Never contemporaries in life, the Audio-Animatronic versions of Ben Franklin and Mark Twain meet each other in the World Showcase at Disney's Epcot Center. Standing in front of the Statue of Liberty's torch, they shake hands and exchange pleasantries. The figures' faces and hands are sculpted from a polymer formulated to mimic skin, then shaded and highlighted with theatrical makeup.

Photos: Walt Disney Co.

Materials in the Magic Kingdom

When it comes to science, Disney doesn't use a Mickey Mouse approach

By CORINNA WU

For many children and adults alike, a trip to one of Walt Disney's four theme parks is like a pilgrimage to Mecca—it's an excursion they feel they have to make at least once and that they anticipate with excitement and reverence. While there, visitors are immersed in a surreal world where the inhabitants range from human to humanoid and historical characters mingle freely with fictional personalities. Events that would be impossible in real life take place regularly within the parks' boundaries.

In Disney World's Hall of Presidents, for example, Audio-Animatronic figures representing 40 U.S. chief executives, living and dead, convene on one stage to impart words of wisdom to the audience. Abraham Lincoln calls roll, and Bill Clinton delivers a speech.

Seeing John F. Kennedy share a stage with George Washington can strike the visitor as fascinating or creepy. Either way, the Disney "Imagineers" have successfully created an illusion. Doing that takes some ingenuity, not just in the mechanisms that imitate facial expressions and gestures, but in the design of materials as well.

At the American Chemical Society meeting in Orlando, Fla., last August, Disney research scientist Kathleen Nelson discussed some of the materials problems facing the theme parks and their approaches to solving them. Nelson is one of a cadre of Disney scientists who dabble in projects ranging from formulating polymers to mimic human skin to making biodegradable casings for fireworks.

Chemistry and materials work takes up less than a tenth of the company's research and development efforts, says Ben Schwegler of Walt Disney Imagineering in Glendale, Calif., but "it's important and highly visible."

In other words, it helps put the magic in the Magic Kingdom.

Unlike some other theme parks, Disney has enough special materials needs to justify its own research. The theme parks operated by Busch Entertainment in St. Louis, Mo., leave materials research to the contractors hired to build rides and attractions, says spokesman Fred Jacobs. Busch does do some research focusing on marine life and zoology, however. Universal Studios Florida in Orlando will not discuss any of its technical projects.

Disney keeps most of the research it conducts with universities, companies, and other organizations (SN: 7/29/95, p. 72) under wraps, too. In general, collaborators are forbidden to discuss their affiliation with Mickey Mouse and Co., Schwegler says. Disney worries that organizations claiming an association with the company will undermine its ability to sell movie merchandising tie-ins. "Companies pay us millions of dollars for the right to use the Disney name," explains Schwegler. "We're trying to protect their investment."

Though Disney scientists may develop formulas for polymers and paints, they don't make the actual substances themselves. Instead, specialty manufacturers mix polymers and paint to Disney's specifications.

One of Disney's unique materials problems is the development of skin for the Audio-Animatronic figures. No commercially available polymer has the combination of properties that fits all of Disney's needs, Schwegler says. For a start, the polymer must be durable yet flexible. When Abraham Lincoln gives the same speech dozens of times a day, the repeated bending and stretching can cause tears and cracks in his skin.

Any material, no matter how tough, is bound to fail after many repetitions of a movement. Therefore, the polymer must also be easy to repair. "The real cost isn't the injection or the molding process," Schwegler says. It's in the labor required after the figure has been cast.

The polymer has to have not only the malleability of real skin but also the tex-

ture. Artists apply theatrical makeup to the figures as if they were human actors. In addition, head and facial hair is planted directly into the polymer, so it must be dense enough to grip the hair tightly. "We never paint on a beard," Schwegler notes.

Since there are four Disney parks in different parts of the world, Disney scientists must take into account how different climates affect the polymer. "The humidity problems in Florida are different from the desiccation in California," Schwegler says. Freezing winters in Paris and Tokyo add other complications. Large temperature swings can make materials expand and contract, causing them to wear out from fatigue. Each set of conditions requires a slightly different material, Schwegler says.

Though Disney will not reveal the formulation of the polymer, polyurethane or rubber is usually used when scientists want something to look like human skin, says E. Bruce Nauman, a chemical engineer at Rensselaer Polytechnic Institute in Troy, N.Y. Custom-made polyurethanes are easier to make than harder plastics. "They're made by blending two different oligomers, or prepolymers, in different proportions," he explains. "Then you cast them in the shape you want."

For more common industrial applications, companies are usually better off to redesign a plastic part so they can avoid using a custom polymer, Nauman says. "For a given application, it's quite an art to choose which polymer is best."

A bevy of familiar figures listens politely as the Audio-Animatronic Bill Clinton, the latest addition to the Hall of Presidents at Walt Disney World, addresses the audience.

Disney often can't rely on commercially available products because the special effects designers rarely use materials as the manufacturer intended, Schwegler says. Take paints, for example. "We dilute them and coat them too thick and too thin. We don't use the right type of brushes. We don't use the recommended applications of spray paint." The Disney scientists modify existing paints to fit their particular needs.

Some Disney attractions require especially reliable paint for outdoor use that falls under the category of architectural coatings. Repainting an attraction like Cinderella Castle, even if it's only done every 15 years, means shutting it down, losing revenue, and, ultimately, disappointing visitors, Schwegler says.

The research also involves keeping up with paint formulas that change—in response to new environmental and safety regulations, for example. "Manufacturers change their formulations frequently without saying anything to their customers," Schwegler says. "For people who are able to follow the manufacturer's recommendations, they never see the difference. But because we don't, problems frequently arise."

Edible—or at least nontoxic—lava erupts from a volcano at Disney World's Energy Pavilion.

When most visitors think about safety, they focus on roller coaster rides like Magic Mountain. But Disney also has to pay attention to less obvious dangers. All material at "kid level"—fake leaves, landscaping, even the lava in the Energy Pavilion at Epcot Center—is nontoxic. "You never know what's going to go in a kid's mouth," says Schwegler. The lava isn't very tasty, he says, but it won't make anyone sick. Some of the special effects in the parks are "literally stuff you could make in your kitchen."

Disney's materials scientists also tackle challenges posed by the nightly fireworks displays. In most areas where Disney sets off fireworks, maintenance crews simply go around and pick up the polystyrene shell casings left after the show. They'd prefer to use biodegradable casings, however, in case the debris falls into water or other inaccessible places.

Some types of plastics that are called biodegradable break into smaller pieces without undergoing any fundamental chemical change. "We had many manufacturers come to us, wanting us to test their products," Schwegler says, but these materials don't fit Disney's criteria for biodegradability.

Disney has successfully collaborated with fireworks manufacturers to develop starch-based casings that break down into carbon dioxide, water, and other harmless molecules. The company does not use those casings yet because safety and "business issues" have yet to be resolved, Schwegler says.

The ideal fireworks shell casing would leave no residue at all but would "vaporize like a magician's flash paper in the sky," says polymer chemist Gary Zeller of Zeller International in Downsville, N.Y. Zeller has sent Disney some information on a biodegradable casing he is developing for military applications. The plastic contains enzymes and microbes to speed up its degradation. "The shell turns into mush in 30 days," Zeller says.

Like most companies, Disney is rather tight-lipped about much of its research, but unlike other companies, Disney says, its silence is not just to keep competitors at bay. "When you're at Disney Land, you're on a stage set," Schwegler says. For Disney to reveal its secrets is "like when you go to a magic show and the magician shows you how to do every trick."

Thanks to the scientists quietly working behind the scenes, however, all people see is the illusion. □