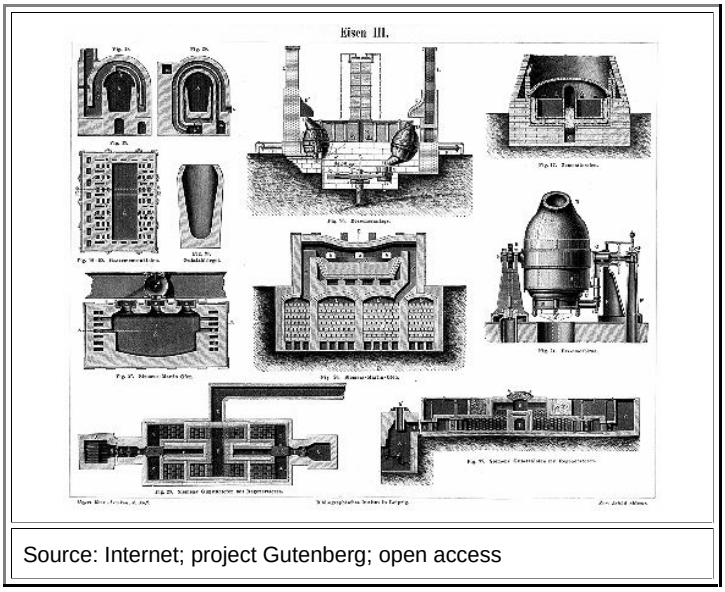
Steel Revolution

The Modules of This Link Hub

- This Science Module Hub leads to some more information about the 1870 "steel revolution" linked to names like Bessemer, Siemens, Martin, Thomas and so on. These modules are not all that scientific; I just will not be very careful to avoid scientific words or the occasional equation. What will be covered is:
  - **1. The Kelly - Bessemer process**
    Yes! Bessemer wasn't quite alone with his invention. One William Kelly actually came up with the idea a bit earlier.
  - **2. The Thomas - Gilchrist Process**
    Why is silica acidic? And quicklime basic? And what does that have to do with phosphorous removal and the Thomas process?
  - **3. The Siemens - Martin Process**
    Mostly a few more pictures.
- The picture below shows a contemporary (around 1890) "poster" with implementations of all the processes mentioned (and more). You can far better appreciate it in a large size format.



Source: Internet; project Gutenberg; open access

What did Bessemer et al. Know About Iron and Steel?

- What did Bessemer and the others know about iron and steel? Or, asking more generally, what was public knowledge about the making of iron and steel, the relation between properties and composition / microstructure, and how all that fits together?
  - There is no simple answer. The *scientists*, for example, learned more and more about the composition - property relations but the practitioners, the people actually making iron and steel, wouldn't listen to them for the usual mix of reasons. They didn't understand it, had learned something else that they liked better, and so on. Most important, however, was the simple fact that all these "theories" did not give them any good clues for making better steel. That hasn't changed all that much. Steelmakers in the second half of the 20th centuries, for example, did now pay a lot of attention to phase diagrams, thermodynamics, kinetics, detailed analytics and so on, the stuff despised by their 19th century brethren, but would not listen to anybody telling them about dislocations and all the other defect stuff, fracture theory, not to mention quantum mechanical stuff relating to solids, for exactly the same reasons given above. And these are *good* reasons! I, personally, once spend several months on analyzing *one* grain boundary in silicon in all its eclectic beauties. The process engineers I supervised 10 years later *made* something like *five zillion* (10^{12} - 10^{14} to be correct) grain boundaries in silicon *every day* - they could not possible be interested in the details.
  - Worse, people within either group - scientists and engineers - were fighting each other tooth and nail about who was right. Almost invariably, all of the still better known ones were right about some important issue and dead wrong about others. It was a bit worse than today but not entirely different; the great Verhoeven - Wadsworth jousting tournament gives a good example
    To top all that, entrepreneurs like Bessemer prided themselves on not knowing much about iron and steel as will become clear in the respective modules.

All in all, there was no general knowledge about the making of iron and steel etc. in the second half of the 19th century. The situation rather resembled a steamy smelly swamp, sprouting all types of weird plants and teeming with life that fed on each other and the plants. Some survived and grew to mighty organisms.
It is impossible to do justice to all the people involved in a major way, the events and accidents that spurred on progress, and the interrelations of all this. Instead I give you simplified tables containing a few of the (for me) more interesting points as a function of time here.

Iron, Carbon and Steel			
Year	**Explanation**	**Name**	**Notes**
350 BC	Steel is especially pure iron	Aristotle (Greek)	Aristotle didn't know what iron is either, of course
1722	Steel is dirty iron	R. A. F. Réaumur	Yes! Good-bye Aristotle.
1770	Manganese in iron is important for making steel.	T.O. Bergmann (Sweden)	Correct up to a point. Manganese oxide in the ore made smelting easier. Completely wrong with respect to the difference between iron and steel but believed by many for some time.
1781	"Plumbago" (meaning carbon) turns iron into steel.	T.O. Bergmann (Sweden)	T.O did get it first. He just didn't know what carbon is and confused (like everybody else then) with lead.
1782	Diamond is carbon	Lavoisier	Carbon is an element. First recognitions of *elements* and a table - with many errors.
1786	Plumbago is carbon - like diamond and graphite. Lead is not carbon.	G. Monge,	and C. A. Vandermonde plus C. L. Berthollet, all French. Finally the "nature " of carbon is established.
1801	Manganese *and* carbon make steel	Gazeran (French)	Typical French compromise
1819	Aluminum makes (at least) wootz steel special	Faraday	Completely wrong but Faraday made up for that later and in many other respects
1821	Silicon is just as important than carbon	Boussingault (French)	No.
1830's	There are *several forms* of carbon relating to steel and cast iron	J.B. Karsten (German)	Karsten recognized correctly graphite, dissolved carbon and carbides - but assumed many kinds ("polycarbides") like FeC, FeC_2, Fe_2C_3, Fe_2C. He missed the only real one (Fe_3C). He corrected himself 1846
1840	You need (unspecified) "steely" ores to make steel instead of iron	Le Play (French)	No. Some ores are better than others from some process but all could work
1860's	Nitrogen (in conjunction) with carbon is "it".	M.E. Frémy (French) and others	No. Nitrogen can harden iron but there is no "nitrogen steel"
1860's	It's carbon - *and* other stuff *and* processing.	E.Gruener (French)	Steel is somewhere between relatively pure carbon-lean wrought iron and carbon-rich cast iron but whatever carbon concentration it is - steel is defined by *properties*. The voice of reason. Steel is *not* something uniquely defined by one special composition. True but not overly helpful
1883	It's cementite	???	Recognition that there is only one carbide: Fe_3C called cementite
1897	First iron - carbon phase diagram	W. Roberts-Austen	First phase diagram but not quite correct before about 1900.

What by Whom When and Where			
Year	**Explanation**	**Name**	**Notes**
1830's	Attempt at a quick tests for carbon concentration	Berthier (France)	Good start but didn't quite make it.
1840	Steam hammer invented	**J. Nasmyth**	Far more force than water-powered hammers with possibility to fine-tune power and stroke depth.
1862	First *working* tests for carbon concentration	V. Eggertz (Sweden)	A color test based on ideas of J. Liebig (German) who perfected the principle for or organic substances
1864	First manual with impact "Metallurgy: Irons and Steel"	**J. Percy** (English)	The first time a handbook containing "theory" was even noticed by practitioners.