Centre County Torch Meeting Minutes
March 12, 2025
Ramada Inn, State College, PA

President Terry Engelder opened the meeting at 6:45 PM.

Approximately 40 members were in attendance.

Annual dues are currently $75 a year. Dinner is $25.

There were no new members or visitors. Terry Engelder reminded current members to submit a biography for inclusion on the Central Pennsylvania Torch website. The site can be found on the internet at http://centralpatorch.org.

Tonight's topic is '**The Iron Furnaces of Pennsylvania'**. Ron Smith introduced the presenter, John Golbeck, as Emeritus Professor of Biochemistry and Biophysics at Penn State. John received his B.S. in chemistry from Valparaiso University, and his Ph.D. in biological chemistry from Indiana University, the latter under Prof. Anthony San Pietro. His postdoctoral studies were carried out at Martin Marietta Laboratories, Baltimore, MD, with biophysicist Dr. Bessel Kok. John's research specializes in the function of iron containing proteins called ferredoxins in photosynthesis. Over the past 50 years, he has edited two books and published 247 peer reviewed scientific papers, and he mentored 20 Ph.D. students and 10 M.S. students.

The Iron Furnaces of Pennsylvania

John began his talk by emphasizing that the history of Pennsylvania is inextricably bound up with the smelting of iron and production of steel. The Commonwealth is rich in the four required items to make iron: hematite and magnetite as iron ore, limestone to remove impurities as slag, forests to make charcoal, and streams to power air bellows. The process of making iron metal from iron ore is called 'smelting', derived from the German word 'schmeltzen' (to melt). The ancients thought that by heating ores with wood, and later charcoal, metals would literally 'melt' out of the stone. It is a bit more complicated than that, as John explained in his talk on the history and the chemistry of iron production in Pennsylvania.

John first discussed the history and economics of iron production in the Juniata iron region of Pennsylvania with a focus on Centre Furnace and Mt. Etna Furnace. Centre Furnace and its stack, located at East College Avenue, were founded by Samual Miles and John Patton in 1791 and remained in blast until 1809. The furnace and its 25 square miles of land were purchased by James Irvin and Moses Thompson in 1826 and remained in blast until 1859. The iron making operation was, in practice, a northern 'plantation', employing upwards of 100 workers and requiring a large infrastructure that consisted of the furnace stack, tenants' houses, boarding houses, a blacksmith's shop, a grist mill, a church, a company store, a school and a post office. None of this remains except for the stack and mansion. In contrast, Mt. Etna furnace, located in Blair County, has several remaining structures, including the iron master's house, a tenant house, a manager's house, forgemen's houses, a church, a store (the latter four now private dwellings), and a bank barn. The iron produced was originally transported to either Baltimore or Pittsburgh by mule, but transportation was eased by the building of the Pennsylvania Mainline Canal on the Frankstown Branch of the Juniata River and later by the Pennsylvania Railroad, which purchased the canal and laid tracks on the towpath. The railroad was abandoned in the 20th century and through a rails-to-trails program the right of way became the popular Lower

Trail. There were in total 18 iron works in Centre County, including an iron ore mine at Scotia that was established by Andrew Carnegie. By 1873, Pennsylvania had a total of 225 furnaces. Because one year of iron production required charcoal made using wood from 2 square miles of land, resource depletion became a major problem by the late 1800's.

The second part of John's talk covered the chemistry of how iron ore is turned into iron metal. Iron exists on Earth as iron oxide because of the presence in the atmosphere of oxygen produced by photosynthesis. He explained the process of oxidation, which is the addition of a molecule of oxygen to a metal such as iron, and the process of reduction, which is the removal of a molecule of oxygen from a metal oxide such as iron oxide. The latter can be done using carbon monoxide, a molecule that has a higher affinity of oxygen than does iron. Charcoal is made by heating wood in a low oxygen environment and is added along with iron ore and limestone to the furnace stack. The carbon monoxide produced by heating the charcoal reacts with iron oxide to produce carbon dioxide and iron metal, which flows from the bottom of the stack into sand molds. The added limestone is converted to lime in the stack; it removes contaminating silicon oxides from the ore, producing the by-produce slag, which floats on surface of the molten iron and is removed. Two major breakthroughs, developed in Europe, became important when deforestation threatened the viability of the iron plantations. One was the use of coke, which is produced by heating bituminous coal in a low oxygen environment, as a substitute for charcoal. The other was the use of anthracite coal, which is abundant in eastern Pennsylvania, and the use of a 'hot blast' to promote burning, in which the air is heated to 900 to 1350 C, before introduction into the furnace. Both provided the carbon needed to produce the carbon monoxide that reduces the iron oxide into iron metal. The final product, pig iron, contains 4.5% carbon, which makes it brittle, but it is still useful for casting pots and stoves for cooking.

John's third topic concerned how pig iron is turned into steel. Steel contains a lower content of carbon and the addition of alloying metals such as chromium to give it strength and durability. The pig iron made in the Juniata region was transported to Pittsburgh, where steelmaking was introduced in the early 1800's. To make steel, the remaining dissolved carbon is completely removed by remelting the pig iron in a Bessemer furnace and blowing air through the melt to oxidize the residual carbon (from the charcoal or coke) into carbon dioxide. Carbon is then re-introduced to a final concentration of 2% and other metals are added to provide desired properties. Improvements such as the introduction of the basic oxygen furnace, which blows pure oxygen on the surface of the molten iron at twice the speed of sound, producing a furious mixing of the melt, and reducing process time from 6 hours to 40 minutes. The later invention of the electric arc furnace, which uses electricity to produce the melt, provided a relatively cheap way to recycle iron metal, and now accounts for up to 50% of all 'new' iron produced. The latest innovation is the use of hydrogen instead of carbon monoxide to smelt the iron ore. This process produces water as the product instead of carbon dioxide. Because up to 9-11% of the carbon dioxide emitted into the atmosphere is produced by iron and steel production, the use of hydrogen can help reduce global warming, the major driver of climate change. Its widespread use, however, will require a cost-effective way to generate hydrogen from water.

The talk ended with a question-and-answer period and the meeting was adjourned at 8:00 pm. April's speaker is Larry Ragan; his topic is 'Learning About Nature Using AI'.

Respectfully submitted,

Art Goldschmidt, (filling in for Charles Maxin, recording secretary), with much help from John Golbeck