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APS 'Deconstructs' the iPad, Shows Congress Link Between Research and Innovation

By Mary Catherine Adams

Congressional staffers gathered at the Rayburn House Office Building in Washington, D.C. on Sept. 21 to learn how early stage scientific research was integral to the development of the iPad – a tool many on Capitol Hill use daily.

In an effort to educate Congress about the importance of scientific research, the American Physical Society, along with the Task Force on American Innovation (TFAI) and several other organizations, hosted an event called "Deconstructing the iPad: How Federally Supported Research Leads to Game-Changing Innovation," which specifically targeted conservative freshman members of the House.

"Our goal was to inform members of Congress on how technologies in the iPad are rooted in early-stage scientific research," said APS press secretary Tawanda W. Johnson.

Photo by Brian Mosley/APS

Rep. Randy Hultgren (R-14th-IL) delivered introductory remarks on Sept. 21 during the Capitol Hill briefing, "Deconstructing the iPad: How Federally Supported Research Leads to Game-Changing Innovation."

William D. Phillips, a Nobel Laureate working at the National Institute of Standards and Technology (NIST), explained that federally funded research was critical in developing the global positioning system (GPS) that enables commonly used navigation apps on the iPad.

Federal funding in the 1950s enabled the creation of the world's most accurate timekeepers – atomic clocks – without which GPS systems would not work. The same research on atoms that led to the development of atomic clocks is now serving as the basis for the development of quantum computing, which has the potential to revolutionize data encryption and bolster national security. Though scientists don't always know where research is going, Phillips said, simply doing it can lead to amazing things like the better understanding of the atom in the 1950s did.

Benjamin Bederson, a University of Maryland professor and co-founder of Zumobi, Inc., which develops apps, told the story of a disabled University of Delaware graduate student who struggled using a standard computer keyboard. The student helped develop capacitive sensing – the thing that makes touch-screens work – in the 1990s thanks to a National Science Foundation (NSF) fellowship and an NSF grant. Martin Izzard, a scientist and researcher at Texas Instruments, spoke about the history of the integrated circuit, which is used in nearly all electronic equipment today.

Luis von Ahn, of Carnegie Mellon University, and founder of

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Major Scientific Programs Could be Slashed or Eliminated Under Debt-Reduction Deal

By Tawanda W. Johnson

The American Physical Society, the nation's leading organization of physicists, is deeply concerned that proposals to drastically reduce the nation's debt would do serious harm to major scientific projects.

APS understands that America must get its fiscal house in order, but the Society also believes that it is important to make wise choices that will create jobs and build a better America.

Under the debt-reduction deal, across-the-board cuts to reduce discretionary spending would mean the cancellation of major scientific projects. In a recent statement, the APS Executive Board expressed dismay that impending U.S. House action on appropriations for Commerce, Justice, Science and Related Agencies had identified the James Webb Space Telescope (JWST) as a prime candidate for termination.

APS urges Congress to restore funding for JWST and believes it deserves special attention for the following reasons:

- Successor to the extraordinarily successful Hubble Space Telescope with similar potential to transform astronomy, JWST is the centerpiece of the future American space astrophysics program. It was the highest-ranked mission in the 2000 National Academy of Sciences' Astronomy Decadal Survey and is a cornerstone of the 2010 Survey.
- JWST is 100 times more powerful than Hubble and would revolutionize our understanding of the birth of the Universe, reveal much about the first stars and galaxies, and play a crucial role in the quest to find life on distant planets.
- Seventy-five percent of the JWST hardware is being fabricated or has been delivered, and $3.5 billion (about half of the total cost) has been spent. The Casani report, commissioned by U.S. Sen. Barbara Mikulski (MD), found no technical problems, and NASA and its contractors have corrected management deficiencies that the report identified.
- JWST would continue Hubble's legacy as one of the greatest inspirations for young people and as a symbol of American leadership in science and space. Cancellation of JWST would eliminate thousands of high-tech jobs, especially in the aerospace industry.

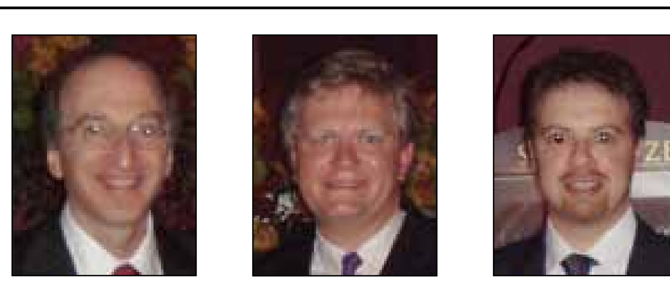
The Canadian and the European Space Agencies are contributing around a billion dollars to JWST; cancellation would again call into question our nation's record as a reliable international partner.

2011 Nobel Prize for Physics: Discovering the Accelerating Expansion of Universe

By James Riordon

The 2011 Nobel Prize for Physics has been awarded to three astrophysicists who discovered the accelerating expansion of the universe through their observations of distant supernovae.

Half the Nobel Prize goes to APS Fellow Saul Perlmutter (Lawrence Berkeley National Laboratory and University of California), and half is shared by Brian P. Schmidt (Australian National University) and APS member Adam G. Riess (Johns Hopkins University and Space Telescope Science Institute).



Saul Perlmutter Brian P. Schmidt Adam G. Riess

The accelerating expansion of the universe is believed to be driven by a mysterious source, which APS Vice President Michael Turner originally coined "dark energy" in 1998. According to Turner, "The discovery of cosmic acceleration and dark energy provided the last piece in the current cosmological model and at the same time gave us the most profound mystery in all of science – what is dark energy, the source of the repulsive gravity that is causing the universe to speed up?"

"On behalf of the American Physical Society," said APS Executive Officer Kate Kirby, "I offer our warmest congratulations to each of the 2011 Physics Nobel Prize winners. Their work has profoundly impacted our view of the universe and has challenged us with new questions."

On the Back Page

U.S. Rep. Chuck Fleischmann discusses Small Modulator Reactors.

Physics Contributes to New Medical Imaging Technique

By Calla Cofield

Stanford University physics graduate student Nicole Ackerman spent the first three years of her graduate career studying neutrinos – subatomic particles that carry no electrical charge. Now, she's working in the field of radiation oncology, investigating the use of Cherenkov radiation in medical imaging. Cherenkov radiation is produced by a particle passing through a medium at a speed greater than that of light through the medium.

"I'm still simulating particles interacting with matter," said Ackerman. "They are just in mice now instead of in a detector."

During the 2011 APS April Meeting in Anaheim, Calif., Ackerman delivered a general session talk and spoke to reporters about her work.

One of the biggest goals of modern cancer research is to develop better imaging techniques. Imaging is key to early diagnosis, effective treatment and finding cancer cells that have metastasized. Many medical imaging techniques rely on nuclear and particle physics principles, and yet, says Ackerman, many of the biologists working with those techniques don't understand the

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APS Members in the Media

National Public Radio

"That immediately gives you a time interval between the first two attacks…You take that, put it into the equation and it gives you an estimate."

***Neil Johnson* (FL-18th)**, *University of Miami, describing how his method can take the timing of two terrorist attacks and predict when the next might occur,* National Public Radio, *July 31, 2011.*

The Houston Chronicle

"On Friday, scientists from the LHC presented their current results on the search for the Higgs boson at an international conference in Grenoble, France. While there is no discovery yet, it is clear its existence will either be proven or disproven in the near future."

***Paul Padley* (TX-9th)**, *Rice University,* The Houston Chronicle online, *July 23, 2011.*

CNN.com

"Right now, we have real gaps in our energy research portfolio. We cannot fill those gaps without large-scale, long-term, well-funded and well-coordinated research programs that bring together the best and most innovative scientists and engineers in academia, industry and the national laboratories."

***Eric Isaacs* (IL-13th)**, *Argonne National Lab,* CNN.com, *June 6, 2011.*

The New York Times

"We will not discover dark matter today…We will be doing this again and again."

***Elena Aprile* (NY-15th)**, *Columbia University, after an initial null result from the XENON Dark Matter Project in Gran Sasso, Italy,* The New York Times, *April 13, 2011.*

FOX News.com

"She didn't just happen on this, she's been pushing hard on the data sets and pushing to understand the simulations for quite a while."

***Robert Rose* (IL-14th)**, *Fermilab, on a leaked memo by Sau Lan Wu's team at CERN which hints at a possible detection of the Higgs boson,* FoxNews.com, *April 25, 2011.*

The New York Times

"We have to deal with our centralized power sources first… This is not an assignment for the next few decades."

***Robert Socolow* (NJ-12th)**, *Princeton, on the efficiency of removing carbon dioxide from air versus from centralized sources like power stations,* The New York Times, *May 9, 2011.*

Snapshots from Physics History

July 21, 2000: Fermilab announces first direct evidence for tau neutrino

"Neutrinos, they are very small/ They have no charge and have no mass/ And do not interact at all," John Updike wrote in his 1960 poem, "Cosmic Gall." Neutrinos were a fairly recent discovery then, and within two years, physicists would discover that they were only just beginning to understand this mysterious "ghost particle." For instance, there was more than one kind of neutrino, and it would take physicists another 40 years to find them all.

Wolfgang Pauli first proposed the existence of neutrinos in 1930 while investigating the conundrum of radioactive beta decay, in which some of the original energy appeared to be missing after an electron was emitted from an atomic nucleus. He hypothesized that to abide by the laws of energy conservation, another neutral particle might also be emitted, accounting for the missing energy.


Wolfgang Pauli, who first hypothesized the neutrino

Pauli was reluctant to publish a paper on this unusual hypothesis, but he penned a letter to a group of prominent nuclear physicists in Tuebingen, Germany, asking for input regarding means of detecting such a particle experimentally.

"I have done something very bad today by proposing a particle that cannot be detected; it is something no theorist should ever do," he wrote, describing his idea as "a desperate remedy."

Among the physicists who took Pauli's idea seriously was Enrico Fermi, who developed the theory of beta decay further in 1934, coining the name "neutrino" ("little neutral one") in the process. It became clear that if such a particle existed, it must be both very light–less than 1% the mass of a proton–and interact very weakly with matter, making it very difficult to detect. But in 1956, Clyde Cowan and Frederick Reines succeeded in doing just that, sending a telegram to Pauli informing him of their discovery.

Pauli died two and a half years later, and thus missed the discovery in 1962 of a second type of neutrino, dubbed the muon neutrino, corresponding to the charged muon lepton. In 1975, a third charged lepton, tau, was discovered, and subsequent experiments hinted strongly that there should also be a third kind of neutrino. While scientists at CERN uncovered further proof in 1989 of the tau neutrino's existence, it would be 25 years from the discovery of the tau before the technology was available to actually detect its neutrino directly.

In the 1990s, Fermilab designed the DONUT (Direct Observation of the NU Tau) experiment to search specifically for tau neutrino interactions. The scientists used the Tevatron to produce an intense neutrino beam, predicting it would contain at least some tau neutrinos. After deploying an elaborate system of magnets and iron and concrete to eliminate as many background particles as possible, the beam was fired at a three-foot-long fixed target: iron plates alternating with layers of a special emulsion sandwiched between them.

Those emulsions captured the tracks of any electrically charged particles produced by the extremely rare tau neutrino interactions. The emulsions were then photographically developed so that scientists could analyze the data, looking for the telltale distinctive short track with a kink that indicates a tau lepton, the result of a tau neutrino interacting with an atomic nucleus. They were literally connecting the dots: small black dots left by particles passing through, which could then be connected to retrace the particles' paths.

After the experimental run in 1997, it took three years of painstaking analysis to sift through all the data, winnowing some 6 million signatures down to 1,000 candidate events. On July 21, 2000, scientists from the DONUT collaboration announced they had identified four tau neutrino signatures demonstrating an interaction with an atomic nucleus. The experiment also validated a number of new techniques for neutrino detection, most notably the emulsion cloud chamber, which significantly increased the number of observed neutrino interactions.

Leon Lederman, who shared the 1988 Nobel Prize in Physics with Jack Steinberger and Melvin Schwartz for the discovery of the muon neutrino, called the achievement "an important and long-awaited result. Important because there is a huge effort underway to study the connections among neutrinos, and long-awaited because the tau lepton was discovered 25 years ago and it is high time the other shoe was dropped."

Among the questions physicists were still pursuing was whether neutrinos might have a tiny bit of mass, and whether they could oscillate and change flavors over time as they traveled through space. For instance, would it be possible for a muon neutrino to change into a tau neutrino via oscillation?

That question was answered with a resounding yes in 2010. Scientists with the OPERA (Oscillation Project with Emulsion-tRacking Apparatus) experiment at Gran Sasso National Laboratory in Italy reported that they had found four instances of the telltale signature of the tau neutrino among a stream of billions of muon neutrinos generated at nearby CERN (European Organization for Nuclear Research) – the first direct observation of a neutrino transforming from one type into another. Experiments are ongoing to further explore this phenomenon and possibly determine specific masses for neutrinos.

With the discovery of the tau neutrino, only one more particle remains to be found to complete the Standard Model of Particle Physics: the elusive Higgs boson. Fermilab's soon-to-be-retired Tevatron is racing against the clock, competing with the Large Hadron Collider at CERN, to make one more significant discovery that will herald the dawn of a new era in particle physics.

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DOE Weighs Its Options for Underground Lab

By Michael Lucibella

A now-defunct gold-and-silver mine in South Dakota was set to host a next generation underground science lab, but the National Science Foundation (NSF) has backed out of the project. The Department of Energy (DOE) is working to save the biggest physics experiments, but because of budget uncertainties, it is unclear how many will ultimately be built.

The DOE and the NSF had planned to jointly build and operate the expansive underground lab in the Homestake mine in Lead, S.D. In December, following a directive from its oversight body – the National Science Board – the NSF unexpectedly pulled out of the project, citing concerns over the cost and its broad role in running the lab. This development halted the project, and the DOE had to rethink its plans for the site.

The Homestake mine is a sprawling web of underground chambers and tunnels at depths up to 8,000 feet. When the mine shut down in 2002, it was the largest and deepest one in the country. After the shut down, water flooded the lowest level. Congress stepped in, appropriating $15 million to run pumps to keep upper levels dry and viable for any future science experiments.

The original plan for the Deep Underground Science and Engineering Laboratory, known as DUSEL, featured a massive multidisciplinary lab at multiple levels in the mine. In addition to physics, the lab would have had facilities for biological, geological and structural engineering experiments. That comprehensive vision is essentially dead. The DOE is considering how to build the three largest physics experiments planned for the mine.

Photo by Rachel Harris

The Homestake Mine in Lead, South Dakota

The biggest hurdle facing the facility, now officially known as Sanford Underground Research Facility at Homestake, is that of funding. According to a recent report by the DOE, the facility would likely cost around $2 billion.

The three experiments the DOE is considering would probe some of the most fundamental questions about the makeup of the universe. A DOE report examined multiple construction options for the proposed experiments. Possible plans range from locating the experiments as deep as 7,400 feet underground, 4,850 feet or as shallow as 800 feet, installing different experiments at different levels, or building some of them in existing labs in other parts of the world.

The report concluded that if the experiments were to be located in the South Dakota mine, bundling them on the same underground level would save money because they could share infrastructure such as electricity, utilities and mine shafts. "Locating the facility in the U.S. would help to promote U.S. leadership in these fields for the foreseeable future," the report stated.

William Brinkman, director of DOE's Office of Science, has said he wants to move forward with the proposed experiments. However, what final form they take remains up in the air because of budget uncertainties.

"I am optimistic about things coming together,"said Kevin Lesko, of the University of California, Berkeley, and DUSEL principal investigator. "I'm optimistic we have all the elements on hand to help the DOE decide how they want to go forward with the facility."

Lesko added, "The science is absolutely first rate. The idea of putting things in the same place to share infrastructure and share intellectual excitement makes sense."

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physics behind them.

In positron emission tomography, or PET, positron-emitting radioactive isotopes are attached to molecules designed to bind to specific types of cancer cells. When the isotopes decay, they produce gamma rays that signal the presence and location of those cancer cells.

In 2009, scientists in Cambridge, Mass., published a paper demonstrating that radioactive isotopes used in medical imaging will cause water-dense tissue to emit optical Cherenkov radiation. In materials, the speed of light is lower than in a vacuum, and high energy particles may emit Cherenkov radiation when they travel faster than the photons. Radioisotopes have been used to treat cancer for more than 50 years, and while some biologists and doctors had noted the optical glow before, no one, it seems, had thought to use it.

In a preclinical and research setting, the technique offers some significant benefits over PET scans, including the fact that optical scans only take 3 minutes, whereas PET scans take 30, and optical scanners are less expensive and used more frequently by research staff.

In the future, Cherenkov light may offer imaging where there is currently none. There are presently no direct ways to image alpha and electron emitters in the body. Cherenkov radiation, however, can be used with positron, gamma, electron and alpha emitters, at short intervals. Rather than delivering one dose of radioactive isotopes to image a tumor and a second to treat it, doctors could watch the treatment dose directly.

Because Cherenkov light is optical, it scatters quickly when traveling through tissue and would likely be used to image shallow tumors such as skin cancer or some breast cancers, or cancer of the esophagus, viewed via an endoscopy. A recent paper proposed using Cherenkov light immediately following tumor removal surgery, to see if any cancerous cells are left behind. Another group has proposed using a molecular component called a fluorophore that would lengthen the wavelength of the Cherenkov light at its source and allow it to travel further through tissue to a detector.

Ackerman's work is focused on modeling the path of the Cherenkov photons as they travel through tissue. She uses a software program called Geant4, which was designed to model particle tracks in high-energy physics experiments. She says she isn't sure yet how exactly the models will be used, but she wants to understand the mechanisms behind the observations her group is making.

"My goal is to find the places where the physics details are important and then take the equations and simulations and turn them into something useful for the other researchers in the field," she said.

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reCAPTCHA, who moderated the event, said, "The iPad isn't the culmination of technology; it's a mile marker." He also told the staffers that because industry primarily funds projects with clear outcomes and obvious profit potential, scientists rely on the federal government to fund things that don't have clear outcomes but that do result in important discoveries.

About 100 people attended the House presentation, which started at noon. Another presentation for Senate staffers was held in the morning and was also well-attended.

The Task Force on American Innovation (TFAI), of which APS is a member, spearheaded the event. Three Republican Congressmen joined the TFAI in sponsoring the event: Randy Hultgren from Illinois; Michael McCaul from Texas; and Ben Quayle from Arizona. Other organizations that sponsored the event include the American Association for the Advancement of Science, the American Chemical Society, the Association for Computing Machinery, the Computing Research Association, IEEE-USA, and Texas Instruments.

Photos by Brian Mosley/APS

Top left: Luis von Ahn, of Carnegie Mellon University, who moderated the event, addressed the audience. The speakers (seated, left to right) were Ben Bederson, of the University of Maryland; Nobel Laureate William D. Phillips; and Martin Izzard, of Texas Instruments.

Top right: Martin Izzard, of Texas Instruments, discussed the integrated circuit, which led to the development of the microchip and powers today's iPad. Bottom left: U.S. Rep. Michael McCaul (R-10th-TX) offered remarks on the importance of research and innovation.Bottom right: Nobel Laureate William D. Phillips provided an overview of how research on atoms led to the atomic clock and the global positioning system.

The Back PAGE

Small Modular Reactors Could Help With U.S. Energy Needs

by U.S. Rep. Chuck Fleischmann

In 1984, less than a decade after the accident at Three Mile Island (TMI), renowned Oak Ridge scientist Alvin Weinberg and several colleagues released a futuristic research report predicting the dawn of a second nuclear era and describing the conditions that would make it successful. The report recommended that a public and private partnership be established to design and build a prototype standardized nuclear reactor to be located in clusters. Low-level wastes and spent fuel should be stored onsite on land permanently dedicated to nuclear power.

A second nuclear era has yet to materialize but today Small Modular Reactor (SMR) technology has positioned the power industry to change the nuclear landscape in the U.S. and overseas.

SMRs are among the most advanced and promising reactor designs currently under development by the nuclear and energy industries. These smaller reactor concepts, 300 megawatts or less, offer many benefits over 1,000 megawatt traditional reactors, including improved safety and affordability. Experts say SMRs could meet our country's increasing domestic power needs while leading the way on energy efficiency and cleaner air.

In an era of considerable financial uncertainty, utility companies would need less upfront capital, pay lower and shorter financing costs and won't require long term predictions for electricity demand. In short, managing investment risks enhances the value of SMRs.

SMRs are among the most advanced and promising reactor designs currently under development by the nuclear and energy industries.

In addition to lower cost, SMRs lower the operational risk for power companies. Design vulnerabilities of large nuclear plants that resulted in a total reactor loss at TMI are much less serious for small reactors. Lower power, smaller size and standardized construction all contribute to less jeopardy for nuclear operators. Since the reactors can be assembled partially in a controlled factory environment and shipped onsite for final construction, vendors say the cost and quality of construction will be better than other reactor designs.

In a post-Fukushima world, safety is still the number one public issue for nuclear power. Some SMR developers plan to build their reactors in underground bunkers to improve safety and security. SMRs have simple, "passive safety" designs, a lower power level and require less cooling after shutdown making them potentially safer than currently operating reactors.

American nuclear power has an exceptional track record of safety with more than 50 years of commercial nuclear energy production in the United States with no radiation injuries or deaths. Many energy industries can't make similar claims. In our worst nuclear incident, no one in or outside the plant was harmed.

The Tennessee Valley Authority (TVA) and Babcock & Wilcox Company (B&W) subsidiary Generation mPower have signed an agreement to develop up to a six pack of SMRs at TVA's Clinch River site in my congressional district in Oak Ridge, Tennessee. The 1,300 acre location was previously developed for a nuclear breeder reactor and has a good historical record of environmental data. Suitability studies are underway as well as initial site characterization. TVA and B&W have developed a solid business case and have a long history of working together.

The proposed SMR project at the Clinch River site is located adjacent to the Oak Ridge federal reservation near the Oak Ridge National Laboratory (ORNL) and the B&W Y-12 National Security Complex, both high demand users of electricity. TVA has indicated one reactor would supply power to TVA customers, and another would power Oak Ridge federal facilities. TVA said it could add more modules later as needed.

As a next step, TVA and Generation mPower must now prepare a construction permit application for submission to the Nuclear Regulatory Commission (NRC). Generation mPower is currently on track to deploy its first small reactor by 2020. This could be the first application received by the NRC for a small modular reactor, and the nation's first SMR.

The timely implementation of small reactors could position the United States on the cutting edge of nuclear technology. As the world moves forward in developing new forms of nuclear power, the United States should set a high standard in safety and regulatory process. Other nations have not been as rigorous in their nuclear oversight with far reaching implications.

In a post-Fukushima world, safety is still the number one public issue for nuclear power.

As we consider the disastrous events at the Fukushima Daiichi nuclear facility, it is imperative that power companies and regulatory agencies around the world adequately ensure reactor and plant safety to protect the public. Despite terrible tragedies like the natural disaster in Japan, nuclear power is still one of the safest and cleanest energy resources available.

The plan to administer these small reactors would create technologically advanced U.S. jobs and improve our global competitiveness. Our country needs quality, high paying jobs. Increasing our competitive edge in rapidly advancing industries will put the United States in a strategic position on the forefront of expanding global technologies in the nuclear arena.

If we delay the implementation of SMRs here at home, we are at risk of being eclipsed by other nations. If we don't make them in America, we will be buying them overseas. By deploying SMRs, we could be taking the first steps in making significant headway to truly gaining energy independence.

Many in Congress strongly support advances in American nuclear power. The U.S. House of Representatives fully funded a Department of Energy program to cost share partnerships for two SMR designs where near-term NRC licensing can be completed. But the program stalled in the Senate where a few influential senators blocked it.

The U.S. can lead the world on Small Modular Reactors, provide clean, safe nuclear power to help meet energy demands, reduce our dependence on foreign oil and provide quality jobs.

While the nuclear renaissance described by Oak Ridge scientist Alvin Weinberg didn't happen, we have another chance to revive his vision. The United States can lead the world on Small Modular Reactors, provide clean, safe nuclear power to help meet the ever increasing energy demands, reduce our dependence on foreign oil and provide quality jobs. That is a win for the nation and the world.

Congressman Chuck Fleischmann is a conservative Republican who represents the 3rd District of Tennessee. Fleischmann received his undergraduate degree in political science from the University of Illinois. He received both Phi Beta Kappa and Magna Cum Laude honors. He then went to the University of Tennessee law school, where he received his Doctor of Jurisprudence.

For 24 years, Fleischmann and his wife ran a small business together in Chattanooga after they both graduated from law school at the University of Tennessee.

He has served on the board of the National Craniofacial Association and on the board of the Cherokee Area Council of Boy Scouts of America. Fleischmann also served as the president of the Chattanooga Bar Association and chairman of the Chattanooga Lawyers Pro Bono Committee.

He serves on three committees, and both are vitally important to the residents of the 3rd District:

- *House Committee on Transportation and Infrastructure*
- *House Committee on Science, Space, and Technology*
- *House Committee on Natural Resources*

Fleischmann and his wife, Brenda, live in Ooltewah, Tennessee, with their three boys.