### MINERALS AND PLANTS

**矿物质和植物**

Research has shown that certain minerals are required by plants for normal growth and development. The soil is the source of these minerals, which are absorbed by the plant with the water from the soil. Even nitrogen, which is a gas in its elemental state, is normally absorbed from the soil as nitrate ions. Some soils are notoriously deficient in micro nutrients and are therefore unable to support most plant life. So-called serpentine soils, for example, are deficient in calcium, and only plants able to tolerate low levels of this mineral can survive. In modern agriculture, mineral depletion of soils is a major concern, since harvesting crops interrupts the recycling of nutrients back to the soil.

研究表明，某些矿物质是植物正常生长发育所必需的。土壤是这些矿物质的来源，它们通过水分被植物从土壤中吸收。即使是元素状态为气体的氮，也通常作为硝酸根离子从土壤中被吸收。众所周知，一些土壤缺乏微量营养素，因此大多数植物不能生长。例如所谓的蛇纹岩土壤，由于缺乏钙，只有那些能忍受如此低含量的钙的植物才能够存活。在现代农业中，土壤矿物质枯竭是一个大问题，因为收割庄稼切断了养分返回土壤的循环。

Mineral deficiencies can often be detected by specific symptoms such as chlorosis (loss of chlorophyll resulting in yellow or white leaf tissue), necrosis (isolated dead patches), anthocyanin formation (development of deep red pigmentation of leaves or stem), stunted growth, and development of woody tissue in an herbaceous plant. Soils are most commonly deficient in nitrogen and phosphorus. Nitrogen-deficient plants exhibit many of the symptoms just described. Leaves develop chlorosis; stems are short and slender, and anthocyanin discoloration occurs on stems, petioles, and lower leaf surfaces. Phosphorus-deficient plants are often stunted, with leaves turning a characteristic dark green, often with the accumulation of anthocyanin. Typically, older leaves are affected first as the phosphorus is mobilized to young growing tissue. Iron deficiency is characterized by chlorosis between veins in young leaves.

矿物质缺乏通常可由特定的症状检测出来，如褪绿（叶绿素损失导致黄叶或白叶的现象）、坏疽（孤立的坏死斑）、花青素的形成（形成深红色叶片和茎色素沉积）、发育不良以及草本植物长木质组织。土壤最常缺乏的是氮和磷。氮缺乏植物表现出了刚才描述的许多症状：叶片黄化、茎短而细以及发生在茎、叶柄以及下叶表面的花青素变色。磷缺乏的植物往往发育不良，叶片变成特殊的深绿色，经常伴随着花青素的积累。由于磷流向新生的组织，通常较老的叶片首先受到影响。铁缺乏症的特点是嫩叶的叶脉之间萎黄。

Much of the research on nutrient deficiencies is based on growing plants hydroponically, that is, in soilless liquid nutrient solutions. This technique allows researchers to create solutions that selectively omit certain nutrients and then observe the resulting effects on the plants. Hydroponics has applications beyond basic research, since it facilitates the growing of greenhouse vegetables during winter. Acroponics, a technique in which plants are suspended and the roots misted with a nutrient solution, is another method for growing plants without soil.

大多数关于营养素缺乏症的研究都基于水培法，即在无土营养液中培养。这项技术允许研究人员创造缺乏某种营养素的溶液，然后观察对植物生长造成的影响。水培法的应用已经超越了基础研究，因为它促进了温室蔬菜在冬季的生长。空气培养法，一种把植物悬挂起来，将其根部喷上营养液的技术，是另外一种无土栽培的方法。

While mineral deficiencies can limit the growth of plants, an overabundance of certain minerals can be toxic and can also limit growth. Saline soils, which have high concentrations of sodium chloride and other salts, limit plant growth, and research continues to focus on developing salt-tolerant varieties of agricultural crops. Research has focused on the toxic effects of heavy metals such as lead, cadmium, mercury, and aluminum; however, even copper and zinc, which are essential elements, can become toxic in high concentrations. Although most plants cannot survive in these soils, certain plants have the ability to tolerate high levels of these minerals.

虽然缺乏矿物质会抑制植物生长，但某些矿物质过量可能会有毒，同样也会抑制植物生长。含有高浓度的氯化钠和其他盐类的盐碱土壤抑制植物生长，于是研究继续集中开发耐盐农作物品种。着重研究重金属的毒性作用，如铅、镉、汞、铝；然而即使是铜和锌这样的必需元素，如果浓度过高也会产生毒性。虽然大多数植物无法在这种土壤生存，某些植物却能够忍耐如此高含量的矿物质。

Scientists have known for some time that certain plants, called hyper accumulators, can concentrate minerals at levels a hundredfold or greater than normal. ■ A survey of known hyper accumulators identified that 75 percent of them amassed nickel, cobalt, copper, zinc, manganese, lead, and cadmium are other minerals of choice. ■Hyper accumulators run the entire range of the plant world. ■ They may be herbs, shrubs, or trees. ■ Many members of the mustard family, spurge family, legume family, and grass family are top hyper accumulators. Many are found in tropical and subtropical areas of the world, where accumulation of high concentrations of metals may afford some protection against plant-eating insects and microbial pathogens.

科学家早前就了解到，某些所谓的富集植物能够比普通植物多集中100倍甚至更多的矿物质。一项对已知富集植物的调查表明，它们中75%积聚了镍，而钴、铜、锌、锰、铅和镉则是其他选择性聚集的矿物质。富集植物存在于整个世界范围，它们可能是草本植物、灌木或树。芥属、大戟属、豆科和禾本科植物中的许多成员都是靠前的富集植物。许多富集植物被发现于热带和亚热带，金属可以为植物提供保护，对抗植食昆虫和细菌病原体。

Only recently have investigators considered using these plants to clean up soil and waste sites that have been contaminated by toxic levels of heavy metals – an environmentally friendly approach known as phytoremediation. This scenario begins with the planting of hyper accumulating species in the target area, such as an abandoned mine or an irrigation pond contaminated by runoff. Toxic minerals would first be absorbed by roots but later relocated to the stem and leaves. A harvest of the shoots would remove the toxic compounds off site to be burned or composted to recover the metal for industrial uses. After several years of cultivation and harvest, the site would be restored at a cost much lower than the price of excavation and reburial, the standard practice for remediation of contaminated soils. For examples, in field trials, the plant alpine pennycress removed zinc and cadmium from soils near a zinc smelter, and Indian mustard, native to Pakistan and India, has been effective in reducing levels of selenium salts by 50 percent in contaminated soils.

直到最近研究者才考虑用这些植物来清理已经被有毒重金属污染的土壤和废弃物物处理点——一种被称为植物修复法的修复方法。这套方案首先从在目标区域种植超积累物种开始，如在废弃矿井和被径流污染的灌溉池塘。有毒矿物质首先被根吸收，随后被运送至茎和叶。收割下来的枝叶将被焚烧以移除有毒化合物或被制成混合肥料回收金属用于工业。经过几年的种植和收割，该污染点将被修复，而其造价远比修复污染土壤的标准做法——挖掘和填埋低得多。举例来说，在实地试验中，高山菥蓂从靠近一个锌冶炼厂的土壤中去除了锌和镉，原产自巴基斯坦和印度的印度芥菜可以将染土壤中硒的水平有效地降低50%。