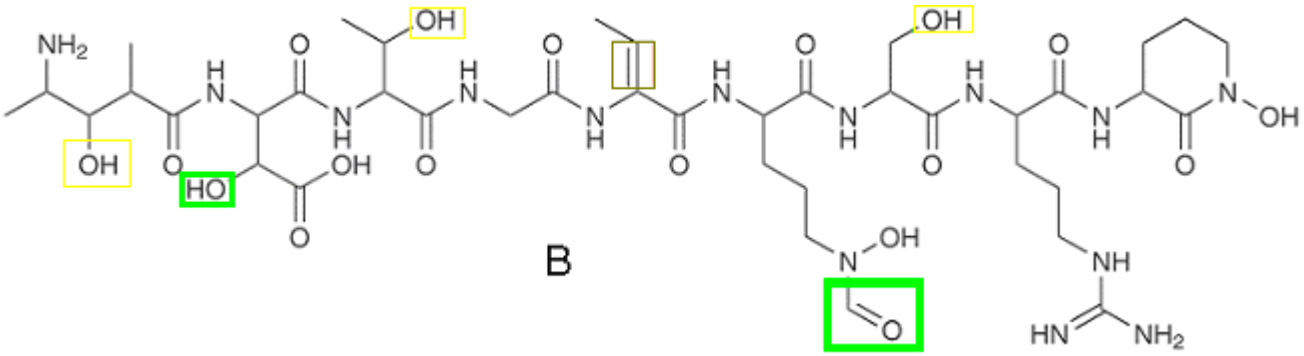
students S

National Student Team Contest (first stage)
Solution of task 3. Gold and bacteria

1. Unlike iron bacteria don't need gold. Gold ions are oxidant and could harm cells, and even the resulting nanoparticles could possess unnecessary activity (i.e. interact with thiol groups). So, bacteria **X** (*Delftia acidovorans*) neutralize it far away from bacteria. Because **B** seems to be finely tuned to bind and to reduce gold, it is probable that bacteria **X** inhabit for a long time the gold-ions rich medium (i.e. near gold deposits or on the surface of gold nuggets).

2.



One should recollect the methods of synthesis of gold (and silver) nanoparticles and find common reducing groups within the **B** molecule for common reductants:

- formyl -CHO group (hidden aldehyde) – formic acid derivatives (i.e. ammonia formate and formamide derivatives);
- α-OH to -CO_2H group – citric acid (and ascorbic acid to a certain extent);
- double bound near carboxylic acid residue – ascorbic acid to a certain extent;
- numerous alcohol groups – alcohols, diols, polysaccharides.

It is worth mentioning that the first stage of **B** oxidation utilizes oxidation of CHO group, because substitution of this group by acetyl group significantly slows down the gold nanoparticles formation.

3. The structure of **B** resembles structures of siderophores and production of B is downregulated by iron concentration as well as for typical siderophores (the more iron in environment the less the need for siderophores). In contrast to the common siderophores, the molecule **B** is rich of reducing groups which imply strong selection toward quick gold reduction. These indicate that B is structurally and evolutionally relates to siderophores (scientists say that **B** is most likely a siderophore that serves at least two purposes for this organism).

   In general, Nature produces new structures on the basis of the existing ones. Siderophore genes are vital for bacteria so it is very probable that they are in more then one copy in a genome. It is possible that in the gold rich medium a mutation in one of siderophore genes led to metallophore which slightly better chelates and (or) reduce gold ions. Subsequent natural selection in this medium led to the mutation fixation and further evolution, resulted to the molecule **B**. Secretion of **B** is still regulated by iron ions as for siderophores, and probably uses some siderophore based mechanisms (i.e. siderophores excretion, because siderophores are also excreted to the exterior in order to catch iron ions).

The well-known examples of such evolution are bacteria flagellum (originated from excretory system proteins) and blood antifreeze molecules of polar fish (originated from digestive enzymes).

4. The main directions of possible utilization are gold extraction and search for gold rich ore using detection of the increased concentration of **B** from bacteria.