Air and Space this Week

ITEM OF THE WEEK

THE GREAT DEBATE OF 1920

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This thing we call "Science" has changed somewhat over the past hundred years. The process of scientific inquiry, of course, is the same as it has always been, but the tools, techniques, communications, and other related technologies are much different.

*Two American institutions have supported the acquisition and diffusion of knowledge all during that time: the National Academy of Science and the Smithsonian Institution. Their early histories are quite intertwined. Both were involved with a debate held on **April 26**, 1920, and the events of that day offer us a look at what Science was like "back in the day," from the shoulders of giants.*

BACKGROUND

TIME OF DISCOVERY, ESPECIALLY IN PHYSICS

All of the physical sciences made great strides forward from the time of Copernicus on through the mid-1800s. The state of scientific inquiry and the technology that enabled it was advancing; each new discovery raised further questions requiring a technology-assisted additional investigation, and so on. Michael Faraday and Thomas Edison made fundamental discoveries in electricity and its utility in the late 1800s. But modern Physics, and its sidekick, Astronomy, would really leap forward with the turn of the century.

Albert Einstein led off with his profoundly-insightful theories of relativity, with what he called his "big year," in 1905. This line of research would be awarded with the Nobel Prize in Physics in 1921.

Albert A. Michelson invented an interferometer, an optical device that could measure distances with great precision, and, with Edward Morely, conducted experiments to detect the existence of the "aether," the hypothesized as the medium necessary for electromagnetic radiation to pass through from one place to another. He became the first American to be awarded the Nobel Prize in Physics, in 1907.

Ernest Rutherford conducted the famous "gold foil" experiment in 1909 that revealed atoms to have most of their mass concentrated in a small nucleus. [See the Didja Know website section.]

The total solar eclipse of 1919 gave Physics and Astronomy to work together more closely than usual. Einstein's theories suggest that a light ray passing near a massive object would be deflected slightly by that object's gravity (what a great "called shot!"). Looking for stars near the Sun's limb while the Moon blocked the direct light should be able to detect the predicted deflection. Two expeditions were sent out; the one headed by Arthur Eddington produced the data that showed Einstein to be correct. Eddington was knighted and received numerous awards.

Niels Bohr expanded on the research being conducted on atomic structure and radioactivity by producing several possible models for the atom. He was awarded the Nobel in 1922, the year after Einstein.

Robert Millikan devised an ingenious "oil drop" experiment to determine the magnitude of the electrical charge of the electron, and was awarded the Nobel in 1923.

Louis de Broglie's Ph.D. dissertation in theoretical physics of "wave/particle duality" in 1924 was the start of our understanding of wave mechanics and was the basis for his Nobel, awarded in 1929.

The advancements continued through the rest of the 1920s and beyond, although somewhat hampered by the global economic woes of the Depression and the build-up to the coming World War II.

THE NATIONAL ACADEMY OF SCIENCE

President Lincoln was a big believer in Science and Technology for agriculture, manufacturing, and military purposes. So was Massachusetts Senator Henry Wilson, who assembled a team of scholars from a number of different fields and helped draft a bill that would establish a "National Academy of Science" that would advise the President and others on most scientific matters. The bill was passed by Congress on March 3, 1863.

Lincoln had been greatly impressed by a demonstration on the military value of hot air balloons, conducted by Thaddeus Lowe on the National Mall near the present site of the National Air and Space Museum, in June, 1861. He immediately sought to include balloons in aerial reconnaissance, especially troop movements, to good effect. When Wilson's bill hit his desk, he signed it immediately.

The fledgling NAS had 50 members, all eminent and successful researchers in their own field. It continued to serve as an advisory board, growing in size and stature for the next 50 years. When WWI came along, the NAS underwent a huge growth spurt. At the start of the War, there were 150 members of NAS, but demand for their advisory services ballooned (sorry) and more distinguished scientists were recruited by President Wilson. A separate organization, the National Research Council, was spun off of NAS in 1918 to help carry the load. Presidents Eisenhower (1956) and Bush 42 (1993) confirmed and amplified the importance of the NRC.

The NAS established the National Academy of Engineering in 1964 and what would become the National Academy of Medicine in 2015.

THE SMITHSONIAN INSTITUTION

Smithson's Bequest

James Smithson was a successful English scientist in both chemistry and geology. His second-biggest claim to fame was the recognition that the zinc ore then known as calamine was actually two different minerals, now called smithsonite (zinc carbonate) and hemimorphite (zinc silicate). [Calamine lotion is different still; its active ingredient is a blend of zinc and ferric oxide.] He had been adopted by a well-to-do family as a boy. That, and the fact that his calamine was very useful in the manufacture of brass, made him quite wealthy. He became a Fellow of the Royal Society on **April 26**, 1787.

Smithson never married, and died on June 27, 1829, at age 64. His will proved rather unusual in one respect. He left everything to his only heir, a nephew, but stipulated that if the nephew was to die without heirs, the entire fortune would be given to the United States (which he had never visited) to create the "Smithsonian Institution" in Washington, DC, dedicated to the "increase and diffusion of knowledge." The nephew died in 1835, without an heir. Nobody has ever figured out why for certain Smithson decided to leave his estate the way he did.

Aaron Vail, the U.S. *chargé d'affaires* in the U.K., sent a message about Smithson's bequest to the U.S. Secretary of State, John Forsythe. Forsythe told President Jackson about it, and he informed Congress, which accepted the legacy and set up a committee to study how to implement it.

Federalists vs. Nullifiers

The seeds of what would become the Civil War were at hand, and the decision of what to do with the Smithson money became a battleground of symbols for the conflict to come. The Federalists were delighted with the idea of having a national institution that would be an international standard for a combination research facility and museum, and an ideal place to display and study all of the artifacts and samples coming back from the various expeditions and voyages of discovery of that time.

The opposition came from a small group of politicians known first as the Nullifier Party, founded by South Carolina senator, John C. Calhoun. They were believers in the priority of State's Rights over any Federal endeavor, and that any State could overrule (nullify) and Federal law they wished to. They wanted no part of a National anything, and held that there was no Constitutional authority to create a National Institution, even if it was paid for by somebody else. The debate pitted Calhoun and the other South Carolina senator, William Campbell Preston, against the Federalists, led by John Quincy Adams, who prevailed. A former Treasury Secretary went to England and retrieved the money, along with Smithson's records and library, in 1838. The final amount came to well over $550,000, a very large sum in those days.

Another eight years passed before the Smithsonian Institution was formally established. It has a unique place in American society, a reflection of the difference of opinion on its purpose as described above. It was specifically not included in any of the three branches of our government, but was rather a “Federal Establishment,” managed by a self-governing Board of Regents, who would decide how the new Institution would be set up. Land was acquired, and the first home of the Institution, a castle-like structure designed by architect James Renwick, was constructed. And it was fortunate for all of us that the person the Regents chose to lead the Institution was physicist Joseph Henry. He took office on December 3, 1846.

Joseph Henry

Joseph Henry was born in Albany, New York, in 1978. His family had little money, and young John worked his way up through school, and eventually became a professor of mathematics at Albany Academy, where he began important research on (applied) electromagnetism and its application in the newly-developed telegraph system. He shifted over to the precursor school that would become Princeton University in 1832, and his research gave him a positive international reputation, so much so that the S*ystème International d’Unités* (SI) unit for electrical inductance is the “henry” in Joseph Henry’s honor.

Henry hit the ground running when got to the Smithsonian, and created a master plan for the new institution. His Programme of Organization, adopted by the Regents on December 13, 1847, contained fourteen points:

1. WILL OF SMITHSON. The property is bequeathed to the United States of America, "to found at Washington, under the name of the SMITHSONIAN INSTITUTION, an establishment for the increase and diffusion of knowledge among men."

2. The bequest is for the benefit of mankind. The Government of the United States is merely a trustee to carry out the design of the testator.

3. The Institution is not a national establishment, as is frequently supposed, but the establishment of an individual, and is to bear and perpetuate his name.

4. The objects of the Institution are, 1st, to increase, and 2d, to diffuse knowledge among men.

5. These two objects should not be confounded with one another. The first is to enlarge the existing stock of knowledge by the addition of new truths; and the second, to disseminate knowledge, thus increased, among men.

6. The will makes no restriction in favor of any particular kind of knowledge; hence all branches are entitled to a share of attention.

7. Knowledge can be increased by different methods of facilitating and promoting the discovery of new truths; and can be most extensively diffused among men by means of the press.

8. To effect the greatest amount of good, the organization should be such as to enable the Institution to produce results, in the way of increasing and diffusing knowledge, which cannot be produced either at all or so efficiently by the existing institutions in our country.

9. The organization should also be such as can be adopted provisionally, can be easily reduced to practice, receive modifications, or be abandoned, in whole or in part, without a sacrifice of the funds.

10. In order to compensate, in some measure, for the loss of time occasioned by the delay of eight years in establishing the Institution, a considerable portion of the interest which has accrued should be added to the principal.

11. In proportion to the wide field of knowledge to be cultivated, the funds are small. Economy should therefore be consulted in the construction of the building; and not only the first cost of the edifice should be considered, but also the continual expense of keeping it in repair, and of the support of the establishment necessarily connected with it. There should also be but few individuals permanently supported by the Institution.

12. The plan and dimensions of the building should be determined by the plan of the organization, and not the converse.

13. It should be recollected that mankind in general are to be benefitted by the bequest, and that, therefore, all unnecessary expenditure on local objects would be a perversion of the trust.

14. Besides the foregoing considerations, deduced immediately from the will of Smithson, regard must be had to certain requirements of the act of Congress establishing the Institution. These are, a library, a museum, and a gallery of art, with a building on a liberal scale to contain them.

Henry took his task most seriously, and focused on research, publication, and international scientific exchanges. In addition to his other SI tasks, Henry created a program of volunteers to make weather observations that would lead to the creation of the National Weather Service. He belonged to a number of scientific societies and also worked tirelessly on behalf of students and young scientists.

One of Henry's many important legacies was his role in the establishment of the National Academy of Science. He helped plan the organization, and when its first president, Alexander Dallas Bache became ill, he agreed to head that organization, too, in 1868. He would serve as head of both SI and NAS until his death in 1878. What an amazing career!

Given that Joseph Henry was the Secretary of the Smithsonian and the head of the National Academy of Science, it should come as no surprise that there was considerable "cross-talk" between both organizations!

One of the things that Henry supported was regular meetings of scientists of a variety of disciplines, and he would relatively-routinely offer up the Smithsonian as a venue. One of the most famous NAS meetings of that sort was held at the Smithsonian on **April 26, 1920.**

The William Ellery Hale Lectures

The Great Chicago Fire of 1871 (more here) killed ~300 people and devastated 3.3 square miles of the city, leaving ~100,000 homeless. The rebuilding effort was monumental, and was for some, a great economic opportunity.

Big city means tall buildings means lots of elevators. William Hale's elevator manufacturing and installation business was in the right place at the right time, and he made a fortune. He invested in real estate and made even more. He was a generous supporter of education. He had two sons and a daughter. One of the sons, George Ellery Hale, became a reasonably-successful astronomer, but his most important contribution to the field was his fundraising and construction of large telescopes, including the 100" Hooker on Mt. Wilson and the 200" Hale on Mt. Palomar.

Mr. Hale died in 1898. His children recognized their father's passion for higher education by sponsoring in 1914 an annual academic lecture series to be held at the National Academy of Science. The initial impetus of the Hale family was a focus on Darwinian evolution, but the topic list expanded as the series went on.

A Hale Lecture was to be the marquee event for the NAS meeting on **April 26, 1920**, a fitting conclusion to the day's super-strong program.

PRESENTATIONS OF THAT DAY

The William E. Hale Lecture may have been the main event that day, but the undercard was absolutely no slouch! Some of the speakers were quite famous or would be soon thereafter. Check out the full agenda of talks here. The presentations included the following.

John M. Clarke, the State Geologist of New York and the Director of the New York State Museum, spoke on "Conservation of natural resources as a proper function of the National Academy." Now was he somewhat ahead of his time, or what?

Raymond Pearl, the Chair of the Department of Biostatistics at Johns Hopkins, spoke "On the rate of growth of the population of the United States since 1790 and its mathematical expression."

Franx Boas, known universally as the "Father of American Anthropology," spoke about "Growth and development as determined by environmental influences."

Charles Doolittle Walcott was the Secretary of the Smithsonian Institution from 1907 until his death in 1927. He was an accomplished field geologist before that, discovering the now-famous fossil assemblages in the Burgess Shale in Canada. He would present this day a talk entitled, "Structure of Marrella and allied Middle Cambrian crustaceans." [Is this not a diverse set of talks? And BTW, Walcott was the only SI Secretary to give some of his own money for scientific research, establishing a fund to support studies on topics otherwise difficult to support. Jim Zimbelman and I used a small grant from that fund to support Mars-analog fieldwork in the Mojave Desert. We colloquially named a small butte on the "shore" of Cadiz Dry Lake "Wally's Knob" in his honor. It's tougher to get to now (I tried last month), but it's a great spot for watching sunrises and sunsets, and to raise a glass in thanks to this generous leader.]

James Rowland Angell was a noted psychologist who had developed testing strategies for Army inductees in WWI, served a term as president of the American Psychological Association, and would be largely responsible for a make-over of Yale University in the 20s and 30s. He spoke about the history and mission of the National Research Council, newly spun off of the NAS.

Robert W. Wood was a physicist at Johns Hopkins, an expert on IR and UV photography, optics, and fluorescence. He uncovered a scientific scam and wrote and illustrated books for children during his interesting career. He spoke on “Spectroscopic phenomena of very long vacuum tubes.”

Robert Millikan, the Nobel Laureate in Physics for 1923, was mentioned above. He spoke on “The effect of molecular structure upon the reflection of molecules from the surface of liquids and solids.”

George Elliot Hale (more on him below) gave a presentation about “The 100-inch Hooker telescope of the Mt. Wilson Observatory.” He had played an important role in its funding and construction, and would do the same for the 200” telescope on Mt. Palomar, which is named in his honor.

A.A. Michelson became the first American awarded the Nobel Prize for Physics, in 1907, fifteen years before the Debate. His talk was, “The vertical interferometer: Preliminary tests to attempt to measure the diameter of stars.”

Edwin H. Hall was the “Grand Old Man” of the meeting. While a he was a graduate student at Johns Hopkins in 1870, he discovered what we now call the “Hall Effect,” the “production of a voltage difference in an electrical conductor that is transverse to an electrical current in the conductor and to an applied magnetic field perpendicular to the current.” The definition is tough to follow, but the Hall Effect is important in a number of electrical and electronic devices. He closed out the daytime part of the April 26 program with a talk about “Thermal conductivity of metals.”

THE GREAT DEBATE

The day of scientific presentations and interactions was amazing enough, but especially so because the evening Hale Lecture was a debate about the nature of the Universe.

State of Astronomy in 1920

Astronomy, like Physics, was on a roll in the half-century centered on 1920. Not only were our view of the Solar System becoming more complete, telescopes and spectroscopy was advancing our knowledge of more distant objects. However, there was no deeper understanding of the scale of astronomical things, especially outside of “island universe,” if it existed. The prevailing view was that the Milky Way, and perhaps its immediate surroundings, was the Universe!

One of the most profound discoveries of this time was made by Henrietta Leavitt at Harvard College Observatory (well, sorta “at” – see here for more). She was looking at high-resolution photographs of the Small Magellanic Cloud taken on a number of nights, and meticulously comparing them to look for any changes. She found a total of 37 that varied in brightness with time in the pattern of the star, Delta Cephei. Since they were all more-or-less the same distance from Earth, their apparent magnitude would be a true reflection of their absolute magnitude. What she found amazed her. There was an obvious relationship between how bright the star was and how rapidly its brightness oscillated. This meant that the "Period-Luminosity Relationship" could be used to determine distances between Earth and the Cepheid variable in question – a very powerful astronomical tool, and one soon put to good use.

Spiral Nebulae: Curtis' View

Astronomers had observed and classified a number of different astronomical objects by 1920. They generally fell into two classes: clusters (of stars) and nebulae (gaseous appearance), or perhaps a combination of the two (like the Pleiades). "Open" star clusters were almost certainly part of the Milky Way; "Globular" star clusters were almost certainly closely-associated with the Milky Way; but the observations were less clear about "nebulae." A number of nebulae were spiral-shaped, and too small (distant) to allow the resolution of individual stars (if there were any). Some astronomers envisioned them as being closely akin to other gaseous nebulae, just happening to show a whirlpool-like shape as seen from Earth due to the internal motion of the gas. Others thought that spiral nebulae were galaxies like our own Milky Way, but extremely far away.

Heber Curtis had been studying spiral nebulae at the James Lick Observatory for 20 years before being named the Director of the Allegheny Observatory in Pittsburgh. His traditional view of the Milky Way was too small by a factor of three, but his view that Andromeda, Triangulum, and other spiral nebulae were other galaxies not too unlike the Milky Way proved correct.

Spiral Nebulae: Shapley's View

A lot of astronomical research during this time period was conducted at observatories funded by wealthy philanthropists and/or science-minded citizens. Many of the larger observatories and telescopes of the day were made possible by the fund-raising skills of Georger Ellery Hale – more about him later.

Harlow Shapley came to professional astronomy in a round-about way, starting as a journalism student. He received a fellowship to Princeton, where he studied under the well-known astronomer Henry Norris Russell. He immediately conducted an important two-fold study of the previously-mentioned globular clusters.

Other astronomers had earlier noticed that the distribution of globular clusters in the sky was not uniform at all, but strongly asymmetric, but they had little way of assessing the situation further. Shapley, however, could apply Leavitt's newly-discovered Cepheid variable law to determine two things about the globular clusters. First, with the location and distances he could plot them in 3-D, and found that they formed a cluster around the part of the Milky Way more heavily-populated by stars (meaning that the Sun was not at/near the center). Second, they were farther away than previously thought, making the Milky Way significantly larger than 30,000 light-years.

Shapley thought of the globular clusters as orbiting the Milky Way, not too far from it. Gaseous nebulae could occupy that near-Milky Way area, too; he saw no evidence for anything "beyond."

Assessment

The Great Debate, and the talks earlier in the day, are a revealing cross-cut of the prevailing state of a variety of the sciences circa 1920, delivered by some of the finest scientists of the day, or any day. It also was a (yet another) milestone in the ongoing mutually-positive interaction between the National Academy of Science and the Smithsonian Institution.

Seen from the perspective of 102 years in the future, the Great Debate also was a milestone in the soon-to-grow-large divide between "Little" Science (requiring but modest funding) and "Big" Science (requiring expensive technology). And I suspect there was a generational aspect to the Debate as well. Curtis was older and traditionally "old school," Shapley was younger and more attuned to the latest technology.

Neither Curtis nor Shapley were entirely wrong/correct. And besides, Edwin Hubble soon settled the issue. He also used Leavitt's period-luminosity law, but he had access to the new 100" Hooker telescope, then the largest in the world. It was capable of resolving individual stars in the spiral nebulae in Andromeda and Triangulum, and if one could see individual stars, one could find Cepheid variables. Their apparent brightness showed them to be much too far away to be part of the Milky Way. Andromeda and Triangulum were galaxies in their own right, not unlike the Milky Way, and by extension, many/most of the other spiral nebulae then known were galaxies, too! That's why there was a Hubble Space Telescope, not a Curtis or Shapley one!

WHAT IT MEANS TODAY

The Smithsonian Institution is now the largest and most-visited Museum system in the world. It is fulfilling Smithson's mandate for the "acquisition and diffusion of knowledge" by being the Nation's Museum in many fields and also a center of research and learning.

The National Academy of Sciences has performed admirably, too. Their many study groups provide valuable guidance for many areas of study. An outstanding example of what I mean can be found in last week's release by the NAS of the *Planetary Science and Astrobiology Decadal Survey 2023-2032*.

NAS decadal surveys provide strong guidance as to the direction and priorities of academic research for that particular field in the coming decade, and in NASA's case, their planning follows Decadal guidance. Of course, there are missions "in the pipeline" (Dragonfly, Lucy, Psyche, DAVINCI, and VERITAS) that won't be stopped by a new decadal, but the ramifications for missions coming after them are considerable.

Highlights of the New Decadal Survey

The NAS team responsible for the report identified three overarching themes for their report: origins, worlds and processes, and life and habitability. They generated a dozen priority scientific questions and made recommendations for the following topics.

NASA's present mix of missions is appropriate and should continue (Discovery program, New Frontiers program, and "Flagship" missions).

Recommended Priorities for NASA

The Uranus Orbiter and Probe (UOP) was given the highest priority for NASA's largest mission program. We've sent sophisticated spacecraft to six planets other bodies, but the only close-up info we have on either Uranus or Neptune, and their moons, came from the fly-by of *Voyager 2* back in the 1980s. *Voyager 2* was an incredibly-successful mission, and is still in operation today. But one fly-by does not planetary understanding make, spacecraft instrumentation has advanced a lot since then, and Uranus is an interesting object of further study anyway.

Second on the Flagship Mission priority list is the Enceladus Orbilander mission, which would orbit Enceladus for two years and then land next to and sample one of its active fountains.

The report also contains recommendations for the targets of new Discovery- and New Frontiers-class missions, on planetary defense, making both the Mars Exploration Program and the Lunar Discovery Exploration Program as dedicated programs, and more.

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The Great Debate

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