complicated general formalism.

Whether biologists finally welcome these new incursions into their field may depend on whether physicists make up for "broken promises" of earlier times, says James Lewis of Arizona State University, who spoke at a session on applying quantum mechanics to large biological molecules. Thirty years ago in his own specialty, says Lewis, "the speculation was that, 'Gee, we ought to be able to turn the crank on any biological system you can think of,'" solving problems of molecular dynamics, such as interactions of electron clouds, more precisely. Physicists' hopes didn't pan out, mainly because available computing power was too small, says Columbia University's Robert Friesner. But he and others argue that hardware and software advances now allow physics to make a major contribution to biology.

Whatever reception such ideas find in biology, they're spawning some interesting physics, says Philip Pincus, a collaborator of Bruinsma's at the University of California, Santa Barbara. "You pick up one of these big biochemistry books," he says, "and on nearly every page you find interesting physics questions that for the most part haven't been studied." In the end, says Pincus, physicists may profit from the wide-open new territory of biophysics at least as much as biologists.

–James Glanz

CHEMISTRY

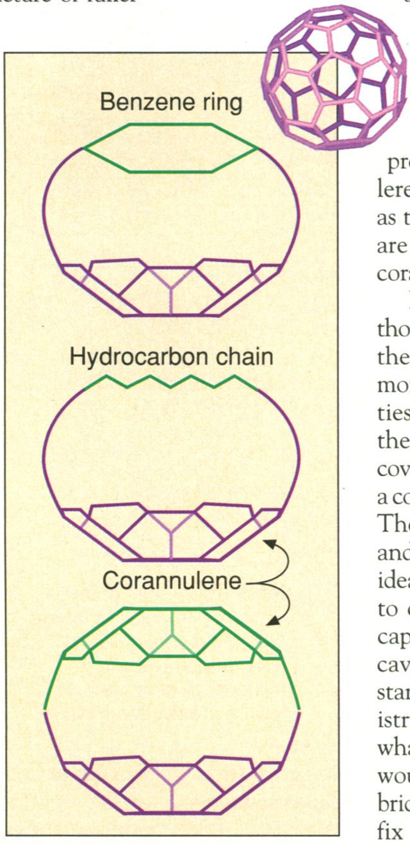
Molecule Promises a Better Buckyball

Ever since the cagelike carbon molecules known as fullerenes were first made in usable quantities 5 years ago, chemists across the globe have been putting aside what they were doing and setting forth into this new territory of fullerene chemistry. Hoping to exploit the unique hollow structure of fullerenes to create new catalysts, sensors, and other chemical marvels, these pioneers have attached almost every known chemical group to the surface of "buckyballs." They have trapped metals inside them, punched holes in them, and made them glow by trapping them inside porous minerals.

But some of the bloom is off the buckyball, says Jay Siegel, a synthetic organic chemist at the University of California, San Diego, because it is hard to tailor buckyballs' chemical and physical properties for a particular use. The problem with buckyballs is that they are made in the flash of an electric arc, with no chance to manipulate their structure as they form. Siegel, however, has an alternative: what might be called buckybaskets.

Last month in the *Journal of the American Chemical Society* (*JACS*), Siegel, Jon Seiders, and Kim Baldridge describe how they synthesized buckyball-type molecules that should retain the advantages of the original, but whose size, shape, and overall chemistry may prove much easier to tailor. "Siegel's work appears to be a real breakthrough. Their approach … promises to afford some very novel compounds," says chemist Peter Rabideau of Louisiana State University in Baton Rouge.

Siegel and his colleagues began with a molecule called corannulene, which is shaped like a skullcap and can be thought of as a fragment of a buckyball. The basic corannulene molecule is essentially five hexagonal benzene molecules fused to form a ring, creating a pentagon in the middle. The molecule assumes a cap shape because a ring of five hexagons simply cannot lie flat when their edges are stuck together. "Some of the properties that make fullerenes interesting, such as their electrochemistry, are already apparent in corannulene," says Siegel.



Basketmaking. By bridging corannulene baskets, chemists hope to mimic the buckyball *(top)*.

He and his colleagues thought they might endow the molecule with even more interesting properties if they could close off the cavity with a kind of cover, forming what's called a corannulene cyclophane. The team hunted around and came up with several ideas for molecular bridges to cross the corannulene cap and so create useful cavities. They then used a standard synthetic chemistry approach to work out what simpler reagents they would need to build the bridge and how they could fix it to the top of the basin. The first bridge they built consisted of a benzene ring with two sulfur-containing branches acting as anchor points on the corannulene cap.

Since submitting their initial results to *JACS*, the team has also spanned the opening with a long-chain hydrocarbon bridge, turning the basin into a basket with a handle. They are now refining the chemistry to use one corannulene molecule to bridge another, going partway to the spherical buckyball shape in what Siegel calls a basketball molecule. Rabideau is intrigued by these particular spin-off molecules. "It will be interesting to discover what sort of things might be captured in the basket and how their properties might be modified," he says.

Such syntheses are of more than academic interest. For many potential applications for fullerenes, a bridged corannulene molecule would do just as well. And given the present awkwardness of dealing with fullerenes, this is an attractive proposition. Such applications could include sieving particular molecules from a mixed solution, if the target molecule were just the right size to slip into the corannulene cyclophane cavity—bigger molecules would not fit, while much smaller molecules would pass through untouched. A fluorescent marker attached to the corannulene might glow to signal the presence of a guest inside the cavity, turning the compound into a sensor. Corannulene cavities might also serve as catalysts by trapping large molecules, stretching their bonds, and making them more likely to undergo chemical reactions.

Siegel and his colleagues are also considering, once they have a double corannulene cyclophane, going the rest of the way and filling in the gaps to make a buckyball proper. As a way to produce buckyballs, such a chemical synthesis might be more efficient as well as more versatile than current arc synthesis. But fullerene pioneer Roger Taylor of Britain's Sussex University estimates that it will be at least 5 years before anyone succeeds in making the basic spherical buckyball in significant amounts by chemical routes.

For Siegel, the real goal is duplicating behavior, not form. "We are more interested in making compounds that mimic fullerene behavior but offer greater versatility in the structure and chemistry," he says. While others kick around buckyballs, Siegel hopes to get new applications in the basket.

–David Bradley

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