music on CD* in 1995. His other books include *Recreational Writing* (2011) and *Markdown for Writers* (2013). Gene maintains a website at *genewilburn.com*.

Marion Turner Wilburn is a retired Canadian educator. While a Professor at the School of Computing and Information Management, Sheridan College, Ontario, she pioneered the use of computers in education by leading the development of Sheridan's first web presence and developing and delivering the first online distance education course. Her publications include several articles and course workbooks. With a life-long passion for family and social history, Marion is deeply involved in traditional and genetic genealogy research. Marion maintains a website at *marionwilburn.com*.

Acknowledgements

We would like to thank Nancy Bueler, Mark Dornfeld, and Luba Lesychyn, our first readers, for providing insightful commentary on the substance and style of our manuscript. Their feedback was helpful in identifying omissions and errors, and helping us present a clear and readable narrative. Thanks also to Junior Teixeira, Brazilian photographer, for his generosity in allowing us to use his photo for our cover.

We give special thanks to the pioneers who envisioned and created the Internet and the World Wide Web.

A huge thanks to the volunteer contributors to *Wikipedia,* an invaluable resource for fact checking and insights on the new technologies.

Production Notes: This book was written using an iPad, Macbook, Chromebook, and Linux laptop. The manuscript was created using Markdown plain-text notation in a text editor and the book was produced with open-source tools. The print edition was produced with the LaTeX typesetting system using LyX. The ebook version was produced with Sigil. Text conversions from Markdown to TeX and Markdown to HTML were handled by Pandoc. Zotero was used to collect and format bibliographic entries. Bash and Vim were used to prepare the production scripts.

Further Reading

"5G." 2019. In *Wikipedia*. https://en.wikipedia.org/w/index.php?title=5G&oldid=911766429.

"7-Inch Single (1949 –)." 2014. Museum of Obsolete Media. April 27, 2014. https://obsoletemedia.org/7-inch-single/.

"101 Social Media Acronyms and Abbreviations for Marketers." 2019. Hootsuite Social Media Management. April 24, 2019. https://blog.hootsuite.com/social-media-acronyms-marketers-know/.

"2019–20 Coronavirus Pandemic." 2020. In *Wikipedia*. https://en.wikipedia.org/w/index.php?title=2019%E2%80%9320_coronavirus_pandemic&oldid=948661941.

"A Short History of the Web | CERN." n.d. https://home.cern/science/computing/birth-web/short-history-web.

"AI Uncovers a Potential Treatment for Covid-19 Patients | WIRED." n.d. https://bit.ly/3eYYFFw.

115

"Alexander Graham Bell." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Alexander_Graham_Bell&oldid=913514448.`

"Altair 8800." 2020. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Altair_8800&oldid=959036571.`

"Altair BASIC." 2020. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Altair_BASIC&oldid=936077644.`

"Anti-Nuclear Protests." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Anti-nuclear_protests&oldid=907747826.`

"ARPANET." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=ARPANET&oldid=914146135.`

"Artificial Intelligence." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Artificial_intelligence&oldid=915532409.`

"Athabasca University." n.d. Home, Athabasca University. `https://www.athabascau.ca/.`

"Atomic Bombings of Hiroshima and Nagasaki." n.d. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Atomic_bombings_of_Hiroshima_and_Nagasaki&oldid=911453793.`

"Augmented Reality." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Augmented_reality&oldid=916692661.`

"Automobile | The Canadian Encyclopedia." n.d. `https://www.thecanadianencyclopedia.ca/en/article/automobile`.

"Benefits & Risks of Artificial Intelligence." n.d. Future of Life Institute. `https://futureoflife.org/background/benefits-risks-of-artificial-intelligence/`.

"Black Swan: The Impact of the Highly Improbable." 2020. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=The_Black_Swan:_The_Impact_of_the_Highly_Improbable&oldid=945271313`.

"Black Swan Theory." 2020. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Black_swan_theory&oldid=948277449`.

Blum, Sam. 2019. "Why The Concorde Is Such a Badass Plane." Popular Mechanics. April 22, 2019. `https://www.popularmechanics.com/flight/airlines/a27206102/concorde-badass-plane/`.

Bowler, Peter J. 2019. "H. G. Wells and the Uncertainties of Progress." The Public Domain Review. June 27, 2019. `https://bit.ly/32Q4xdF`.

Brahic, Catherine. n.d. "Traces of Mystery Ancient Humans Found Lurking in Our Genomes." New Scientist. Accessed June 8, 2020. `https://bit.ly/3d0cS2L`.

"Brief History of the Internet." n.d. *Internet Society* (blog). Accessed August 12, 2019. `https://www.internetsociety.org/internet/history-internet/brief-history-internet/`.

"C Programming Language, The." 2020. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?`

title=The_C_Programming_Language&
oldid=949821828.

"Calculator." 2019. In *Wikipedia*. `https://en.wikipedia.`
`org/w/index.php?title=Calculator&`
`oldid=915323838.`

"CANDU: A Canadian Success Story." 2016. Text. Canadian
Geographic. June 1, 2016. `https://www.`
`canadiangeographic.ca/article/`
`candu-canadian-success-story.`

Castells, Manuel. n.d. "Impact of the Internet on Society: A
Global Perspective." MIT Technology Review. Accessed
September 10, 2019. `https://bit.ly/369qqqj.`

"CBME-FM | History of Canadian Broadcasting." n.d.
`https://www.broadcasting-history.ca/`
`listing_and_histories/radio/cbme-fm.`

"CFS Carp." 2019. In *Wikipedia*. `https://en.wikipedia.`
`org/w/index.php?title=CFS_Carp&`
`oldid=900147967.`

"Citizens Band Radio." 2019. In *Wikipedia*. `https://en.`
`wikipedia.org/w/index.php?title=Citizens_`
`band_radio&oldid=907724745.`

"Civil Rights Movement." 2019. In *Wikipedia*. `https://en.`
`wikipedia.org/w/index.php?title=Civil_`
`rights_movement&oldid=913145008.`

"Civilization.ca - Watching TV - Television in Canada, the Early
Years." n.d. Accessed July 25, 2019. `https://www.`
`historymuseum.ca/cmc/exhibitions/hist/tv/`
`tv03eng.html.`

"Colossus: The Forbin Project." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Colossus:_The_Forbin_Project&oldid=908232800`.

"Communications Satellite." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Communications_satellite&oldid=908215700`.

"Compact Disc." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Compact_disc&oldid=905241290`.

"Coronavirus Disease 2019." 2020. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Coronavirus_disease_2019&oldid=948700117`.

"CRISPR." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=CRISPR&oldid=917567553`.

"CRISPR Gene Editing." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=CRISPR_gene_editing&oldid=915518696`.

"Dark Web." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Dark_web&oldid=915560535`.

"DARPA." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=DARPA&oldid=914151782`.

"Digital Revolution." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Digital_Revolution&oldid=913057050`.

"Distance Education." 2019. In *Wikipedia*. `https://en.` `wikipedia.org/w/index.php?title=Distance_` `education&oldid=916356417.`

"DNA." 2019. In *Simple English Wikipedia, the Free Encyclopedia*. `https://simple.wikipedia.org/w/` `index.php?title=DNA&oldid=6577787.`

"Don Messer | The Canadian Encyclopedia." n.d. Accessed October 2, 2019. `https://www.` `thecanadianencyclopedia.ca/en/article/` `don-messer-and-his-islanders.`

"Dot-Com Bubble." 2019. In *Wikipedia*. `https://en.` `wikipedia.org/w/index.php?title=Dot-com_` `bubble&oldid=909118036.`

"Electric Power | The Canadian Encyclopedia." n.d. Accessed July 25, 2019. `https://www.` `thecanadianencyclopedia.ca/en/article/` `electric-power.`

"ENIAC." 2020. In *Wikipedia*. `https://en.wikipedia.` `org/w/index.php?title=ENIAC&oldid=956244154.`

"Etymology of *Ham Radio*." 2020. In *Wikipedia*. `https://en.` `wikipedia.org/w/index.php?title=Etymology_` `of_ham_radio&oldid=937526628.`

"Facebook." 2019. In *Wikipedia*. `https://en.wikipedia.` `org/w/index.php?title=Facebook&` `oldid=916262797.`

"Family Radio Service." 2019. In *Wikipedia*. `https://en.` `wikipedia.org/w/index.php?title=Family_` `Radio_Service&oldid=904574777.`

"FM Broadcasting in Canada." 2016. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=FM_broadcasting_in_Canada&oldid=707567068`.

"FM Broadcasting in the United States." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=FM_broadcasting_in_the_United_States&oldid=903736714`.

"Free Software Foundation." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Free_Software_Foundation&oldid=904081480`.

"Generations of Mobile Networks: Explained." 2018. Just Ask Gemalto US. August 2, 2018. `https://www.justaskgemalto.com/us/generations-mobile-networks-explained/`.

"Global Positioning System." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Global_Positioning_System&oldid=908307695`.

"GNU General Public License." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=GNU_General_Public_License&oldid=920538874`.

"Gopher (Protocol)." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Gopher_(protocol)&oldid=914552749`.

Government of Canada, Canadian Space Agency. 2006. "Canadarm." Canadian Space Agency Website. November 8, 2006. `http://www.asc-csa.gc.ca/eng/canadarm/default.asp`.

Haire, Meaghan. 2009. "A Brief History of The Walkman." *Time*, January 7, 2009. `http://content.time.com/time/nation/article/0,8599,1907884,00.html`.

"Happy 70th Birthday, TV – Variety." n.d. Accessed July 25, 2019. `https://variety.com/2011/tv/news/ happy-70th-birthday-tv-1118039380/.`

Helmstetter, Michael. n.d. "Promise And Fear Of Gene Editing, The." Forbes. Accessed June 7, 2020. `https://www.forbes. com/sites/michaelhelmstetter/2020/03/30/ the-promise-and-fear-of-gene-editing/.`

"History of Air Travel." n.d. Accessed August 16, 2019. `https://www.air-travel-tips.com/ history-of-air-travel.html.`

"History of Cable." n.d. CCTA. Accessed July 25, 2019. `https://www.calcable.org/learn/ history-of-cable/.`

"History of Electricity." n.d. *Canadian Electricity Association* (blog). Accessed July 25, 2019. `https://electricity. ca/learn/history-of-electricity/.`

"History of IPhone." 2019. In *Wikipedia*. `https://en. wikipedia.org/w/index.php?title=History_of_ iPhone&oldid=907400219.`

"History of Linux, Who Invented Linux, How Was Linux Invented." n.d. Accessed August 11, 2019. `https://www. livinginternet.com/i/iw_unix_gnulinux.htm.`

"History of Mobile Phones." 2019. In *Wikipedia*. `https://en. wikipedia.org/w/index.php?title=History_of_ mobile_phones&oldid=911148058.`

"History of Television." 2019. In *Wikipedia*. `https://en. wikipedia.org/w/index.php?title=History_of_ television&oldid=907816966.`

"History of the Automobile." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=History_of_the_automobile&oldid=908682094`.

"History of the Internet." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=History_of_the_Internet&oldid=910262030`.

"History of the Light Bulb | Lighting Basics." n.d. Bulbs.Com. Accessed August 26, 2019. `https://www.bulbs.com/learning/history.aspx`.

"History of the Telephone." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=History_of_the_telephone&oldid=905662485`.

"History of the Transistor." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=History_of_the_transistor&oldid=909276086`.

"History of Unix." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=History_of_Unix&oldid=905218427`.

"History of Video Games." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=History_of_video_games&oldid=916712461`.

"Homebrew Computer Club." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Homebrew_Computer_Club&oldid=909971685`.

"How Do Transistors Work?" n.d. Explain That Stuff. Accessed October 12, 2019. `http://www.explainthatstuff.com/howtransistorswork.html`.

"How Many Satellites Orbiting the Earth in 2019?" 2019. Pixalytics Ltd. January 16, 2019. `https://www.`

pixalytics.com/
satellites-orbiting-earth-2019/.

"How Transistors Work." 2001. HowStuffWorks. January 1, 2001.
https://electronics.howstuffworks.com/
transistor.htm.

"Human Genome Project." 2019. In *Wikipedia*. https://en.
wikipedia.org/w/index.php?title=Human_
Genome_Project&oldid=911763045.

"Humans Share 70% Of Our DNA With.... Sea Sponges??" n.d.
TreeHugger. Accessed August 24, 2019. https://www.
treehugger.com/natural-sciences/
humans-share-70-of-our-dna-with-sea-sponges.
html.

"Hypertext." 2019. In *Wikipedia*. https://en.wikipedia.
org/w/index.php?title=Hypertext&
oldid=910970013.

"Hypertext Transfer Protocol." 2019. In *Wikipedia*. https://
en.wikipedia.org/w/index.php?
title=Hypertext_Transfer_Protocol&
oldid=909952475.

"IBM Personal Computer." 2019. In *Wikipedia*. https://en.
wikipedia.org/w/index.php?title=IBM_
Personal_Computer&oldid=909947292.

"Importance of DNA." n.d. Accessed August 23, 2019. http://
www.exploredna.co.uk/the-importance-dna.
html.

"IMSAI 8080." 2019. In *Wikipedia*. https://en.
wikipedia.org/w/index.php?title=IMSAI_8080&
oldid=910000222.

"Information Age." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Information_Age&oldid=914321871`.

"Intel 8008." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Intel_8008&oldid=907124423`.

"International Space Station." 2020. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=International_Space_Station&oldid=958832431`.

Khan, Suliman, Muhammad Wajid Ullah, Rabeea Siddique, Ghulam Nabi, Sehrish Manan, Muhammad Yousaf, and Hongwei Hou. 2016. "Role of Recombinant DNA Technology to Improve Life." Research article. International Journal of Genomics. 2016. `https://doi.org/10.1155/2016/2405954`.

"Large-Screen Television Technology." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Large-screen_television_technology&oldid=887939660`.

"Laser." 2020. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Laser&oldid=953656616`.

Lauret, Julien. 2019. "Tech Dirty Secret: AI Is like Santa Claus." Medium. July 26, 2019. `https://bit.ly/30CGLDz`.

"List of Augmented Reality Software." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=List_of_augmented_reality_software&oldid=914312824`.

"List of Canadian Telephone Companies." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?`

title=List_of_Canadian_telephone_companies&
oldid=908808270.

"List of Early Microcomputers." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=List_of_early_microcomputers&oldid=896495339`.

"List of Space Telescopes." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=List_of_space_telescopes&oldid=908765275`.

"Mainframe Computer." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Mainframe_computer&oldid=912118145`.

May 16, Tanya Lewis-Staff Writer, and 2013. n.d. "5 Fascinating Facts About Fetal Ultrasounds." Livescience.Com. `https://www.livescience.com/32071-history-of-fetal-ultrasound.html`.

McLuhan, Marshall. n.d. *Understanding Media; The Extensions of Man*. Critical edition. Gingko Press.

"Microwave." 2020. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Microwave&oldid=951941252`.

"Microwave Oven." 2020. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Microwave_oven&oldid=954011145`.

"Minicomputer." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Minicomputer&oldid=906576508`.

"MP3." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=MP3&oldid=907411341`.

"NASA." 2019. In *Wikipedia*. `https://en.wikipedia.`
`org/w/index.php?title=NASA&oldid=909126117.`

"NASA Spinoff Technologies." 2019. In *Wikipedia*. `https://`
`en.wikipedia.org/w/index.php?title=NASA_`
`spinoff_technologies&oldid=909022455.`

"Netflix." 2019. In *Wikipedia*. `https://en.wikipedia.`
`org/w/index.php?title=Netflix&`
`oldid=908335597.`

"Nielsen Ratings." 2019. In *Wikipedia*. `https://en.`
`wikipedia.org/w/index.php?title=Nielsen_`
`ratings&oldid=913340313.`

Noam Chomsky - The Purpose of Education. n.d. Accessed
October 27, 2019. `https://www.youtube.com/watch?`
`v=DdNAUJWJN08.`

"Palomar Observatory." 2019. In *Wikipedia*. `https://en.`
`wikipedia.org/w/index.php?title=Palomar_`
`Observatory&oldid=913680934.`

Polson, Nick, and James Scott. 2019. *AIQ: How People and*
Machines Are Smarter Together. New York: St. Martin's Griffin.
www.stmartins.com.

Powell, J A, M Darvell, and J A M Gray. 2003. "The Doctor, the
Patient and the World-Wide Web: How the Internet Is Changing
Healthcare." *Journal of the Royal Society of Medicine* 96 (2):
74–76.

"Princess Telephone." 2019. In *Wikipedia*. `https://en.`
`wikipedia.org/w/index.php?title=Princess_`
`telephone&oldid=891715536.`

"QSL Card." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=QSL_card&oldid=896704654.`

"Quantum Computing." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Quantum_computing&oldid=916548878.`

"Qubit." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Qubit&oldid=915101022.`

"Radio Amateurs of Canada." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Radio_Amateurs_of_Canada&oldid=904289555.`

Radiology (ACR), Radiological Society of North America (RSNA) and American College of. n.d. "Ultrasound (Sonography)." Accessed April 30, 2020. `https://www.radiologyinfo.org/en/info.cfm?pg=genus.`

"Remote Sensing (Archaeology)." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Remote_sensing_(archaeology)&oldid=902949627.`

"Satellite Television." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Satellite_television&oldid=904950113.`

"Scientific Calculator." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Scientific_calculator&oldid=914419281.`

Semiconductor, Kynix, transistor, The Function of Transistor, The Characteristics of Transistor, and The Types of Transistor. n.d. "What Is Transistor and Its Functions and Characteristics."

Accessed October 12, 2019. `http://www.apogeeweb.net/article/72.html`.

"Shortwave Radio." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Shortwave_radio&oldid=905897705`.

"Soylent Green." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Soylent_Green&oldid=911798271`.

"Sputnik 1." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Sputnik_1&oldid=908481058`.

"Stereophonic Sound." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Stereophonic_sound&oldid=898951137`.

"Stone Age." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Stone_Age&oldid=921954186`.

Taleb, Nassim Nicholas. 2010. *Black Swan: The Impact of the Highly Improbable*. Kindle Edition. Random House.

Tandy-Connor, Stephany. 2018. "False-Positive Results Released by Direct-to-Consumer Genetic Tests Highlight the Importance of Clinical Confirmation Testing for Appropriate Patient Care." *Genetics in Medicine* 20 (12): 1515–21. `https://doi.org/10.1038/gim.2018.38`.

"Television in Canada." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Television_in_Canada&oldid=902664593`.

"Text Messaging." 2019. In *Wikipedia*. `https://en.
wikipedia.org/w/index.php?title=Text_
messaging&oldid=915240497`.

"Top 10 Internet Scandals of All Time | PCWorld." n.d. Accessed
June 4, 2020. `https://www.pcworld.com/article/
128554/article.html`.

"Top 10 Tech Embarrassments You'll Want to Avoid | PCWorld."
n.d. Accessed June 4, 2020. `https://www.pcworld.com/
article/155510/tech_embarrassments.html`.

"Tragic Birth of FM Radio." n.d. Damn Interesting. Accessed
July 25, 2019. `https://www.damninteresting.com/
the-tragic-birth-of-fm-radio/`.

"Trans-Canada Highway." 2019. In *Wikipedia*. `https://en.
wikipedia.org/w/index.php?
title=Trans-Canada_Highway&oldid=906525815`.

"Transistor Computer." 2019. In *Wikipedia*. `https://en.
wikipedia.org/w/index.php?title=Transistor_
computer&oldid=903709515`.

"Turtle Graphics." 2019. In *Wikipedia*. `https://en.
wikipedia.org/w/index.php?title=Turtle_
graphics&oldid=901607801`.

"TVA - Our History." n.d. Accessed July 25, 2019. `https://
www.tva.gov/About-TVA/Our-History`.

"Twitter." 2019. In *Wikipedia*. `https://en.wikipedia.
org/w/index.php?title=Twitter&
oldid=916207156`.

"UHF Television Broadcasting." 2019. In *Wikipedia*. `https://
en.wikipedia.org/w/index.php?title=UHF_
television_broadcasting&oldid=900272624`.

"Ultrasound." 2020. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Ultrasound&oldid=952703844`.

"Underground Nuclear Weapons Testing." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Underground_nuclear_weapons_testing&oldid=909355007`.

"Usenet." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Usenet&oldid=914688070`.

"Vehicle Emissions Control." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Vehicle_emissions_control&oldid=904440209`.

"Web 2.0." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Web_2.0&oldid=909891214`.

"Web Search Engine." 2019. In *Wikipedia*. `https://en.wikipedia.org/w/index.php?title=Web_search_engine&oldid=910313733`.

"What Are Cookies - Computer Cookies - What Is a Cookie." n.d. Accessed August 14, 2019. `http://www.whatarecookies.com/`.

"What Is a Quantum Bit (Qubit)? - Definition from Techopedia." n.d. Accessed September 23, 2019. `https://www.techopedia.com/definition/2742/quantum-bit-qubit`.

"What Is a Transistor? <History of Transistors> | Electronics Basics | ROHM." n.d. Accessed August 6, 2019. `https://`

`www.rohm.com/electronics-basics/transistors/`
`history-of-transistors.`

"Wi-Fi." 2019. In *Wikipedia.* `https://en.wikipedia.`
`org/w/index.php?title=Wi-Fi&oldid=914734675.`

"Yuri Gagarin." 2019. In *Wikipedia.* `https://en.`
`wikipedia.org/w/index.php?title=Yuri_`
`Gagarin&oldid=908314416.`