The author celebrates her quadranscentennial and considers the next one.

As our company celebrates its silver anniversary, I started to reminisce about the progress made in the electronics industry over the last 25 years. It has been a remarkable journey.

My Curtis Mathes black-and-white TV made in the USA finally died. My computer has been upgraded many times. Communication methods have changed from fax to large couriers like UPS to email. Dialup modems are not around anymore (miss that sound?). We didn't have a website, because the Internet was not available to the general public. When I wanted to make a call while driving, I had to search for a pay phone. (What's a pay phone? my 15-year-old asks.)

Eventually, I purchased one of those brick cellphones from Motorola and gradually moved up to a Motorola StarTAC. Now, my iPhone keeps me in constant communication by text or phone, talks to me, keeps me from getting lost (sometimes), and gives me the latest news. It is so small, I sometimes lose it in my purse. It contains a built-in iPod (my Sony Walkman long discarded and probably in a landfill by now). My MacBook Air is really light, but my latest iPad is helping me organize my photos and take great videos of my daughter's basketball games. We all have Internet addresses, domain names, websites, and some of us have Facebook pages. We tweet, we text, and we sometimes email. Some of us are on LinkedIn (aka Facebook for adults). We are in constant communication with everyone in the world, and political change is made possible through social media.

So, what's next? What innovations will we see in the next 25 years?

Health care and medicine. The recent Meptec Microfluidics workshop was a glimpse into the future. Some of the top next-generation breakthroughs will combine developments in electronics with medical advancements.

Microfluidics refers to the behavior and control of liquids constrained to volumes near the micro liter range. Early microfluidics were enabled through silicon processing technology. Future cost reductions will be enabled by printed electronics or other fabrication methods.

Today's cancer treatments will look as primitive in the next decades as leeches or the chisels once used to drill holes in skulls. Pharmaceutical-infused implants, micro-machined from silicon, will enable precise drug delivery to tumors in the body, killing cancer cells but sparing the body from harmful side effects induced by high doses of chemotherapy. Additional evolving products include neurosurgical assemblies, new forms of orthopedic and cardiac implants, new silicone valves, transdermal patches intraocular implants, micro needle arrays, improved insulin

delivery, implantable batteries, and biopresorbable polymer implants.

A cartoon from the Meptec workshop shows a mother who has just transmitted data based on a fluid sample taken from her sick child to a pharmacy, where appropriate prescription drugs will be formulated to treat the illness. Microfluidic devices are evolving from silicon or glass structures fabricated using semiconductor process techniques to lower-cost structures made from polymers. Lab sample analyses will be possible in minutes in a doctor's office or even the home; illnesses or even biomarkers indicating what type of disease we might be susceptible to will be available in an hour or even minutes. Low-cost polymers will enable disposable devices that limit cross-contamination between samples.

Cell sorting based on microfluidics will enable better treatment of disease by detecting abnormalities in blood, including the presence of microscopic tumor cells. Better analysis of DNA will be possible to prescreen for medical conditions before they become fatal.

The next big breakthrough will be the use of smartphones and wireless services to enable improved health care monitoring. Blood pressure monitoring is already possible. Ingestible pills that can track the body's response to medication are on the horizon. Better ways to monitor the health of the world's aging population will be possible by combining smartphones and wireless communications. Use of sensors will enable many future products that make our lives better and safer.

Wearable electronics. Military electronics applications include the development of electronic clothing for soldiers in battlefield. Communication and computing functions will be designed into military uniforms of the future.

Breakthroughs in battery technology will enable consumer devices to run longer. Electronics will be contained in our clothing, and our bodies will provide the energy to power communication devices like smartphones. Many research institutes are working on these technologies today.

Consumer products and the home of the future. In the not too distant future, iTV or something similar will do for television what the iPod has done for music. An expensive subscription to cable TV or satellite TV will not be necessary.

Game interaction is likely to become too real. Vacations will be possible without leaving your room, enabling a trip to the beach without even a slight sunburn. Relaxation will be possible without the hassle of travel.

Voice communication will control functions in the home by talking to the walls. Sensors and improvements in electronic monitoring will enable our homes to be safer, more energy-efficient, and more enjoyable.

Computing. Photonics will enable our networking and computer needs. Data will be parked in the clouds and accessed at lightning speed. Novel data storage technologies will be invented.

Transportation. Automobiles will be more energy-efficient and also safer thanks to on-board

computing and collision avoidance. Greater use of sensors will be the enabler. Entertainment systems will allow passengers to enjoy greater comforts. While Scotty may not be able to move us around with a transporter beam, transportation by planes, trains, and automobiles will be faster and safer.

Many future technological developments will be enabled by new materials and processes. Increasingly, device manufacturing will take place at the wafer level in panel and roll-to-roll formats. Lower dielectric constant substrates fabricated with new materials will be introduced, new underfills, die attach and molding compounds will be developed, and advanced thermal materials will be adopted. Electronics that stretch will be as common as fabric for clothing. 3D ICs with multiple functions in a single stack will make possible lower-power products with higher performance. Embedded components, actives and passives, will be used in IC packages for products ranging from mobile communications to military. Embedding devices in flex circuit or laminate substrates will continue in the manufacturing process of many PCB and flex makers. Optical interconnects combined with silicon interposers and 3D stacking will enable faster communication. The next 25 years promises to be as exciting as the last.

Ed.: TechSearch, in conjunction with the IEEE Women in Engineering Committee, has established the IEEE Frances B. Hugle Engineering Scholarship, a scholarship for women entering the field of engineering.

IEEE WIE will present a $2,500 scholarship to one female in her third year of undergraduate study in an engineering curriculum at an accredited US university or college. Student membership in the IEEE is required. Vardaman seeded the scholarship with a $5,000 donation. Donations can be made online at ieee.org/donate by selecting the Frances B. Hugle Memorial Fund, or by check payable to the IEEE Foundation – Frances B. Hugle Memorial Fund and mailed to IEEE Foundation, 445 Hoes Lane, Piscataway, NJ, 08854.

E. Jan Vardaman is president of TechSearch International (techsearchinc.com); jan@techsearchinc.com .
Her column appears bimonthly.