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A STUDY ON ROLE OF PROTEINS IN REDUCING THE LEVELS OF ARSENIC IN CONTAMINATED SOIL AND WATER

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Abstract
Chemicals found in the environment are in daily use for all and some may lead to risks. As a part of this, Arsenic contaminated soil and groundwater assure risks. Proteins of some plants' mechanisms in interacting with contaminated soil and water, were shown their unique roles of participation in lowering these risks and a study was made on this aspect.

1.Introduction

Chemicals that act as environmental contaminants in soil and which potentially cause hazards, are either inorganic or organic compounds [1].

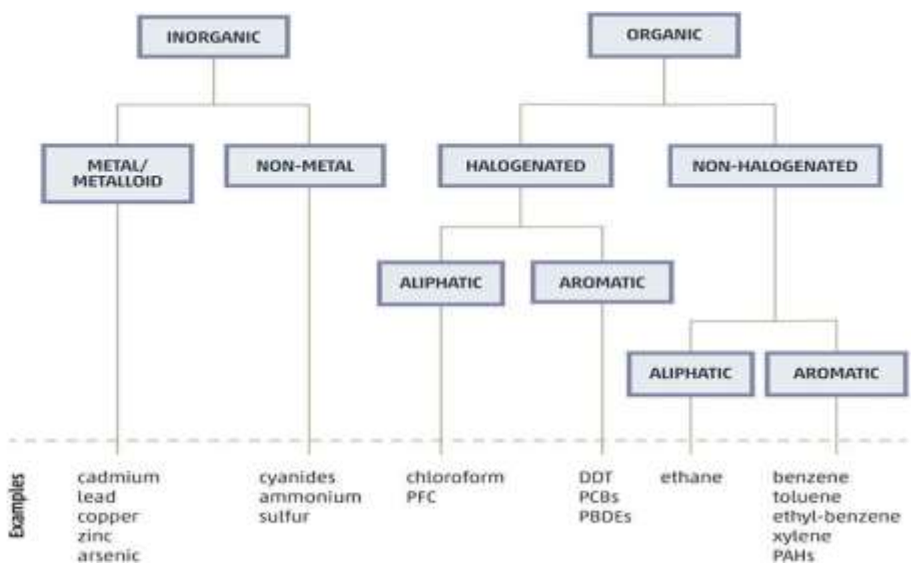

Figure 1

Figure1 introduces a systematic categorization and was taken from chapter 2 of Food and Agriculture Organization of the United Nations. The most commonly occurring inorganic soil contaminants are trace elements such as arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), lead (Pb), manganese (Mn), nickel (Ni), zinc (Zn), and radionuclides. Despite the natural occurrence of trace elements, hazard to the environment and human health can result if these elements are present at concentrations and/or in a chemical form that can be

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toxic for living organisms.While the most important chemical risks in drinking water arise from arsenic, fluoride or nitrate, emerging contaminants such as pharmaceuticals, pesticides, per- and polyfluoroalkyl substances (PFASs) and microplastics generate public concern. In this paper only arsenic was discussed [2]. An organism has many different genes, and so can produce many different proteins. These proteins have functions that affect the organism's traits.

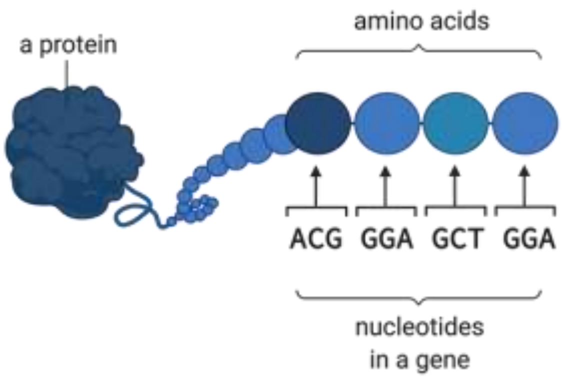

Figure 4

A protein is shown as a globular, or lumpy ball-like, shape. Stretching out from the protein is a string of amino acids, which are represented as circles. Beneath four of the amino acids is a series of letters labeled nucleotides in a gene. An arrow points from the letters A C G to one of the amino acids. Other arrows point from the letters G G A, G C T, and G G A to different amino acids. Proteins are made up of amino acids. The order of amino acids in a protein is determined by the order of nucleotides in its corresponding gene [13].

2. Literature Review

The fern *Pteris vittata* tolerates and hyperaccumulates exceptionally high levels of the toxic metalloid arsenic, and this trait appears unique to the Pteridaceae. Once taken up by the root, arsenate is reduced to arsenite as it is transported to the lamina of the frond, where it is stored in cells as free arsenite [3].

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A recent study by Cai *et al.* [4] has shown that a bacterial-like tolerance mechanism has evolved in an arsenic-hyperaccumulating fern, *Pteris vittata*, which enables it to tolerate and accumulate high concentrations of arsenic (Figure 2).

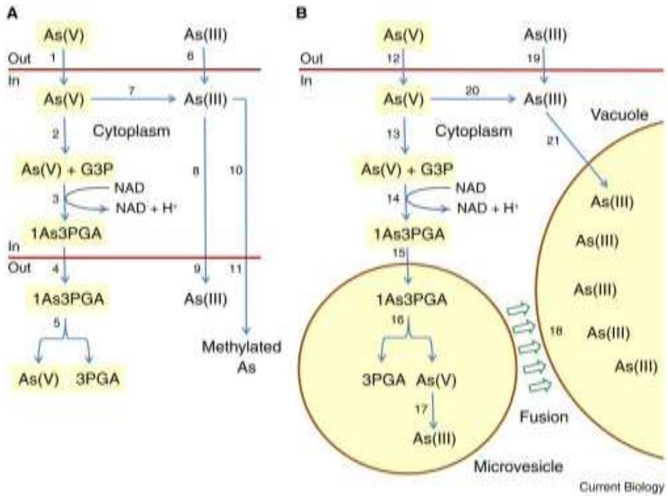

Figure 2

Brake fern, *Pteris vittata*, not only tolerates arsenic but also hyper-accumulates it in the frond. The hypothesis that arsenic hyperaccumulation in this fern could function as a defense against insect herbivory was tested [5].

Arsenic (As) contaminated soils and waters are becoming major global environmental and human health risks. The identification of natural hyperaccumulators of As opens the door for phytoremediation of the arsenic contaminant. Pteris vittata is the first identified naturally evolving As hyperaccumulator. More than a decade after its discovery, we have made great progress in understanding the uptake, transport, and detoxification of As in the fern. The molecular mechanisms controlling As accumulation in P. vittata are now beginning to be recognized [6].

3. Materials and Methods

Under materials, followed the knowledge of CmCT, where Cm : Cell Membranes, C : Catalyst and T : Tolerate

Cell Membranes

The structure and function of cells are critically dependent on membranes, which not only

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separate the interior of the cell from its environment but also define the internal compartments of eukaryotic cells, including the nucleus and cytoplasmic organelles [7]. OCT4 is a membrane protein, controlling the transfer of compounds through the cell membrane.

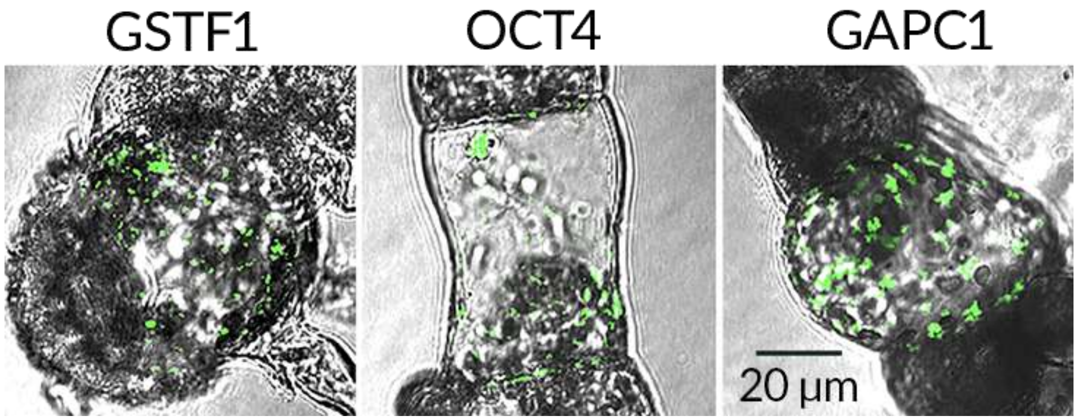

Figure 3

Figure 3 was taken from C. CAI ET AL/CURRENT BIOLOGY 2019
Pteris vittata ferns take up arsenic and store it in their fronds using three proteins, called GSTF1, OCT4 and GAPC1. Scientists forced the trio to reveal their cellular locations by making the proteins glow green, as seen in these microscope images.

Catalyst

Iron (oxyhydr)oxides play an important role in controlling the mobility and toxicity of arsenic (As) in contaminated soils and groundwaters [8].

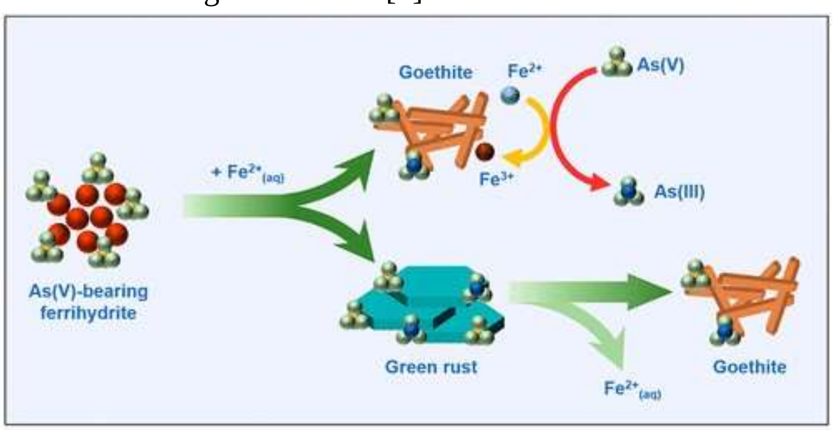

Figure 4

GST is an arsenate reductase, which serves as a catalyst to turn arsenate from the soil into arsenite, the form of arsenic that can be sequestered. Figure 4 was taken from American Chemical Society Publications.

Tolerate

The GAPC1 protein in other plants uses phosphate to help break down glucose for energy, and arsenate interferes with its normal function. In *Pteris vittata* fern, however, GAPC1 has a higher affinity for arsenate than phosphate, allowing the plant to tolerate the otherwise toxic substance [9].

Methods

In this, description and role of each protein was discussed.

Role of Protein : OCT 4

Octamer-binding transcription factor 4 (Oct4), a homeodomain transcription factor of the Pit-Oct-Unc (POU) family, is well established as one of the most important transcription factors that control the self-renewal and pluripotency of pluripotent stem cells, and is increasingly appreciated as an important non-cell surface marker for TICs [10]. OCT4 plays a role as a transcriptional activator for GDF3 transcription in pluripotent human embryonic carcinoma NCCIT cells and contributes to the understanding of the molecular networks of stem cell regulators in germ cell-derived pluripotency and tumorigenesis. Banks and her team showed that OCT4 is a membrane protein, controlling the transfer of compounds through the cell membrane.

Role of Protein : GST

The glutathione transferases (GSTs; also known as glutathione S-transferases) are major phase II detoxification enzymes found mainly in the cytosol. In addition to their role in catalyzing the conjugation of electrophilic substrates to glutathione (GSH), these enzymes also carry out a range of other functions[11]. GST is an arsenate reductase, which serves as a catalyst to turn arsenate from the soil into arsenite, the form of arsenic that can be sequestered.

Role of Protein : GAPC1

Key enzyme in glycolysis that catalyzes the first step of the pathway by converting D-glyceraldehyde 3-phosphate (G3P) into 3-phospho-D-glyceroyl phosphate. Essential for the maintenance of cellular ATP levels and carbohydrate metabolism. Required for full fertility (PubMed:18820081).Involved in response to oxidative stress by mediating plant responses to abscisic acid (ABA) and water deficits through the activation of PLDDELTA and production of phosphatidic acid (PA), a multifunctional stress signaling lipid in plants (PubMed:22589465) [12]. The GAPC1 protein in other plants uses phosphate to help break down glucose for energy, and arsenate interferes with its normal function. In *Pteris vittata* fern, however, GAPC1 has a higher affinity for arsenate than phosphate, allowing the plant to tolerate the otherwise toxic substance. To understand more about the combination of these proteins in fern plant, a multiple sequence alignment also was performed using clustal omega tool and the results are shown in the figure 5

Figure 5

From multiple sequence alignment, OCT4, GAPC1 proteins are closely related to each other in sequence pattern and away from protein GSTF1, which in turn may indicate that the function may differ.

4. Conclusion

From materials and methods, with the help of multiple sequence alignment, can say that, protein GSTF1 have different function from that of other 2 proteins OCT4, GAPC1. This shows that every protein may have a unique role in reducing the levels of arsenic in contaminated soil and water.

5. References

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