twenty-five years ago, it was commonly thought that cancers arose from fundamental changes in the genetic code; that something, somewhere had gone awry with the building blocks of DNA and that doctors could do little to reverse the process. But in the 1980s, cancer researchers turned their attention from the genome, the sets of chromosomes that we inherit from our parents, to the epigenome: a group of chemical switches and markers that affect how our genes are utilized, or expressed, sometimes over generations.

The epigenome (literally “above the genome”) tells each cell in the human body which of the almost 200 cell types it should become: brain, heart, skin, etc.

“If you think of the genome as words in the English language,” says Paul Soloway ’79, professor of nutritional sciences, “then you can think of the epigenome as the punctuation, or the grammar, that makes sense out of those words by regulating the expression of genes properly and also preserving genome stability so one gene isn’t amplified or silenced over another.”

Unlike the genome, the epigenome, is very mutable and can be influenced easily by environmental factors. Toxins in pollution and poor nutrition can disrupt important epigenetic processes such as DNA methylation (in which a methyl group made up of one carbon atom and three hydrogen atoms attaches to and shuts down a gene), causing them to spin out of control. Such manic methylation has been shown to shut down tumor-suppressor genes.

The good news is that methylation and other epigenetic phenomena are reversible with pharmaceutical therapeutics currently on the market. But we don’t yet understand the rules behind DNA methylation, so current treatments aren’t as targeted as they could be.

Soloway is seeking to solve that problem. “If you don’t know what you’re manipulating, then it’s hard to come up with a cure, a diagnosis, a therapeutic that can have benefit,” explains Soloway. His lab is working to identify the patterns, rules, and clues that control epigenetic marks in the genome.

And he’s using nanotechnology to solve this big mystery. Working in conjunction with Harold Craighead, MS ’77, PhD ’80, in the School of Applied and Engineering Physics, as part of the National Institutes of Health Roadmap Epigenomics Program,
Soloway is developing technology that could possibly revolutionize epigenomic studies and provide a tool that could lead to advances in cancer treatments. Using a nanoscale device and different fluorescent dyes and reagents, one of Soloway’s aims is to assess multiple epigenetic modifications, simultaneously, using very small quantities of genetic material through a process known as the single-molecule approach. And his group is weeks, not years, away from doing so.

“There are very useful techniques right now for forming epigenomic analysis, including methods that I use in my own lab, but there are some aspects to the single-molecule approach that can potentially supplant the existing methods and provide much richer information,” he says.

An aspirin a day?

Could a cure for cancer lie in something as simple as aspirin? Taking her cue from research that found the use of anti-inflammatory drugs can prevent colon, breast, and pancreatic cancer, Animal Science Professor Pat Johnson, PhD ’83, gave aspirin to chickens and found that it slowed the progression of ovarian cancer. She is now conducting studies to see if earlier initiation of such treatment could stop the tumors from developing altogether.

Chickens are the only species besides humans that develop spontaneous ovarian cancer at a high incidence, with 20 to 30 percent of hens developing the disease by their third year of life. Ovarian cancer is the fifth-leading cause of cancer-related deaths in American women, according to the American Cancer Society. Johnson attributes our shared predisposition to ovarian cancer to abundant egg production; humans and chickens ovulate frequently.

While conducting the aspirin studies, Johnson also noticed that hens with early-stage ovarian cancer produced significantly fewer eggs in the year prior to diagnosis than those without cancer. So she is exploring the possibility that egg production may represent a new method of early detection, which improves chances of survival.

“It is exciting to use our background in avian reproduction to work on a disease of human relevance. We keep working on it because the disease is so bad and advances have been slow coming.”

—Pat Johnson

Another obstacle in early recognition of the disease is finding where in the body the cells start to become tumors, Johnson says. Until recently, scientists believed the cancer originated among ovarian surface epithelial cells, but they now think it may develop in areas such as the oviducts or fallopian tubes.

Johnson’s ultimate goal is to develop ovarian cancer diagnostics similar to the PSA test, commonly used to detect prostate cancer.

“If we know where it originates, we may more effectively identify an early marker,” Johnson says.

From food lab to med lab

Unlike many of his food scientist colleagues, microbiologist Carl Batt did not start his career with the intention of finding a cure for cancer, but that is exactly where it has led.

From his lab in Stocking Hall, Batt has spent the past decade working in conjunction with researchers at the Weill Cornell Graduate School of Medical Sciences in New York City and Ludwig Center for Cancer Research branch at Memorial Sloan Kettering Cancer Center to develop a vaccine that will encourage the immune system to respond to patients’ existing cancerous lesions.

Here’s how it works: the vaccine starts by identifying a molecule, usually a protein, which is found more often on cancer cells than on normal cells. The vaccine then stimulates the immune system to attack just the cancer cells that have those unique molecules.

With the vaccine in Phase I clinical trials for the past year, Batt and his colleagues look to decipher the best formulation of components to elicit a safe and proper immune response.

“Right now the trials are not to cure cancer but to further understand how you might get this immune response in the first place,” Batt says. “Your immune system goes from the ‘good guy’ status, attacking bacteria and attacking viruses, to the ‘bad guy’ status, which is auto-immune disease. It’s a fine line between getting your immune system to respond and not getting it to respond too well.”

He’s also experimenting with heat to kill cancer cells, mimicking the way the body induces fever to fight off viruses and infection. The challenge is in localizing heat within the body, exposing harmful cancer cells with-
out harming the body’s healthy cells, he says.

Batt believes his vaccine could fill some gaps in standard treatments—surgery, radiation, and chemotherapy—and maybe even provide a cure for cases that are particularly stubborn and unresponsive to those treatments.

“This particular treatment is for after you get done with surgery, after you get done with radiation, after you get done with chemotherapy, and there is this recalcitrant population that is left,” he explains.

As for the directed heat treatment, Batt sees it as a “mop up” after surgery, since a major complication of cancer operations is removing the entirety of cancerous cells associated with a tumor, while preserving healthy tissue.

An ounce of prevention
On the 1.6 million-acre Hopi reservation in northeastern Arizona, native cultural beliefs can be barriers to cancer prevention. Angela Gonzales believes they can also contribute to solutions.

The associate professor in development sociology is using the rich tradition of storytelling—with a modern twist—as a vehicle to deliver messages that educate her people about cancer prevention and encourage screening.

As part of a project funded by the National Institutes for Health Center for Population Health and Health Disparities at the University of Washington and Black Hills Center for American Indian Health, she is using narration, images, sound, and video—in both English and Hopi—to produce DVDs featuring women who have been diagnosed with cervical cancer and parents speaking about the importance of getting their sons and daughters vaccinated.

“By combining the rich tradition of storytelling in Native communities with digital technology, we can empower community members to share their personal stories about cancer, as well as develop HPV [Human Papillomavirus, which can lead to cervical cancer] vaccination and screening messages that are culturally relevant and speak to Hopi values around health,” Gonzales says.

She hopes it will help reduce the incidence of HPV in the community or catch it before it develops into cervical cancer.

Two strains of the virus—HPV 16 and 18—are responsible for 75 to 80 percent of all cases of cervical cancer, and can be prevented through a vaccine recommended for adolescent girls between ages 9 and 12. The vaccine is free for members of federally recognized tribes in Arizona, yet hesitation among Hopi parents has prevented widespread immunization.

In addition, fewer than 50 percent of Hopi women receive the recommended annual pap tests, which screen for HPV, so Gonzales is encouraging the use of at-home testing kits.

“If you can reduce the presence of the virus in the community as well as identify it and treat it early on, the potential to reduce cervical cancer in the community is tremendous,” Gonzales says. “Because it is such a small, rural, isolated community, these interventions, if effective, could dramatically reduce the incidence of cervical cancer in the population across generations.”

It’s a personal quest for Gonzales, who lost both her father and maternal grandmother to cancer. The process of getting treatment for her grandmother, a member of the Hopi Tribe who did not speak English, was particularly difficult, she says, partly due to the stigma and fear associated with cancer among many American Indians, and partly due to the lack of preventive screening services.

Phone home!
According to Geri Gay, mobile phones can be powerful tools for cancer treatment and support.

Gay, the Kenneth J. Bisset ’89 Senior Professor and chair of the Department of Communication, has spent several years encouraging healthy behavior and providing easier ways to monitor medical treatment through use of “persuasive technology.”

As part of her latest effort, members of the Interaction Design Lab led by graduate student John P. (J.P.) Pollak ’00, MPS ’08, have developed Aurora, a smart phone application designed specifically for patients undergoing cancer treatment.

The virtual support and social networking system is like “Twitter with images,” Gay says. Patients at the Weill Cornell Graduate School of Medical Sciences select pictures that illustrate their moods and post them into a live feed, which other users can view to see how their fellow patients are feeling.

Not only could the program create a supportive peer network among patients, it could lead to better health care by aggregating experiential information for researchers and health care providers.

“If nurses or doctors are monitoring these things and notice that someone is really depressed for two or three days, they can do an intervention,” Gay says.

Gay hopes the system will enable her to better understand the concept of “emotional contagion”—how knowing someone else’s mood can impact your own. Pollak says he hopes to study whether use of the system could reduce patient anxiety.

“They’re not thinking about their treatment when they take out our apps and use them,” he says. “It’s a fun and social way to help them get through the day, get through their treatment, get through whatever it is that they’re going through.”

Pollak anticipates that Aurora will be available to the public within a few months, along with several other smart phone applications developed by the Interaction Design Lab.