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The earth's perfume

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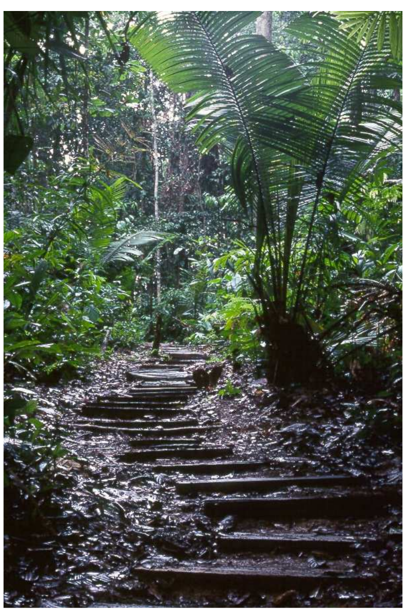
Have you ever brought a glass of wine – or drinking water – to your lips and discovered a musty taste? Geosmin is what produces it. Geosmin is a germacranoid sesquiterpene or a *trans*-1,10-dimethyl-*trans*-9-decalol for the more chemically minded. Human taste buds are extremely sensitive to geosmin; the average person can detect 0.7 parts per billion! The chemical is produced by a number of microorganisms amongst which the mycelial soil bacteria *Streptomyces*, which have become invaluable in the medical field since they are an important source for naturally occurring antibacterial and antifungal agents as well as anticancer drugs and immunosuppressants.

Geosmin is the distinct smell that soil gives off when it is disturbed or on which it has just rained. A pleasant smell for most. So pleasant, it is used to confer an earthy scent to perfumes. A number of enzymes are involved in the making of geosmin, one of which is a key enzyme: germacradienol synthase.



Rainforest

Courtesy of Amazon Explorama Lodges
Iquitos, Peru

The genome of *Streptomyces coelicolor* was recently sequenced and on it was found the sequence for germacradienol synthase. It is a protein of just over 700 amino acids, of which little is known save that it is made of two homologous domains. Out of the two, only one – the N-terminal one – is actually necessary for geosmin synthesis.

The detail of geosmin biosynthesis is still a bit of a mystery, though the discovery of the germacradienol synthase is certainly helping to unveil the biochemical pathway which leads to it. It has been suggested for some time now that the formation of geosmin in all likelihood involves the action of a germacranoid sequiterpene synthase on farnesyl pyrophosphate. And this has indeed turned out to be the case. Germacradienol synthase probably catalyses the cyclization of the farnesyl pyrophophate, which is an early step in geosmin biosynthesis. The subsequent steps – leading to the metabolite geosmin itself – involve the actions of at least three other enzymes, such as a cyclase, a reductase and a hydroxylase.

What could be the role of a metabolite like geosmin? Surely it cannot be just to give wine and water a different taste. There are a number of hypotheses. Some think it may be for defensive reasons: produce a pong and predators will steer clear from their prey. But geosmin could also be a sly way of promoting sporulation. The particular fragrance let off by geosmin usually occurs where humidity is involved. Camels may well smell out an oasis by sniffing the air for traces of the fragrant metabolite. While camels quench their thirst, hordes of *Streptomyces* spores will be supped with the water or will find a way to stick onto the animals' hides. In this way, spores can be carried for miles. In the same way, some cacti flowers may also use the geosmin scent to fool insects, in a sort of fragrant mimicry. Indeed, insects are attracted to the plants in the hope of a little refreshment, and in their quest for water, they actually serve as pollinators!

Besides bestowing a musty taste to liquids, the earthy taste of geosmin can also seep into the flesh of fruit and vegetables, and even fish, making them quite distasteful for consumption. Pharmaceutical plants that use *Streptomyces* in the production of antibiotics for example, but also factories such as pulp mills also create whiffs characteristic of geosmin, especially in warm weather. The problem is that geosmin resists oxidation and is difficult to remove using standard treatments. Turning off the smell, in these instances, could be an asset. To achieve this a greater knowledge of geosmin biosynthesis as well as of the function and 3D structure of germacradienol synthase is necessary. But who would want to give up the musty fragrance that reaches our nostrils after a summer rainfall? And name one camel that would prefer to do without an oasis.

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