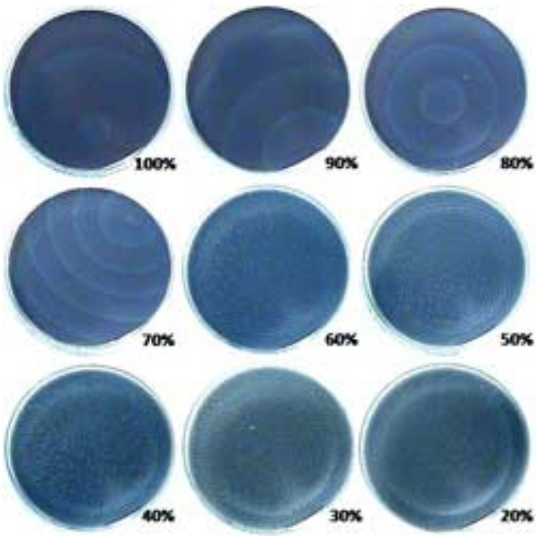
Research shows change in biochemical wave patterns may signal damaged organs

January 7 2011



Wave patterns change from targets to spirals as “active” beads decrease and “inactive” beads increase. The percentage of active resin beads is labeled in the bottom right corner of each image.

(PhysOrg.com) -- Studying how bacteria incorporate foreign DNA from invading viruses into their own regulatory processes, Thomas Wood, professor in the Artie McFerrin Department of Chemical Engineering at Texas A&M University, is uncovering the secrets of one of nature’s most primitive immune systems.

His findings, which appear in *Nature Communications*, a multidisciplinary publication dedicated to research in all areas of the

biological, physical and chemical sciences, shed light on how bacteria have throughout the course of millions of years developed resistance to antibiotics by co-opting the DNA of their natural enemies: viruses.

The battle between bacteria and bacteria-eating viruses, Wood explains, has been going on for millions of years, with viruses attempting to replicate themselves by — in one approach — invading bacteria cells and integrating themselves into the chromosomes of the bacteria. When this happens a bacterium makes a copy of its chromosome, which includes the virus particle. The virus then can choose at a later time to replicate itself, killing the bacterium — similar to a ticking time bomb, Wood says.

However, things can go radically wrong for the virus because of random but abundant mutations that occur within the chromosome of the bacterium. Having already integrated itself into the bacterium's chromosome, the virus is subject to mutation as well, and some of these mutations, Wood explains, render the virus unable to replicate and kill the bacterium.

With this new diverse blend of genetic material, Wood says, a bacterium not only overcomes the virus' lethal intentions but also flourishes at a greater rate than similar bacteria that have not incorporated viral DNA.

"Over millions of years, this virus becomes a normal part of the bacterium," Wood says. "It brings in new tricks, new genes, new proteins, new enzymes, new things that it can do. The bacterium learns how to do things from this.

"What we have found is that with this new viral DNA that has been trapped over millions of years in the chromosome, the cell has created a new immune system," Wood says. "It has developed new proteins that have enabled it to resists antibiotics and other harmful things that

attempt to oxidize cells, such as hydrogen peroxide. These cells that have the new viral set of tricks don't die or don't die as rapidly."

Understanding the significance of viral DNA to bacteria required Wood's research team to delete all of the viral DNA on the chromosome of a bacterium, in this case bacteria from a strain of E. coli. Wood's team, led by postdoctoral researcher Xiaoxue Wang, used what in a sense could be described as "enzymatic scissors" to "cut out" the nine viral patches, which amounted to precisely removing 166,000 nucleotides. Once, the viral patches were successfully removed, the team examined how the bacterium cell changed. What they found was a dramatically increased sensitivity to antibiotics by the bacterium.

While Wood studied this effect in E. coli bacteria, he says similar processes have taken place on a massive, widespread scale, noting that viral DNA can be found in nearly all bacteria with some strains possessing as much as 20 percent viral DNA within their chromosome.

"To put this into perspective, for some bacteria, one-fifth of their chromosome came from their enemy, and until our study people had largely neglected to study that 20 percent of the chromosome," Wood says. "This viral DNA had been believed to be silent and unimportant, not having much impact on the cell.

"Our study is the first to show that we need to look at all bacteria and look at their old viral particles to see how they are affecting the bacteria 's current ability to withstand things like antibiotics. If we can figure out how the cells are more resistant to antibiotics because of this additional DNA, we can perhaps make new, effective antibiotics."

Provided by Texas A&M University