	Name :	Date :	
	Industrial Revolution *How to create steel*	Course 1ère – Tale Page 1 on 3	*Note :*

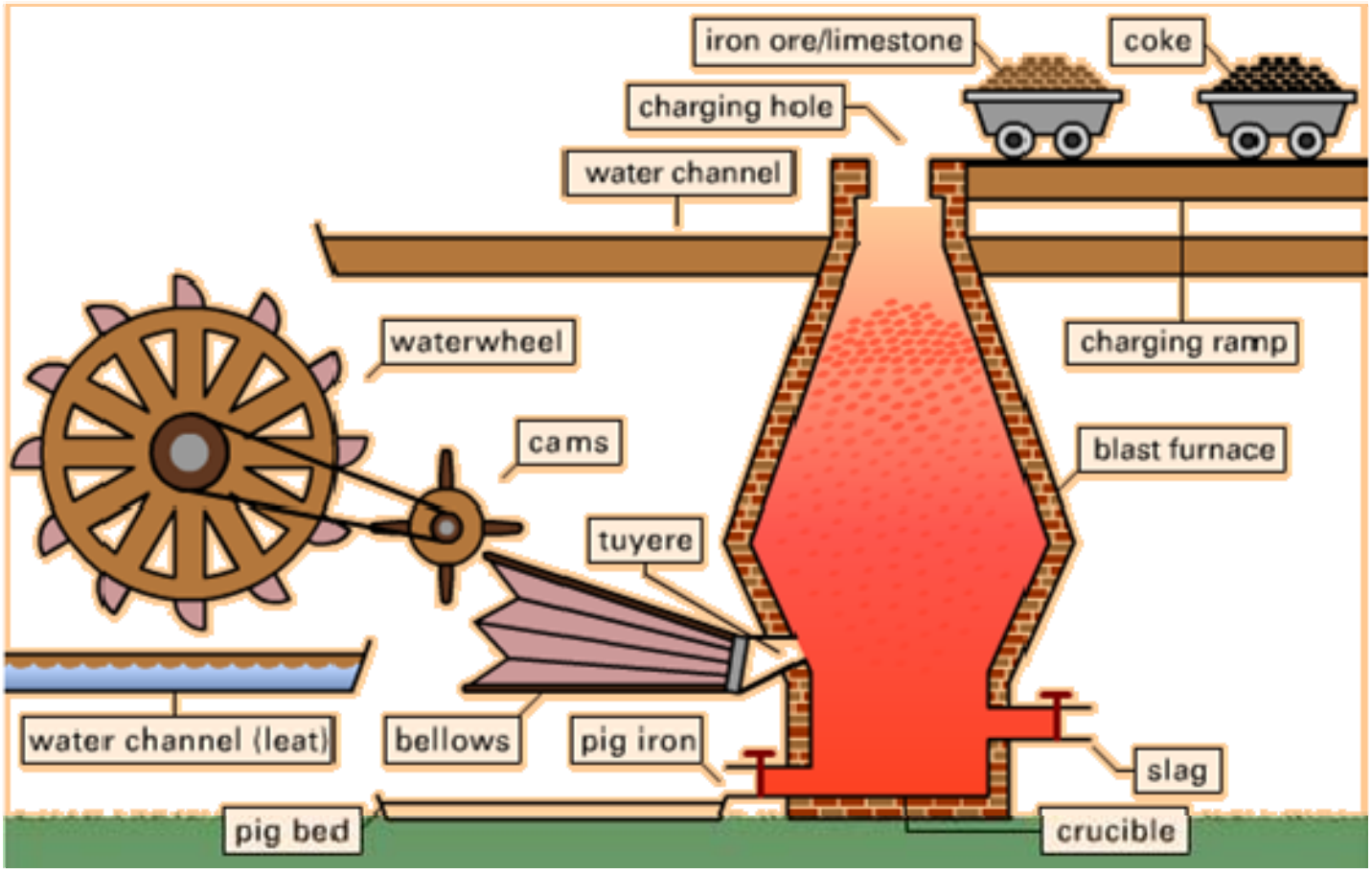
Up to 1709, furnaces could only use charcoal to produce iron. However, wood (which is what charcoal is made from) was becoming more expensive, as forests were being cleared for farmland and timber.

Coal was a possible alternative to wood, but although it was cheap and plentiful, it wasn't a feasible fuel for making iron, because it contained sulphur, and this made the iron too brittle to be of any use.

However, in 1709, a man called Abraham Darby finally succeeded in smelting iron using coke (see list of terms below) as fuel, and he bought all his workers beer, in celebration of his discovery.

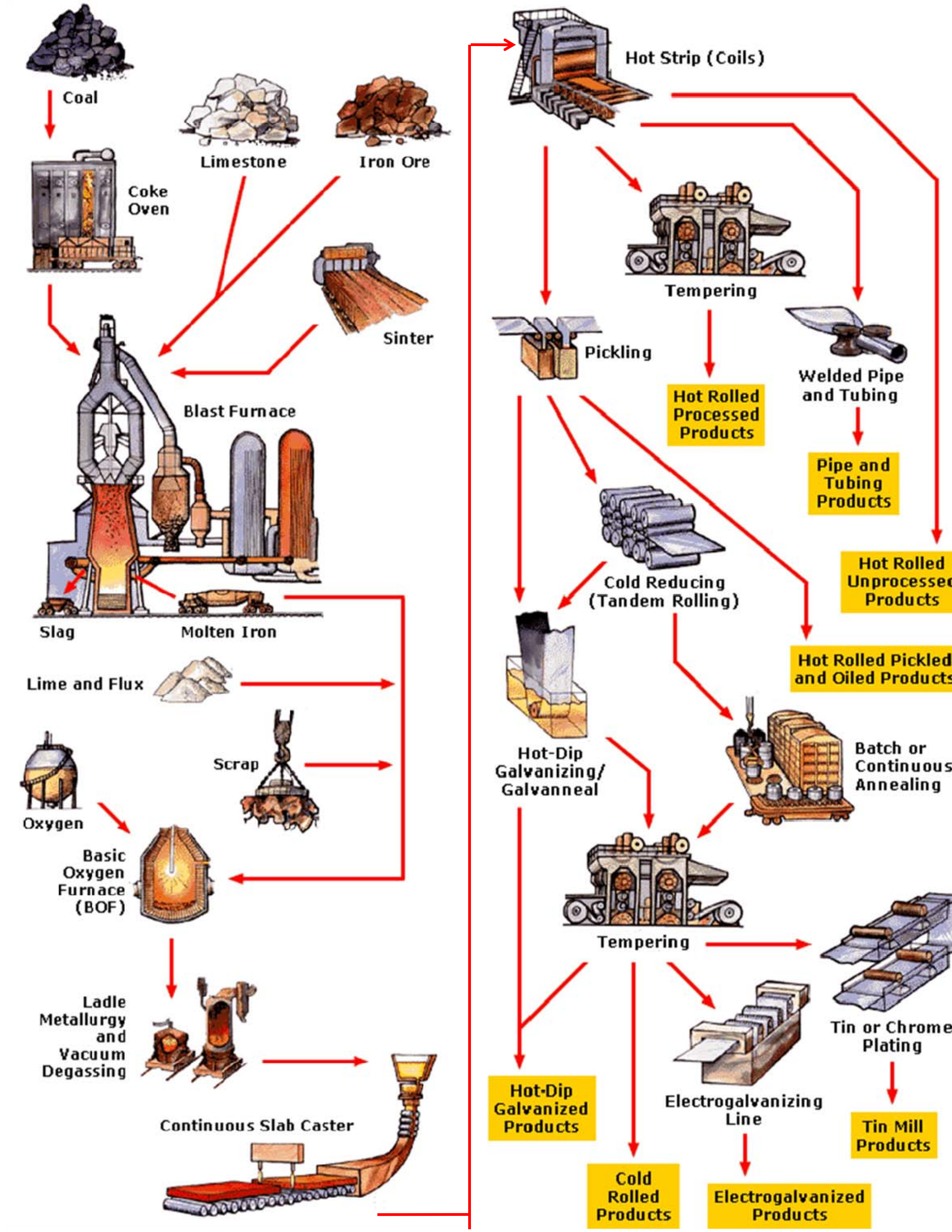
This technological achievement allowed a major expansion of the iron trade, and ultimately it helped lead to the Industrial Revolution. In the space of 40 years, the small village of Coalbrookdale, in Shropshire, where Darby made his discovery, became a major mining site, employing about 500 people.

After 1709, Coalbrookdale saw other achievements, such as the first cast-iron bridge - built over the River Severn - and the first cast-iron framed building - built in Shrewsbury.



http://www.bbc.co.uk/history/interactive/animations/blast_furnace/index_embed.shtml

Steel process diagram:



Creating Iron

The more advanced way to smelt iron is in a blast furnace. A blast furnace is charged with iron ore, charcoal or coke (coke is charcoal made from coal) and limestone ($CaCO_3$). Huge quantities of air blast in at the bottom of the furnace, and the calcium in the limestone combines with the silicates to form slag. Liquid iron collects at the bottom of the blast furnace, underneath a layer of slag. The blacksmith periodically lets the liquid iron flow out and cool.

At this point, the liquid iron typically flows through a channel and into a bed of sand. Once it cools, this metal is known as **pig iron**. To create a ton of pig iron, you start with 2 tons (1.8 metric tons) of ore, 1 ton of coke (0.9 metric tons) and a half ton (0.45 metric tons) of limestone. The fire consumes 5 tons (4.5 metric tons) of air. The temperature at the core of the blast furnace reaches nearly 3,000 degrees F (about 1,600 degrees C).

Pig iron contains 4 to 5 percent carbon and is so hard and brittle that it's almost useless. If you want to do anything with it, you have three options. First, you can melt it, mix it with slag and hammer it out to eliminate most of the carbon (down to 0.3 percent) and create strong, malleable wrought iron. The second option is to melt the pig iron and combine it with scrap iron, smelt out impurities and add alloys to form **cast iron**. This metal contains 2 to 4 percent carbon, along with quantities of silicon, manganese and trace impurities. Cast iron, as the name implies, is typically cast into molds to form a wide variety of parts and products.

The third option for pig iron is to push the refining process even further and create **steel**.

Creating Steel

Steel is iron that has most of the impurities removed. Steel also has a consistent concentration of carbon throughout (0.5 to 1.5 percent). Impurities like silica, phosphorous and sulfur weaken steel tremendously, so they must be eliminated. The advantage of steel over iron is greatly improved strength.

The **open-hearth furnace** is one way to create steel from pig iron. The pig iron, limestone and iron ore go into an open-hearth furnace. It is heated to about 1,600 degrees F (871 degrees C). The limestone and ore form a slag that floats on the surface. Impurities, including carbon, are oxidized and float out of the iron into the slag. When the carbon content is right, you have carbon steel.

Another way to create steel from pig iron is the **Bessemer process**, which involves the oxidation of the impurities in the pig iron by blowing air through the molten iron in a **Bessemer converter**. The heat of oxidation raises the temperature and keeps the iron molten. As the air passes through the molten pig iron, impurities unite with the oxygen to form oxides. Carbon monoxide burns off and the other impurities form slag.

However, most modern steel plants use what's called a basic oxygen furnace to create steel. The advantage is speed, as the process is roughly 10 times faster than the open-hearth furnace. In these furnaces, high-purity oxygen blows through the molten pig iron, lowering carbon, silicon, manganese and phosphorous levels. The addition of chemical cleaning agents called **fluxes** help to reduce the sulfur and phosphorous levels.

A variety of metals might be alloyed with the steel at this point to create different properties. For example, the addition of 10 to 30 percent chromium creates stainless steel, which is very resistant to rust. The addition of chromium and molybdenum creates chrome-moly steel, which is strong and light.

When you think about it, there are two accidents of nature that have made it much easier for human technology to advance and flourish. One is the huge availability of iron ore. The second is the accessibility of vast quantities of oil and coal to power the production of iron.