METALS
Terminology and Classification

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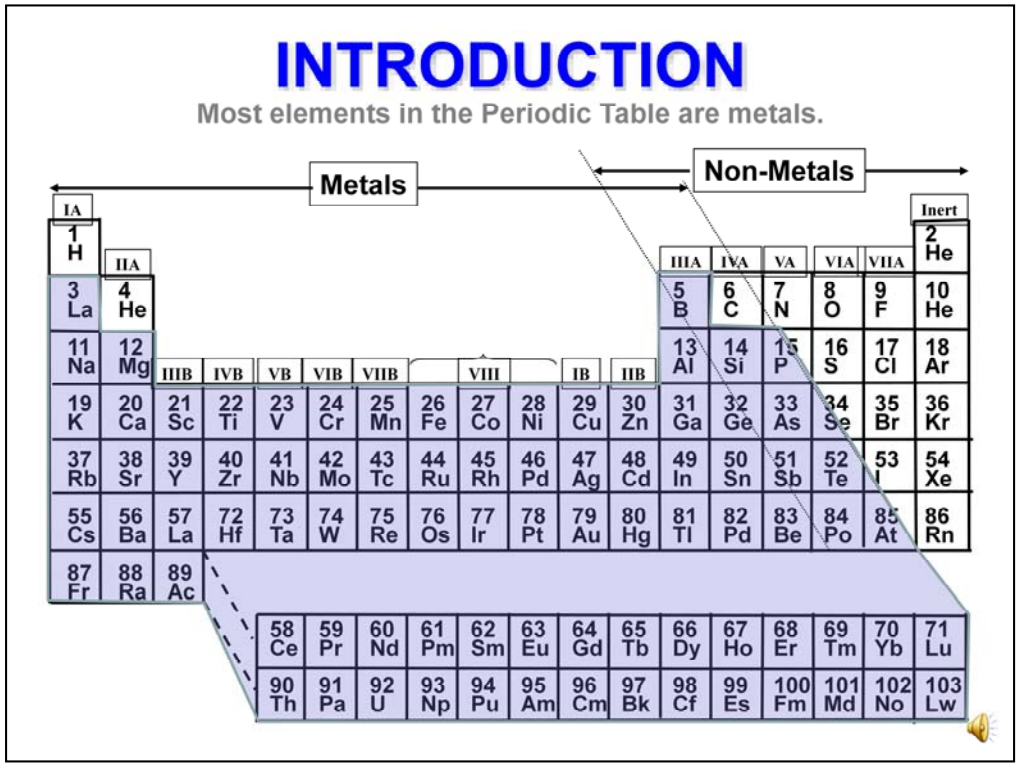
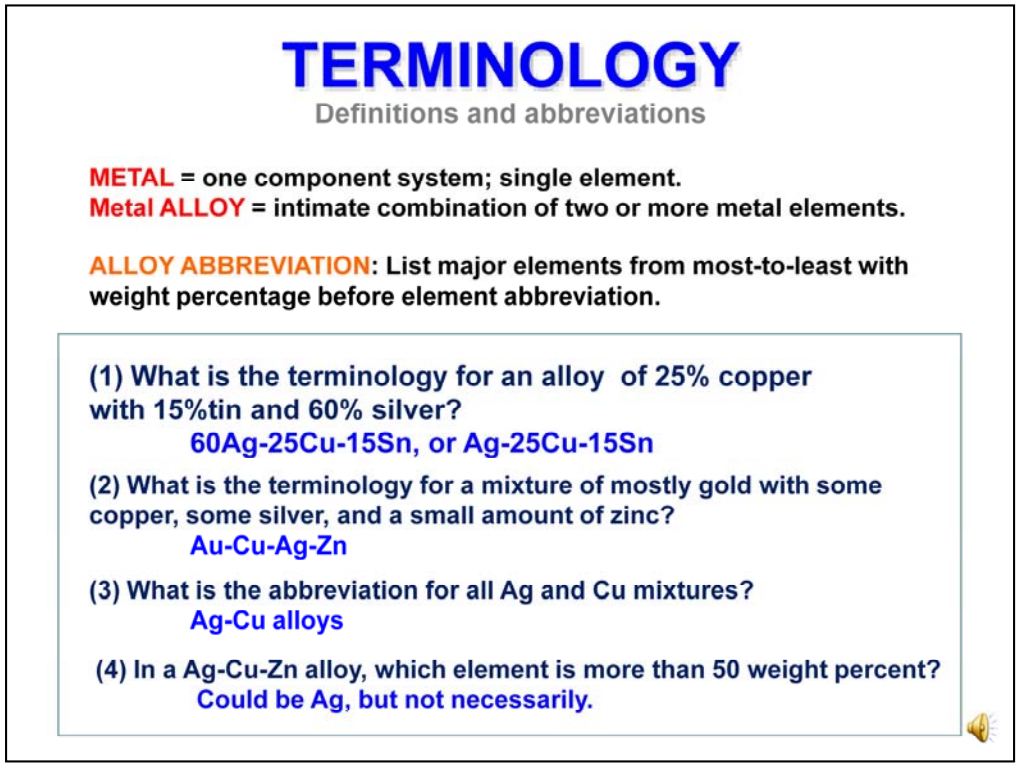
Metals are still a major part of the dental armamentarium. This module will examine the correct terms to use in describing metallic systems and review the classification systems that might come up as part of dentistry. Metals are found almost everywhere as part of the crust of the earth but are relatively hard to refine. Most metallic elements have a propensity to corrode or oxidize. Thus they are found as ores or oxides. By adding heat, one can chemically destroy the oxide, drive off the oxygen, and re-obtain the pure metal. Very few things are found in an almost pure state, except things such as gold. Because of gold's relative resistance to corrosion, it has been in popular use in dentistry for more than 150 years.



As we have noted before, **[CLICK]** most of the elements in the periodic table are metals.



Technically, the term “METAL” should only be used for a pure element. All mixtures of metallic elements are referred to as METAL ALLOYS or just ALLOYS.

[CLICK] An alloy is represented as the string of metal abbreviations listed with hyphens between the elements. The most prevalent element is listed first. If the weight percentages are included then those numbers are placed just in front of the elements. An 80% nickel alloy that contains 20% chromium is represented as 80Ni-20Cr. Sometimes the percentage of the major element is not shown. A steel alloy might be list as Fe-0.8C-0.15Si. Collections of alloys with the same major elements may exclude the percentages, such as Au-Cu alloys. Sometimes all possible alloys of a single major element may be just called something like Au alloys.

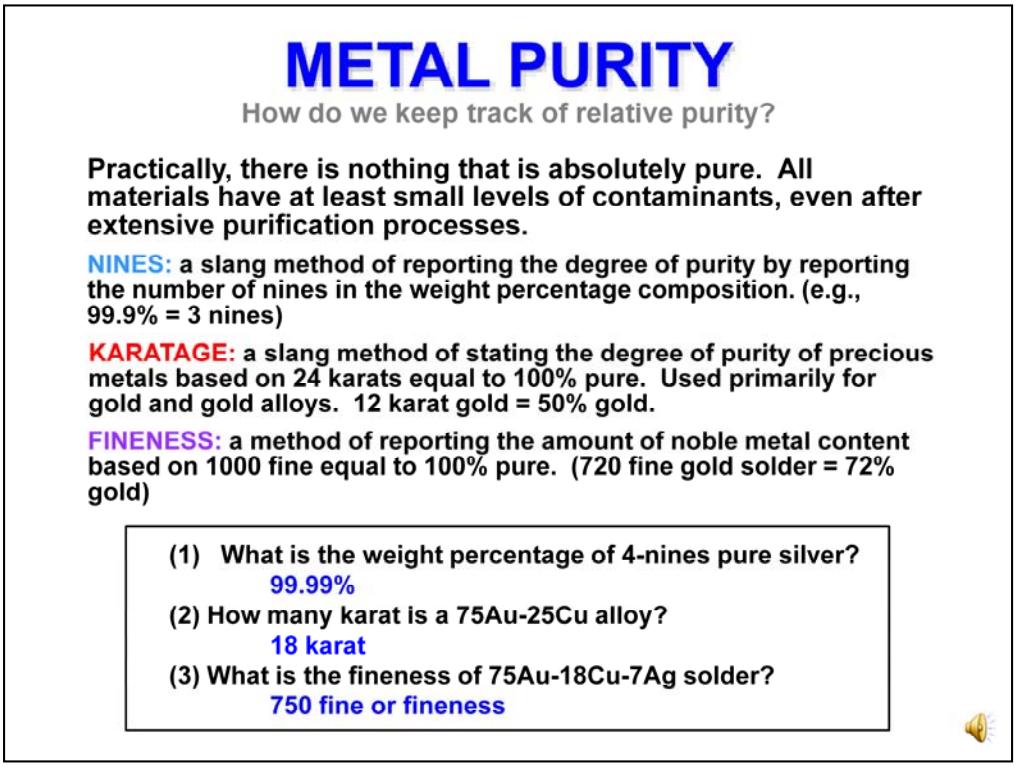
Practice the terminology for a second. **[CLICK]**

(1) What is the terminology for an alloy of 25% copper with 15% tin and 60% silver? **[CLICK]** 60Ag-25Cu-15Sn or Ag-25Cu-15Sn. **[CLICK]**

(2) What is the terminology for a mixture of mostly gold with some copper, some silver, and a small amount of zinc? **[CLICK]** Au-Cu-Ag-Zn. **[CLICK]**

(3) What is the abbreviation for all Ag and Cu mixtures? **[CLICK]** Ag-Cu alloys. **[CLICK]**

(4) In a Ag-Cu-Zn alloy, which element is more than 50 weight percent? **[CLICK]** It could be Ag but it does not have to be. The alloy could be 45Ag-35Cu-20Zn and still be represented by that abbreviation.



Technically, all mixtures are alloys. However, when just a very minor amount of material is mixed into an otherwise almost pure metal, the minor elements are considered contaminants. They usually arise because the process of purification is unable to remove the last little bit of material easily. It is still important to keep track of the purity and we do so in a variety of ways.

[CLICK] If an alloy is 99% pure gold we talk about it as 2-nines pure. If it is 99.99% pure, then we call it 4-nines pure. The number of nines expressing the weight percentage of the main element is the nines purity. This is very common as a way to express the purity for Au, Ag, and other precious metals. Precious metals are ones with high economic value.

[CLICK] Gold has traditionally be assessed in terms of the gold content of the alloy as well. A very old scale is karatage or karats. Pure gold is 24 karats. Anything less than 100% Au is less than 24 karats. If an alloy is 50% gold then it is 12 karats. This scale is confined to precious metal assessment and usually just used for gold alloys.

[CLICK] A system similar to karatage for tracking gold or other precious metal content of alloys is called fineness. It assumes that 1000 fine is 100% purity. A gold alloy that is 70% Au is named 700 fineness. This scale has been more popular for describing gold and silver solders. We use gold solders in dentistry and so this term will come up later.

Let's see if you can use these terms. **[CLICK] [CLICK]**

(1) What is the weight percentage of 4-nines pure silver? **[CLICK] [CLICK]**

(2) How many karats is a 75Au-25Cu alloy? **[CLICK] [CLICK]**

(3) What is the fineness of a 75Au-18Cu-7Ag solder? **[CLICK]**

There is a great variety of classification methods for alloys based on historical priorities for creation, selection, or use. We will address a universal system shortly.

Most alloys can be quickly divided into CAST or WROUGHT systems based on their intended method of fabrication for end uses. **[CLICK]** Cast alloys as melted, cast, and then cleaned up to make a final shape. **[CLICK]** Wrought is the past participle of the word work. It means that you are going to distort the original shape to make the final shape.

Most alloys in use in the world are based on iron. **[CLICK]** With judicious additions of small amounts of carbon, iron becomes steel. **[CLICK]** With the addition of chromium to steel, one obtains stainless steel. **[CLICK]** Small amounts of nickel are generally added to stabilize the chromium. You should know these definitions.

Iron, steel, and stainless steel alloys may have several possible phases present [austenite, ferrite, and/or martensite] and may be named based on the major phase. In the early days of metallurgy, phases were often named for the discovers and so austenite and martensite refer to people's last names.

It is also common to cluster alloy types based on final applications – such as stainless, heat-resistant, or tool steels. This list could be quite extensive in terms of categories.

Finally, certain trade or brand names become major ones and then become the names of the classes of alloys. There is a specific formula for the original alloy but many subsequent variations may be included.

Now try to think about the great variety of metal or alloy applications in the dental office. **[PAUSE]**

Office furniture **[CLICK]**

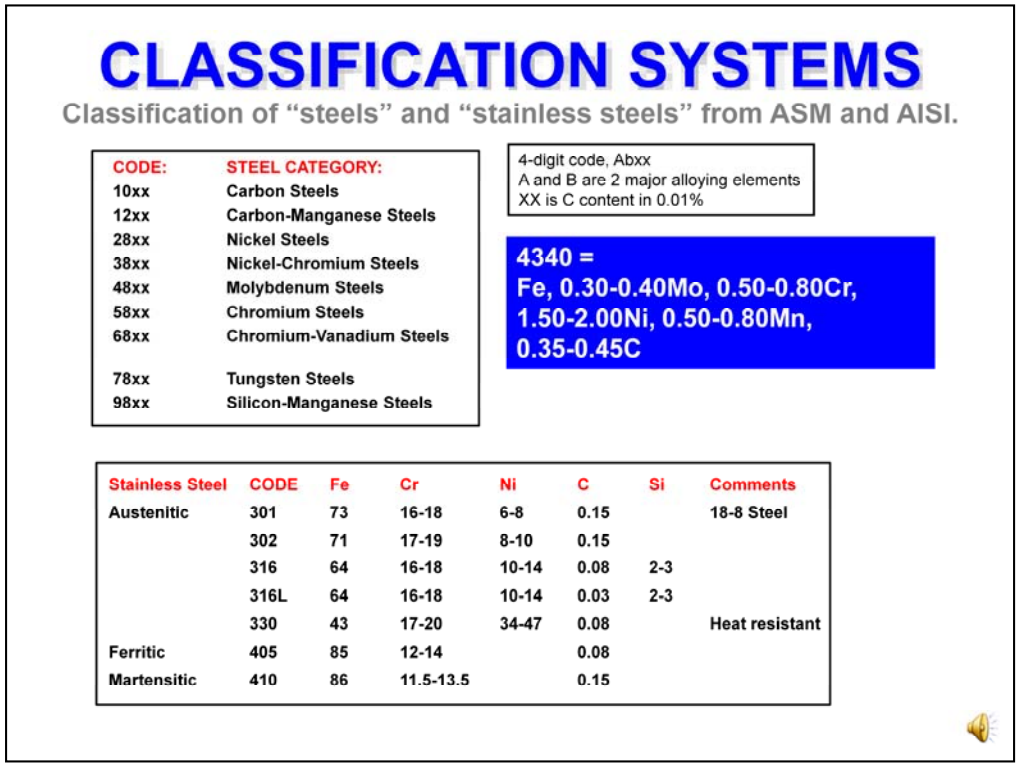
Office equipment **[CLICK]**

Dental armamentarium **[CLICK]**

Restorative materials **[CLICK]**

[PAUSE for 8 seconds]

It is quite diverse.



As just noted, most of the alloys of commercial interest are based on iron. Therefore, more sophisticated naming systems have arisen to manage the many variations of alloys. Both ASM (American Society of Metals) and AISI (American Iron and Steel Institute) have come up with classification systems. Let's look at systems for steels and for stainless steels. Because these alloys tend to have many different elements and carefully added concentrations of elements, the abbreviations are replaced by numbering codes.

[CLICK] Traditional steels are classified using a 4-digit code, where the first two digits are codes for the 2 major alloying elements with Fe, and the last two digits represent the C content in 0.01%. Check the table above. 10xx refer to carbon steels. 78xx refer to tungsten steels. **[CLICK]** If you look up the code for 4340 you see that the composition is complicated.

[CLICK] Stainless steels use a 3-digit numbering system to represent steels with specific types of phases present. Austenite steels are 300-series steels. In dentistry we are interested in stainless steels. 316 is an austenitic stainless steel. 316L is a special version for dentistry and medicine that has lower carbon content.

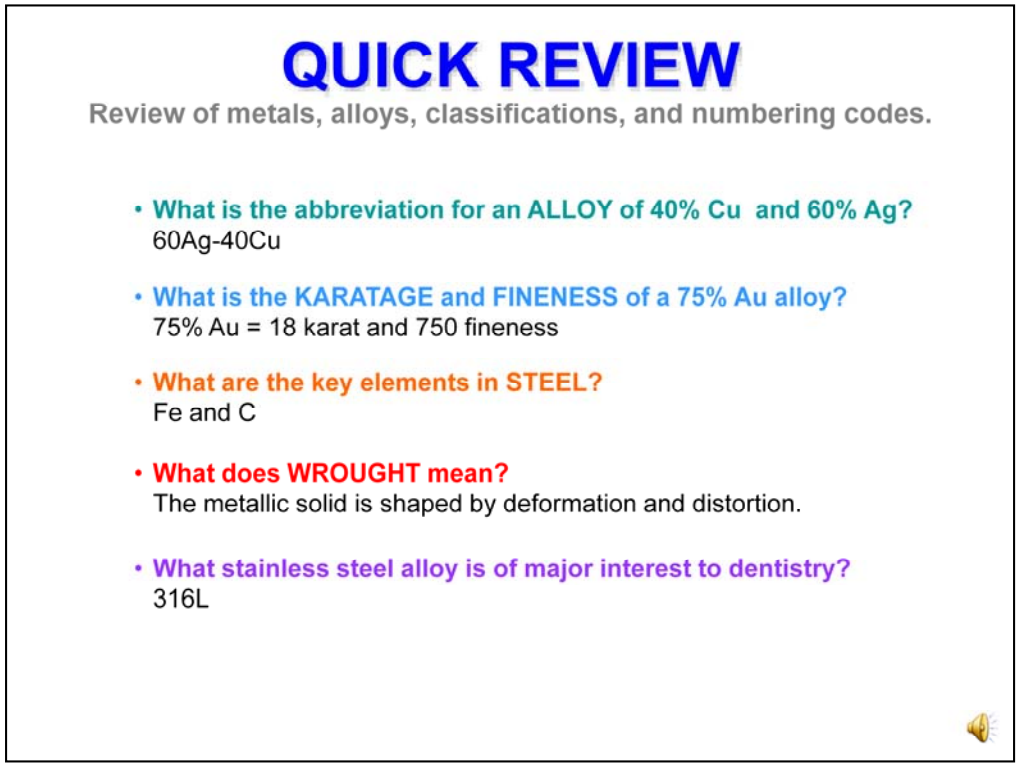
Stainless steels contain nickel. 11% of women have nickel allergies? Is their contact with stainless steel something that precipitates an allergic response? As you will find out later, the Ni must be somehow released and in a form to cause the allergic response. It is fairly stable and tightly bound in stainless steel and almost never causes any problems during normal contact. However, in other alloys this is not necessarily the case.

CLASSIFICATION SYSTEMS

Universal system for classifying all alloy types.

CODE:	CATEGORY:	Number:
Axxxxx	Aluminum and Aluminum Alloys	346
Cxxxxx	Copper and Copper Alloys	366
Exxxxx	Rare Earth Metals and Alloys	41
Fxxxxx	Cast Irons	93
Gxxxxx	AISI and SAE Carbon and Alloy Steels	198
Hxxxxx	AISI and SAE H-Steels	87
Jxxxxx	Cast Steels (except Tool Steels)	193
Kxxxxx	Miscellaneous Steels and Ferrous Alloys	423
Lxxxxx	Low Melting Metals and Alloys	68
Mxxxxx	Miscellaneous Non-Ferrous Metals and Alloys	66
Nxxxxx	Nickel and Nickel Alloys	63
Pxxxxx	Precious Metals and Alloys	39
Rxxxxx	Reactive and Refractory Metals and Alloys	82
Sxxxxx	Heat and Corrosion Resistant (Stainless) Steels	118
Txxxxx	Tool Steels (Wrought and Cast)	86
Zxxxxx	Zinc and Zinc Alloys	16

The Unified Numbering System (UNS) is an attempt at a universal code for all alloys and clusters things together based on their major alloying element and/or specialized application. **[CLICK]** The first letter in the code indicates the first major classification level. **[CLICK]** P is for precious metals and alloys and would include gold alloys in dentistry. Five other codes are added to designate the specific alloy composition. You need to look up the alloy composition from the code. At the right in the table, you can see the number of alloys assigned to these codes in the year 2000. Iron-based alloys clearly dominate, but copper and aluminum alloys are very common as well.



Here is a quick review of the concepts from this module.

[CLICK] (1) What is the abbreviation for an ALLOY of 40% Cu and 60% Ag.
[CLICK]

[CLICK] (2) What is the KARATAGE and FINENESS of a 75% Au alloy?
[CLICK]

[CLICK] (3) What the key elements in STEEL?
[CLICK]

[CLICK] (4) What does WROUGHT mean?
[CLICK]

[CLICK] (5) What stainless steel alloy is of major interest to dentistry?
[CLICK]

THANK YOU.