Problem set for Hungarian Tour (International Chemistry Tournament)

P1. Deep sea analytics

Although manned mission visited each of the deepest points of oceans by now, still a lot of mysteries lay behind the surface as of today. Despite all the intuition, the trenches have vivid wildlife, about which we know very little, since the extreme pressures and darkness make it very difficult to tell a flatfish apart from a sea cucumber. To save this ecosystem from pollution, we need to monitor the chemical composition of deep waters. Suggest a method you would use to measure the quantity and quality of gases dissolved in the seas kilometres below the surface. What are the limitations of your system?

P2. Explore and exterminate

Mercury is a severe poison for humans, which induces memory problems amongst other symptoms. The main source of mercury in our diet is fish and shellfish, which absorb it from shallow waters, where it is accumulated from anthropogenic sources (small-scale gold production, mostly). To prevent mercury poisoning, also called Minamata-disease you need to detect and remove mercury from fish such that it remains edible.

P3. Methane hydrate

Although nonpolar methane molecules are generally regarded as hydrophobic, under high pressures and certain temperatures they can form a white solid cocrystal, called methane hydrate, which causes a lot of headache for climate scientists. The problems is, there is heck a lot of this compound on the seabed, which can decompose as the temperature increases, and methane is one of the most effective greenhouse gases. Let's assume this theory holds. This can generate a positive feedback loop, where the methane heats the planet even further, and generating further methane. How would you stop the runaway effect?

P4. Deep sea fish' colours

Lot of deep sea species emit short wavelength (blue or green) light as a trap to attract their prey when it is already nearby. On other hand, some malacosteus species emit long wavelength (red) light to illuminate their surroundings in their search for food when resources are scarce. Suggest a biochemical method so that a species can shift the wavelength of its bioluminescent light with respect to food availability.

P5. Thermotropic bacteria

Nature goes a long way to fill every niche with variety of species, such that no environment remains unpopulated by various life forms. While mostly they harvest energy from either sunlight or other beings, bacteria in the deep ocean are observed to exploit chemical energy stored in sulphates, or other compounds such as pyrite, but thermal energy is not used by any known organism.

Suggest biochemistry for a mono- or multicellular organism, which can feed on temperature variations of the environment. How would it generate ATP? Where would it live?