Anne Johnson: Welcome to Environmental Health Chat, a podcast about how the environment affects our health, from the National Institute of Environmental Health Sciences. I'm your host Anne Johnson. I'm going to start with a familiar story. From our parents, we inherit genes, which are made of DNA. Those genes, the so-called "code of life," make us who we are. But that story has gotten a lot more complicated recently. It turns out that proteins really do the heavy lifting in our cells, by interpreting the genome and carrying out the functions that keep us alive. And those proteins get their marching orders from all these little marks that are scattered along the genome, telling the proteins when and where to activate certain genes. All those little marks together make up what's now called the "epigenome."

Today's guest, Dr. Randy Jirtle, says the epigenome impacts our health in a big way. Randy is a Visiting Scientist at the University of Wisconsin, Madison and Professor of Epigenetics at the University of Bedfordshire in the United Kingdom. Given his background in computer science, he likes to explain it this way.

Jirtle: The genome is comparable to the hardware of the computer. Now, the epigenome is comparable to the software, telling the genome when, where, and how to work. Even though every cell in our body has the same genome, we have 250-300 different cell types in our body and the reason we have that is that during early development, the developmental process involved layering down and setting down these different chemical marks that tells the cell that 'you are now going to be a liver cell, a skin cell, an eye cell, a hair cell, etc.' So we're a conglomeration of cells that have very different functions. They have the same 'computer,' but the programs that are running in each one of these cells are very different.

Johnson: A lot of these epigenetic marks are laid down during early development, when a fetus is exposed to hormones and other chemical signals from its mother. But there's an environmental component, too. Chemicals from the foods a mom eats, or other substances she's exposed to, can change the epigenome.

Jirtle: Environmental factors can come in and alter these marks when they're being placed, or alter the maintenance of them later in life. So that's how the environment ultimately interacts with the genome, and it can do it in a positive way, or can sometimes do it in a very negative way.

Johnson: Randy says it's possible that alterations in your epigenome might ultimately be responsible for more health problems than mutations in the genes themselves.

Jirtle: Genetic mutations, in other words, changes in the genes themselves, or if you're looking at a computer a physical change in a hard drive or a chip in the computer, can be problematic. But if you use computers a lot, you know that most of the problems you have are not really problems with the hardware. It's very often bugs, viruses, etc. that mess up the software of the programs that alters your ability to use that computer effectively.

Johnson: So Randy and other scientists are looking for those software bugs—that is, changes in the epigenome—that could cause disease. But epigenomics is still a very new field. Randy says we can probably guess that some things, like smoking, taking drugs, or drinking large quantities of alcohol during pregnancy probably have detrimental effects.

But sometimes the research will surprise you. Case in point: Randy recently did a study in mice in which baby mice that had been exposed to low doses of ionizing radiation early in their development actually

turned out to be healthier than mice who weren't exposed to radiation. They were less prone to weight gain, diabetes, and cancer.

Jirtle: Low doses of radiation caused a positive adaptive response. It looks like, in fact, a bit of stress on these cells in early development is advantageous.

Johnson: In another twist, Randy also found that antioxidants negated the positive effects of the radiation. This phenomenon—the idea that a small dose of a toxin or other stressor might actually have positive effects—is called hormesis. It's an old idea, and some think it's a rather strange one, but Randy says the epigenome might help explain the biological basis for hormesis. It's just one of many intriguing aspects of epigenomics. But at this point, Randy says it's hard to know how his mouse study might translate to people, because a mouse's epigenome is probably very different from a human's. Randy also says some things can have positive effects on the epigenome in some cases and negative effects in other cases.

Jirtle: It's not just the compound. It's the dose of compound you're exposed to and the time at which you're exposed. So one shoe doesn't fit all feet.

Johnson: It's a new field with lots of questions, lots of surprises, and lots of opportunity. Another ripe area of study is what effects a mother and father's epigenome might have on the epigenome of their children. There's reason to believe we may pass on some epigenomic alterations from the chemicals we're exposed to during life.

Jirtle: We're sort of guardians of the epigenome and we need to guard it diligently. The nice thing about the epigenome is that it is adaptable and plastic so you can change it by altering your behavior. The disadvantage, I suppose, is that there's a responsibility that goes along with that. When you inherit a mutation, there's not much you can do about it, but the epigenome—if those marks aren't completely cleared off from generation to generation—could be passed on to the children, the grandchildren, the great-grandchildren. This field is not really solid as we would like it to be, but I think once we find these marks that are critical, we will be able to follow them not only from the single offspring from mother and father to the child, but into the next generation and the following generation. But we're not there yet.

Johnson: Check out our website for more about the science of epigenomics, including a video featuring our guest Dr. Randy Jirtle. Thanks to Randy for joining us today. You've been listening to Environmental Health Chat. I'm your host Anne Johnson, and our podcast is brought to you by the Partnerships for Environmental Public Health, a program of the National Institute of Environmental Health Sciences. Find us online at niehs.nih.gov/podcasts.