corresponding iron (III) comple... $HClO_4$ is $3\times10^{...}$

## 8.7. Vitamins and Coenzymes

*Vitamins* are traces of organic, metallo-organic or organometallic substances, essential for functionings of most life forms. Some organisms are unable to synthesize vitamins. They obtain these important chemicals from exogeneous sources. Vitamins may be water soluble or water insoluble. Water soluble vitamins function as building block components of a number of different *coenzymes* or *cofactors* and play vital roles in central metabolic pathways. Coenzymes or cofactors help the enzymes in tailoring to fit the substrates. These are frequently metal ions, metal complexes, nucleotides, *etc.* When the coenzyme is bound so firmly to the enzyme that it can not even be removed by dialysis, it is called a *prosthetic group*, *e.g.* the heme groups in hemoglobin, myoglobin, cytochromes, catalase and peroxidases are prosthetic groups. Vitamin $B_{12}$ and vitamin $B_6$ have interesting bioinorganic chemistry and so deserve special consideration.

### (a) Vitamin $B_{12}$ and $B_{12}$-Coenzymes

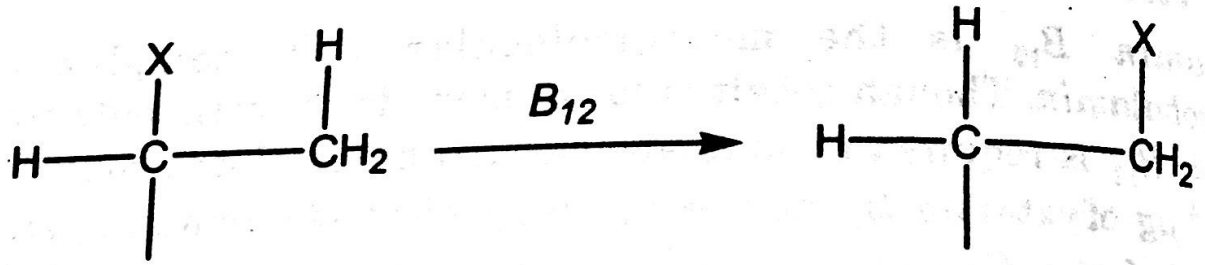
*Vitamin* $B_{12}$ is the macromolecular $Co^{III}$ complex called *cyanocobalamin*. Though cobalt is long known for growth, only traces of *vitamin* $B_{12}$ is required by animals. Normal human blood contains only $2\times10^{-4}$ $\mu g$ of vatamin $B_{12}$ per *ml*. It was first isolated from *anti-pernicious anaeamia factor*. *Pernicious anemia* is caused due to vitamin $B_{12}$ deficiency in diet and failure to absorb it from injested food. Neither plants nor animals can synthesize vitamin $B_{12}$. It is biosynthesized only by certain bacteria, *viz.*, *propeionibacterium sherimanii*, *streptomyces olivaceus*, *etc*

organometallic ...

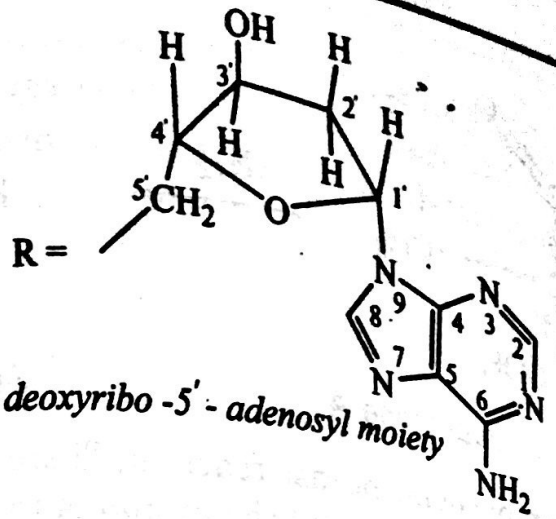
**Reaction requiring vitamin $B_{12}$ coenzymes :**

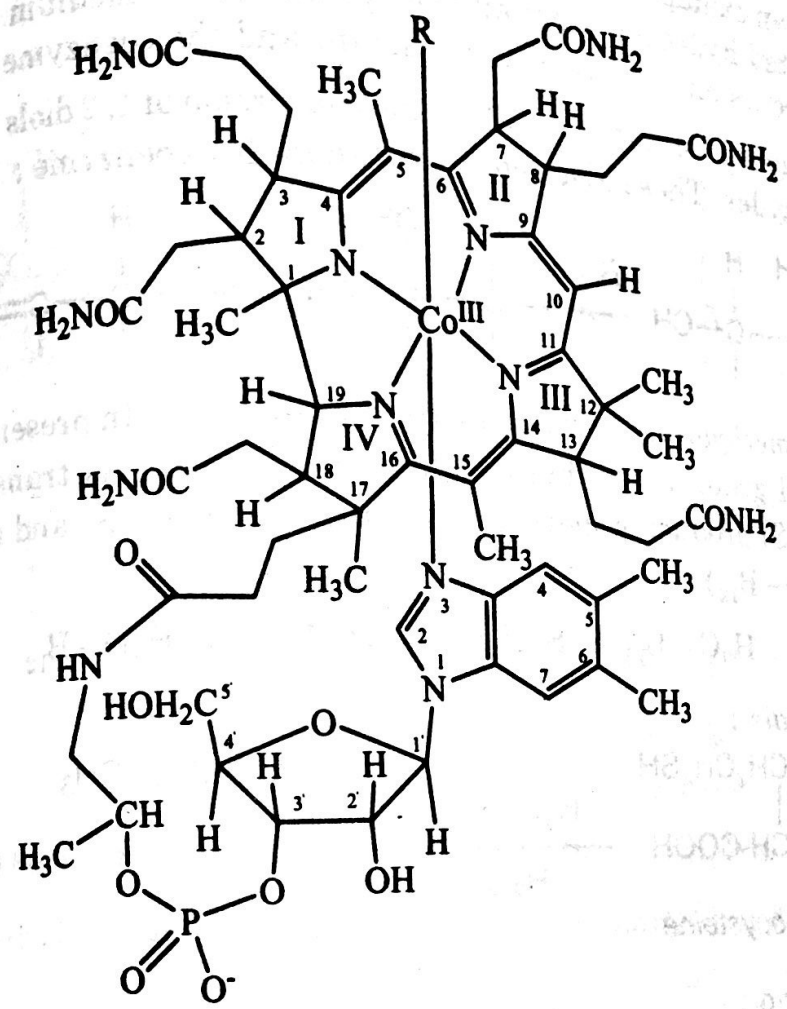
*(i) Isomerase reactions :*

Vitamin $B_{12}$ serves as the cofactor in several enzyme catalyzed reactions involving swapping of a H atom with suitable substituent (X) on adjacent carbon atoms :



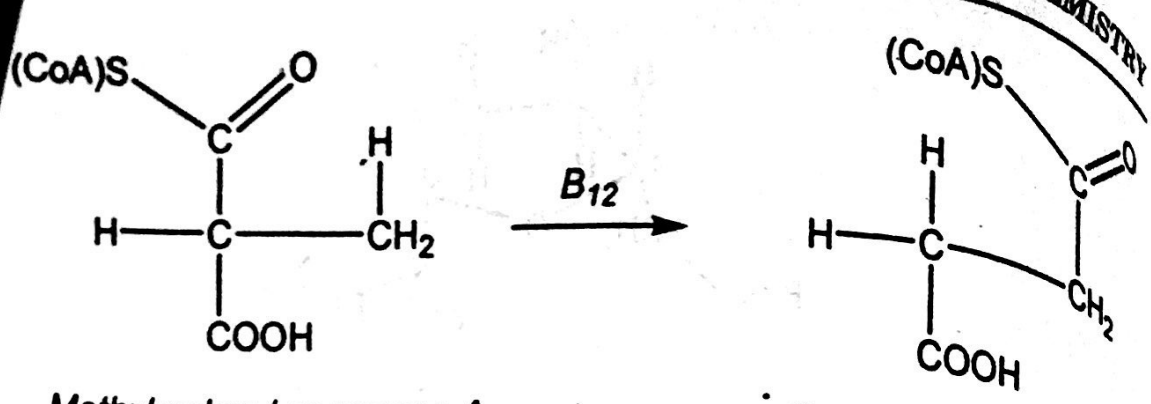

In mammalian system, the only enzyme requiring vitamin $B_{12}$ coenzyme as the cofactor, is *methylmalonylcoenzyme A mutase*, which catalyzes the conversion of *methyl malonyl coenzyme A* into *succinyl coenzyme A*.



| *R* | *Representation* | *Cobalamines* |
|---|---|---|
| 2′-deoxyriboadenosyl | $B_{12}$ coenzyme | 2′-deoxyriboadenosyl cobalamine (native form) |
| $H_2O$ | $B_{12}H_2O$ | Aquacobalamine |
| $OH^-$ | $B_{12}OH$ | Hydroxocobalamine |
| $CH_3$ | $B_{12}CH_3$ | Methylcobalamine |
| $CN^-$ | $B_{12}CN$ | Cyanocobalamine (isolable form) |

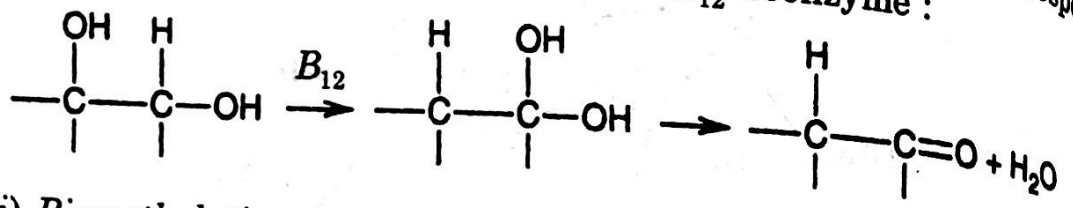
**Fig. 8.109. Structure of vitamin $B_{12}$ coenzymes (cobalamines).**




*Methylmalonyl coenzyme A* *Succinyl cenzyme A*

This is an example of isomerase reaction. There is no exchange between the migrated hydrogen atom and the proton of the medium. Exchange of H atom occurs only between the reactant and the coenzyme.

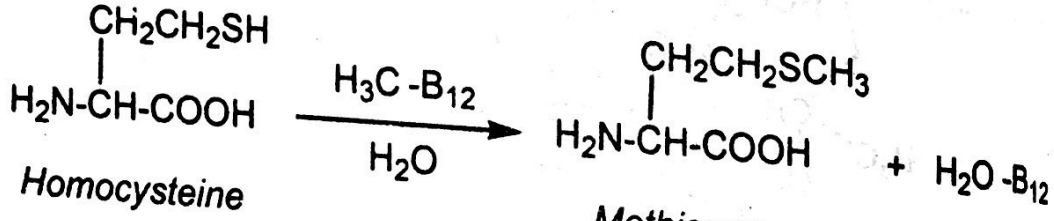
*Dioldehydrase* enzymes catalyze the conversion of 1, 2 diols to corresponding aldehydes. These also require vitamin $B_{12}$ coenzyme :




(*ii*) *Biomethylation or methyl transfer reactions* : In presence of water, the methyl group of methyl cobalamine $H_3C-B_{12}$ is transferred to a substrate (S) producing methylated substrate ($H_3C-S$) and aquacobalamine ($H_2O-B_{12}$):

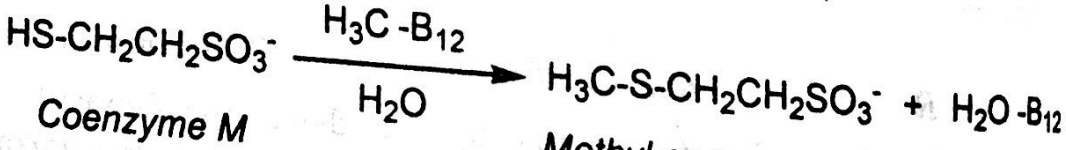
$$H_3C-B_{12} + S, H_2O \rightarrow H_3C-S + H_2O-B_{12}$$

*In animals* :




*Homocysteine* *Methionone*

*In bacteria* :




*Coenzyme M* *Methyl coenzyme M*

Biosynthesis of metal alkyls is recognised as a microbial response to the toxicity caused by heavy metals. Formation of extremely poisonous *methyl mercury* cation, ($H_3CHg^+$), as one of the products of the reaction of $Hg^{II}$ salts with methylpentacyanocobaltate (III) according to :

$$[H_3CCo(CN)_5^{3-}] + Hg^{2+} + H_2O \rightarrow [(H_2O)Co(CN)_5^{2-}] + CH_3Hg^+$$

points to the involvement of *methyl cobalamin* ($H_3C-B_{12}$) (*i.e.*, $R=-CH_3$) in biological methyl transfer reactions, which are responsible for the formation of methyl mercury ($H_3CHg^+$) and dimethyl mercury ($(H_3C)_2Hg$ (Fig. 8.110).

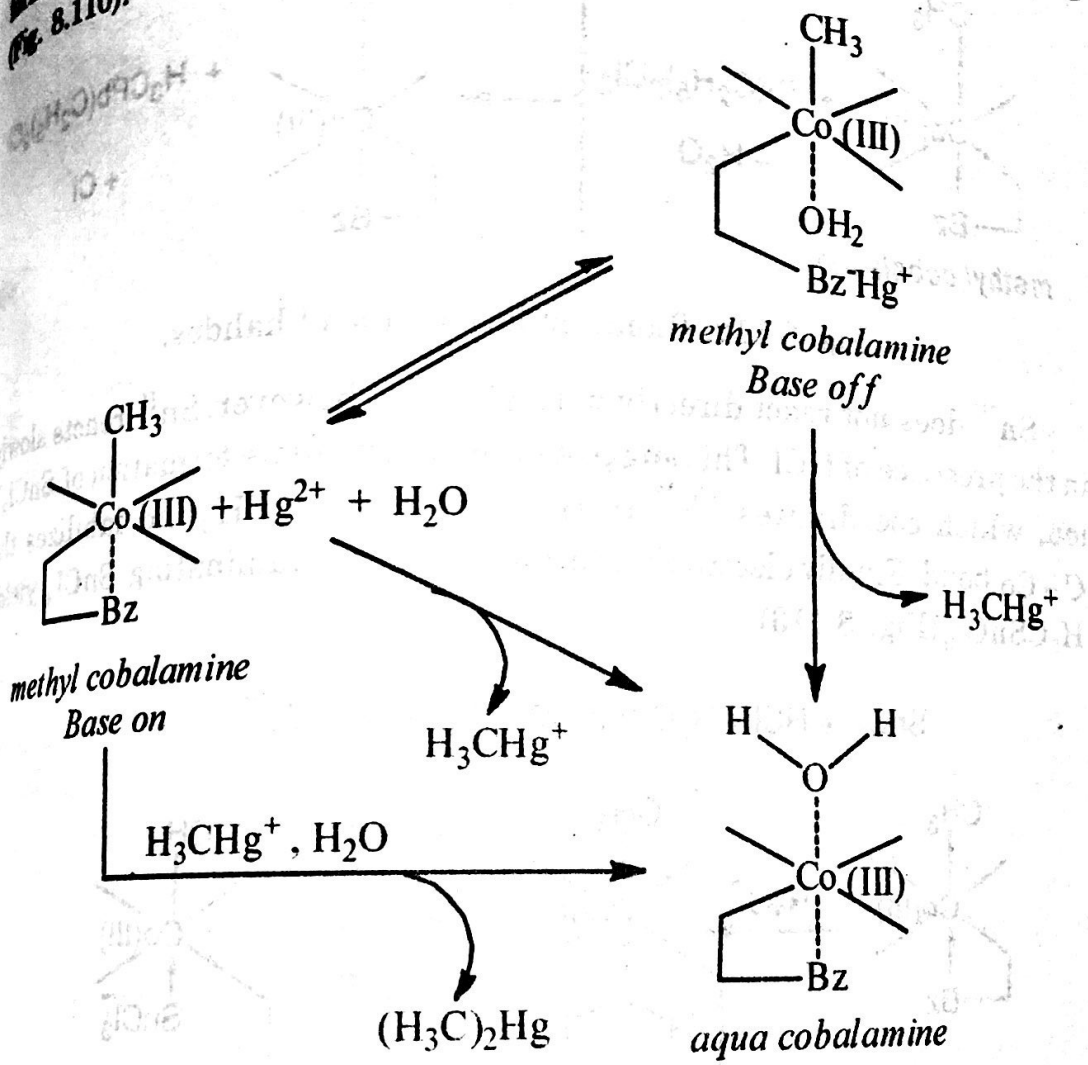
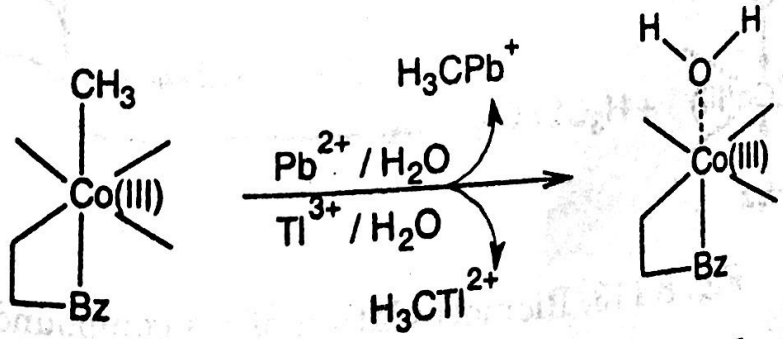



Fig. 8.110. Methyl transfer reactions: biomethylation of $Hg^{2+}$.

Biomethylation of $Pb^{II}$ and $Tl^{III}$ occur similarly (Fig. 8.11).




*Methyl cobalamine* *Aquacobalamine*

Fig. 8.111. Biomethylation of $Pb^{2+}$ and $Tl^{3+}$.

Biomethylations of lead and tin are important in the environmental

Reactions of lead halide compounds with methyl cobalamin, $H_3C-B_{12}$, are slow, but the rates are enhanced in the presence of halide abstracting agents such as silver acetate (Fig. 8.112).

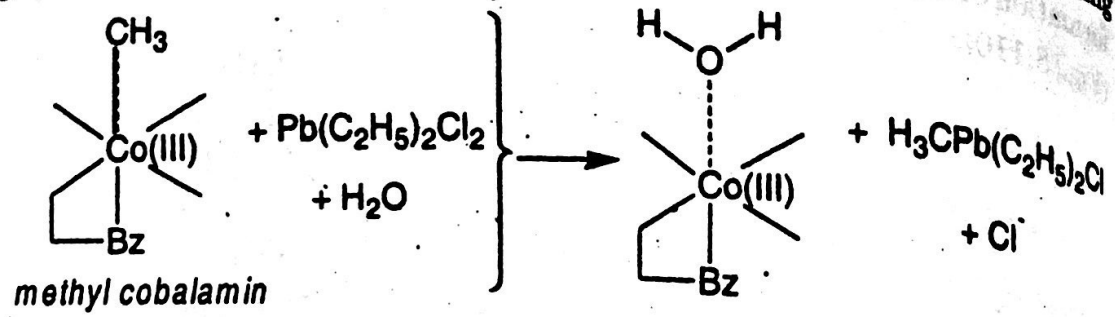



Fig. 8.112. Biomethylation of lead halides.

$Sn^{IV}$ does not react directly with $H_3CB_{12}$, however, $Sn^{II}$ reacts slowly in the presence of HCl. This suggests the intermediate formation of $SnCl_3^-$ ion, which coordinates $Co^{III}$ in $H_3CB_{12}$ *trans-* to $CH_3$ and labilizes the C – Co bond. Finally electrophilic attack by the contaminating $SnCl_4$ yields $H_3CSnCl_3$ (Fig. 8.113).

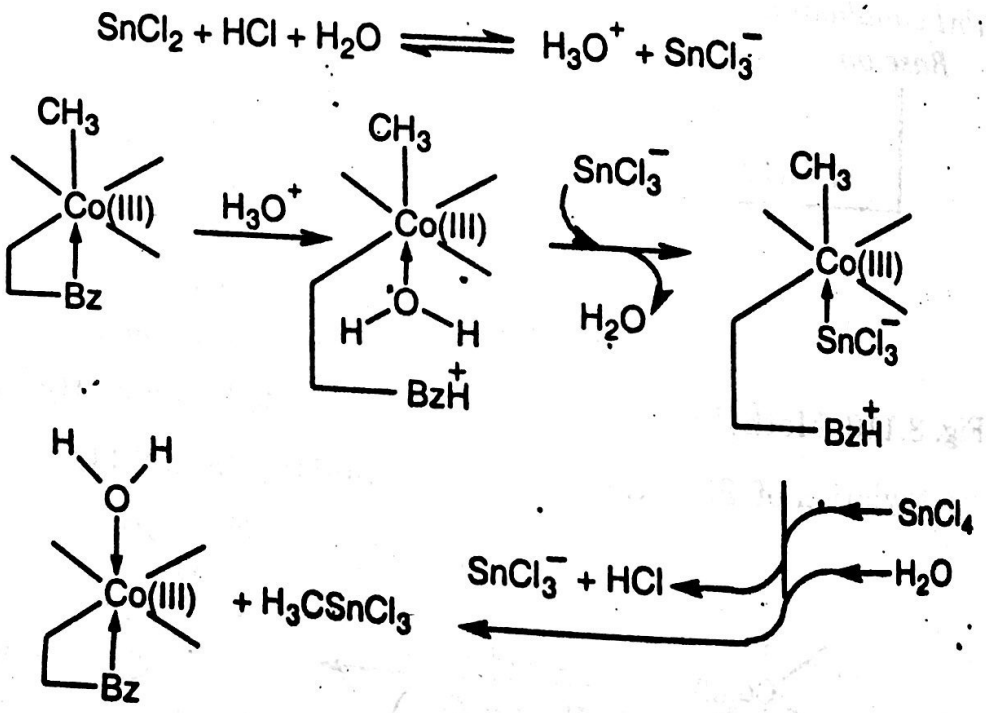



Fig. 8.113. Biomethylation of tin compounds.

$H_3C-B_{12}$ is also involved in biomethylation of proton to methane, of carbon monooxide to acetic acid and also of platinum, palladium, gold, sulfur, selenium, tellurium and arsenic to cooresponding methylated derivatives. Most of the methylated derivatives are even more poisonous than the parent elements.