

1. Introduction

1.1 What You Will Find in this Hyperscript

1.1.1 The "What" Questions

If you have ever tried to get some information about swords and steel, the Internet provided you with plenty of stuff. You have found hardcore science articles, more or less incomprehensible, and straight balderdash, to use a polite word that starts with "b". Between those extremes you ran across many good contributions. Some dealt with general points about steel technology or sword making, and others revolved around some special topics like "wootz steel", "martensite", or "carbon and hardness". If you are not sure about some of the terms I'm using here, refer to the ["glossary" module](#) or the ["Index"](#).

In general, many good articles can be found that are *descriptive*. They deal mostly with what I am going to call the **"what"** questions. They answer questions you might have in a descriptive or empirical way. Sometimes they explain something not-so-clear by referring to something that is actually completely unclear but sounds or looks good.

Let's look at a few examples of good questions and typical answers:

- *What* is steel? Iron with a little bit of carbon in it!
A perfectly true answer. It is even useful, provided you have some idea about what iron and carbon is. Now you know that mixing iron and carbon might get you steel. But you still do not know anything about steel.
- *What* is a "Berliner Weiße"? **Beer** with some raspberry syrup in it!
Once more a perfectly true answer. It is even useful, provided you have some idea about what beer and raspberry syrup is. Mix the stuff and you get a Berliner Weiße. However, as long as you didn't *taste* a Berliner Weiße, you still don't know anything about it.
- *What* is carbon doing in iron? Making it harder!
- *What* is raspberry syrup doing in beer? Making it tastier!

Aha! You get the idea now. Let's go on.

- *What* is the advantage of damascene technology? It combines hard and brittle steel with soft and tough steel, producing hard and tough steel!
- *What* is the advantage of a Berliner Weiße? It combines the best of beer and juice!

Aha once more! You got answers. *But are they true?* Mixing something might also bring out the undesirable properties of the constituents, after all. You rarely run across "cheese and spinach ice cream", for example. To get closer to the truth, you first need to define and *measure* the properties "harder" or "tastier". But let's go on:

- *What* is wootz steel? Some kind of more or less mysterious ancient Indian high-carbon steel with special properties from which superior blades with a "watered pattern" could be produced! Good answer. Now you know. Or do you?
- *What* happens if you "quench" (rapidly cool) hot steel? It gets very hard because somehow martensite is formed!
- *What* is martensite? A particular hard kind of steel. **Aha.**

I guess you get the idea by now. None of the answers is totally wrong but none of the answers really explains much. They deal with the matter the same way you deal with your child when it asks: "what is this bird?" Your answer might be: "a sparrow". Your child will be satisfied—but it hasn't really learned a thing about sparrows. How they live, what kind of nest they build, how they raise their young, if the couple stays together or just meets accidentally for raising offspring, what they eat, if they migrate south in the winter, how they relate to other birds, and so on and so forth. Having a **name** for something does *not* mean that you *know* anything about the thing you named (except, of course, if you know the hidden ["true name"](#)).

Your child, by the way, probably would also have been satisfied by answers like: "a sperling" (German for sparrow), "some kind of finch" (correct) or "it's a young thrush; it will grow bigger when it gets older" (wrong, but plausible to a child and probably many adults).

[Basic
Module](#)

Glossary

- Have you ever been satisfied with answers like those above to your questions about steel? Could you tell if somebody giving those answers was out of his depth? How can your child tell that you are out of your depth when you provide answers to its questions? In particular, when you're not even sure yourself if your answer is right or wrong—after all, a sparrow might be some kind of thrush. Your child can't tell. Neither can you, the non-scientists out there, when you encounter information to steel and swords that is a bit off or just wrong but looks reasonable. You find this kind of (mis)information for example in all [museums](#)—without fail!

Being a Materials Scientist who practiced and taught the field for many years, I do notice if what I read about steel and swords is wrong or not quite convincing.

However, there is no such thing as complete knowledge when it comes to the nitty-gritty. I do *not* claim that I know all there is to know about iron, steel and swords. I'm very grateful about this because scientists like me would not be able to hold nice jobs if everything there is to know about steel (or aluminum, or silicon, or superconductors, or organic semiconductors, or ...) would be already known.

This means that I have to make educated guesses on occasion because I don't know for sure. I even might be proved wrong here and there. Either because what scientists think they know at present about some particular topic will prove to be not quite correct in the future (then I couldn't know better) or because I personally got it wrong or presented it somewhat skewed (more likely).

Rest assured, however, that there will be no major mistakes in the core of what you will read here.

- One day in the not too distant future we shall know (almost) all there is to know about *steel*. However, we will never know all there is to know about *swords* for the simple reason that most swords forged in the past do not exist anymore. They have died and turned to rust, achieving steel nirvana. At best they left a rust-colored spot in the earth.

The same is true for the people who made and used them. They are all dead too. Most of them didn't leave a single trace. From a few we might find a bone or two but that will not tell us much about the person and how he made or used swords.

So as soon as I look back into ancient times, without much recorded history and few surviving iron artifacts, I need to do what all historians do:

I guess a lot

- However, I don't just make wild guesses but educated guesses like serious archeologists and historians. That means that I do take into account all the information accrued over the years from analyzing artifacts and the ancient lore that has survived. While I certainly know far less about that than professional archeologists or historians, I can compensate this deplorable weakness to some extent by knowing more about what can be done, and what cannot be done, with materials like iron and steel.

Now let's look at the *hard* questions, the "**why and how**" questions. This Hyperscript is about the answers to those questions. Let's look at the "*what is?*" questions from above once more but now with *why* and *how* in mind:

- So a little bit of carbon makes iron hard? Indeed—but *why*? And *how*?
- *Why*, if you put a bit more carbon into your iron than just "a little bit" (to be more precise: more than about 1 %), will it now tend to be *brittle*?
- *Why* does *carbon* harden iron while *sulfur* does not? *How* about phosphorous? Or boron, oxygen, lead or some of the other easily available **80** elements from the [periodic table](#)?
- *Why* are damascene swords supposed to combine just the *good* properties of the two kinds of steel they are made from, and not the *bad* ones? Or do they?

Did you miss something? No? You're not paying attention. A written something of this kind usually comes with a preface where the author goes on and on about his inner workings and who contributed to his work. I spared you that. Well—not quite. [Here](#) it is.