Impurities give crystals that special glow

Kids know that the easiest way to create a miniature light show is to munch on wintergreen candy in the dark. When a piece is cracked, the sugar emits light that the wintergreen flavoring intensifies. Many materials exhibit this phenomenon, called triboluminescence.

In a new study, Linda M. Sweeting of Towson (Md.) State University and her colleagues try to deduce what makes sparks fly from some materials but not others. Their findings, reported in the May CHEMISTRY OF MATERIALS, support the idea that crystal structure and impurities are central to whether a material is triboluminescent.

For years, scientists suspected that only materials with an asymmetrical crystal structure would flash when crushed. Splitting such a crystal into two pieces puts positive charges on one face and negative ones on the other (SN: 7/30/88, p. 78). The charges immediately recombine, crackling through the air like tiny lightning bolts.

However, several materials with symmetrical crystal structures also show the characteristic sparks, Sweeting says. To study this discrepancy systematically, the researchers synthesized a group of 12 related compounds, coaxed them to grow into crystals, and identified their structures with X-ray diffraction. They tested the crystals for triboluminescence by mashing them with a glass rod in a test tube and watching carefully for light.

The very first compound Sweeting synthesized sparked in the dark, which makes it "the first compound designed to be a triboluminescent molecule," she says. All of the substances with asymmetrical structures glowed, whereas only half of the symmetrical ones did.

Moreover, those symmetrical crystals lost their triboluminescence once they were purified. "Impurities in crystals can reduce the symmetry that you think you have," says Bart E. Kahr, a chemist at the University of Washington in Seattle. "As you get down to the microscale, the differences between the pure and impure crystal can be extreme."

Those local structural asymmetries could explain why materials that are symmetrical overall can still exhibit triboluminescence, Sweeting says.

A surprising finding underscored the significance of impurities: One of the asymmetrical compounds also lost its ability to flash when purified, indicating that impurities may be required to generate light even in asymmetrical materials. In past experiments, some ostensibly pure asymmetrical compounds may have contained enough impurities to create triboluminescence, Sweeting notes.

Scientists are still far from a full understanding of the effect, which not only explains wintergreen candy but may account for other mysterious lights observed in nature, such as deep-sea luminescence (SN: 9/7/96, p. 156). Arnold L. Rheingold, a crystallographer at the University of Delaware in Newark who collaborated on the study, calls triboluminescence "a beautiful phenomenon in search of an application."

Sweeting imagines that one day, triboluminescent coatings could be used in remote sensing applications to signal mechanical failure. — *C. Wu*

A price tag on the planet's ecosystems

It's like trying to audit the books of someone missing a lot of receipts and bank statements. Yet a group of 13 researchers has pulled together an emerging body of studies on the value of ecosystems and come up with a rough figure for the annual worth of Earth's natural goods and services: $33 trillion.

That includes an estimated value for just about everything under the sun—from recreational beaches to forest lumber to hidden services like the ocean's regulation of atmospheric carbon dioxide and grasslands' provisioning for pollinators. A few natural resources were omitted, such as nonrenewable fuels and minerals. In comparison to the ecosystems' worth, the researchers report in the May 15 NATURE, the world's annual gross national products total about $18 trillion.

One goal of the exercise, says Robert Costanza of the Institute for Ecological Economics at the University of Maryland in Solomons, is to answer a lingering question in economics: "Are environmental services big potatoes or small potatoes? . . . We're saying they're very big potatoes."

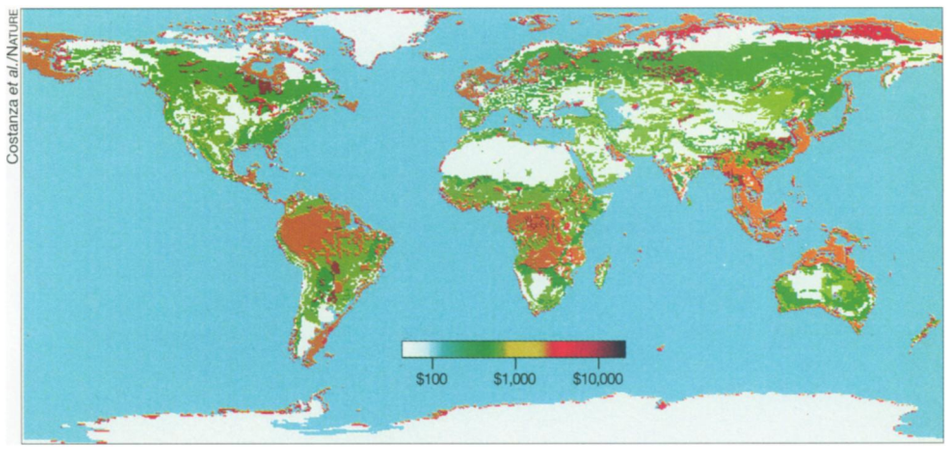
They're probably even bigger than $33 trillion, the researchers and other observers say. That figure, the average of calculations ranging from $16 trillion to $54 trillion, comes from converting and tallying a range of ecosystem values from more than 100 studies. For example, says Costanza, data relating the size of shrimp harvests in Louisiana to the extent of local wetlands were included in calculations of the average value of a hectare of wetland, which was then applied to the global extent of that habitat. Recreational values came from reports of people's willingness to pay for access to a coral reef, lake, or other natural area.

The overall average is conservative because it omits ecosystem services in several biomes, such as desert and tundra, that haven't been studied in terms of ecosystem values. Ecologist Stuart L. Pimm of the University of Tennessee in Knoxville points out that it also ignores the services in urban areas, despite the substantial value of green spaces like New York's Central Park.

The most valuable ecosystems per hectare turn out to be estuaries and wetlands—in part, because these areas have been the object of the most study, says Costanza. Other ecosystems will probably increase in value as they are examined more extensively.

The field of ecological economics underlying this analysis is only about a decade old, and its practitioners acknowledge its limitations—the researchers list a dozen caveats to their study. "We're putting this forth as a starting point," says Costanza.

It's a reasonable one, says environmental economist Lawrence H. Goulder of Stanford University. Pimm says the power of the analysis comes from the per hectare value of habitats and "the way in which it will inform local decisions" when it comes to planning. — *C. Mlot*



Value of Earth's ecosystems in 1994 U.S. dollars per hectare per year. White areas indicate lack of information.