Elements in groups 3-12 are d-block metals, often referred to as "transition metals." Here are some d-block metals naturally occurring in biology:

- V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Mo, Cd, W.

d-block metals used as probes of biological systems and/or pharmaceuticals include: Cr, Co, Y, Tc, Ag, Cd, Pt, Au, Hg.

Roles of metals in biology include:

- Global cycling of nitrogen, carbon, hydrogen; biosynthesis of vitamins and deoxynucleotides; respiration; photosynthesis etc.

**IN THEIR OWN WORDS**

Dr. Sarah Bowman studies a protein from a pathogenic bacterium that is found in the stomach and is known to cause ulcers. She explains how the bacterium survives in the low pH environment of the stomach by using nickel-dependent proteins to buffer the acidity of its environment.
II. Coordination Complexes

A key feature of transition metals is their ability to form complexes with small molecules and ions.

Positive metals ions can attract electron density, usually a lone pair of electrons from another atom or molecule to form a coordination complex.

Donor atoms are called ligands (Lewis __________ – typically _______________ one lone pair of electrons)

Examples of ligands: \( \text{NO}_2^- \), \( \text{O}^2- \), \( \text{CN}^- \), \( \text{SCN}^- \), \( \text{NCS}^- \)

Acceptor atoms are transition metals (Lewis __________ – _______________ one lone pair of electrons)

Examples of transition metals: Ti, Cr, Mn, Fe, Co, Ir, Pt, etc

Coordination complexes are composed of metals that are surrounded by ligands.

Example:

Coordination number (CN) is the number of ligands bonded to the metal ion.

Here CN = 6. _______ ligands comprise the primary coordination sphere.

CN numbers typically range from 2-12. Six is the most common.

Coordination Complex Notation

\[ [\text{Co(NH}_3)_6]^{3+} \quad 3\text{Cl}^- \]

\[ \text{NH}_3 \text{ within bracket is bound to Co; Cl outside bracket is a counter ion.} \]
Chelates: another name for coordination complexes, from the Greek word for claws.
Ligands _______________ a metal by binding with one or more sites of attachment

Monodentate (one tooth): one point of attachment
Bidentate: __________ points of attachment
Tridentate: __________ points of attachment
Tetradentate : ________points of attachment
Hexadentate: ________ points of attachment

Examples of multidentate chelates
1. Vitamin B_{12}.
Cobalt is coordinated by a planar tetradentate ligand (corrin ring).
It is also coordinated by an upper axial ligand (5'-deoxyadenosine) and a lower axial ligand (dimethylbenzimidazole)
It’s structure was determined using X-ray crystallography by British Crystallographer Dorothy Crowfoot Hodgkin. She won the Nobel Prize in 1964 for this work and for determining the structure of pencillin.
2. Ethylenediamine tetraacetic acid (EDTA).

Geometry around M is

dentate

Binding of EDTA is favorable.

Six molecules of H₂O are released for every 1 molecule of EDTA bound.

The Chelate Effect refers to the unusually favorable entropic factor accompanying release of non-chelating ligands (usually H₂O) from the coordination sphere.

Uses of EDTA

Isomers

Geometric isomers can have vastly different properties.

[Pt(NH₃)₂Cl₂] has two geometric isomers

Cisplatin cured Lance Armstrong of cancer.
Optical isomers (enantiomers, _____________ molecules) are non-superimposable mirror images of each other.

Chiral molecules have different properties in chiral environments (such as a human body).

III. d-Electron Counting in Coordination Complexes and d-Orbitals

d-electron count of metal = group number (periodic table) - oxidation number of metal

1. find oxidation number

   for Co in [Co(NH$_3$)$_6$]$^{3+}$ = __________

   Hint: NH$_3$ is a neutral ligand

2. d-count is 9 - _____ = _____

   d$^{??}$

Practice with d-counts

<table>
<thead>
<tr>
<th>Complexes</th>
<th>Oxidation number of metal</th>
<th>d-count</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Ni(CO)$_4$]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[Co(H$_2$O)$_2$(NH$_3$)Cl$_3$]$^-$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

mirror plane
**d Orbitals**
There are five d orbitals: \( d_{xy}, d_{xz}, d_{yz}, d_{x^2-y^2}, d_{z^2} \).

You need to be able to draw their shapes.

- \( d_{x^2-y^2} \) has maximum amplitude along the y and z axes and a doughnut in the xy plane.
- \( d_{z^2} \) has maximum amplitude along the x and y axes.
- \( d_{xy} \) has maximum amplitude 45° to the x and y axes.
- \( d_{xz} \) has maximum amplitude 45° to the x and z axes.
- \( d_{yz} \) has maximum amplitude 45° to the y and z axes.