DNA computer 'calculates square roots'

2 June 2011 Last updated at 18:11 GMT

By Jason Palmer Science and technology reporter, BBC News

DNA computing is just one of several "biological computing" approaches

Researchers have shown off a "DNA computer" of unprecedented complexity, which can calculate square roots.

DNA computing uses chemical reactions to solve problems in which a number of DNA strands act as "bits".

The work, **reported in Science**, required 130 strands of DNA to work in a cascade of programmed chemical changes.

The approach is not designed to rival traditional electronics, but rather to allow computing to occur in biological contexts, perhaps even in the body.

DNA computing was **first proposed by Leonard Adelman in 1994**, to solve what is known as the "travelling salesman problem" - determining the shortest path that joins a number of geographically separated locations.

Since then, a wide array of approaches has aimed to make use of the properties that make DNA attractive for computing: it can be made to order and its interactions with itself are well-studied and reliable.

In 2006, Erik Winfree of the California Institute of Technology (Caltech) and his colleagues **published an article in Science** a framework making use of one of these approaches, known as strand displacement.

Stretches of DNA made of just one strand (rather than the two joined strands that form the well-known double helix) were used as anchor points for other single strands.

By carefully "programming" the movement of these strands, the researchers were able to recreate a number of elements familiar from conventional computing, including logic gates, amplification, and feedback.

"Those circuits were smaller [than those of the current work], but more importantly, they were built using more complex DNA molecules that made systems more difficult to debug and had other problems," Professor Winfree told BBC News.

Stranded

Now, Professor Winfree and his collaborator Lulu Qian have employed a scheme using what they call "seesaw gates", which accomplish the shuffling and exchange of DNA strands using simpler machinery.

The work showed that seesaw gates could again be used to create logic gates - the basis of electronic computing's manipulation of information - and represented a five-fold leap in the number of DNA sections ever implemented in such a DNA computer.

The approach can be scaled up in complexity far further, the authors suggest - but the process is slow.

For example, it was used to calculate the square root of a four-bit number, but the process took between six and 10 hours.

However, Professor Winfree said that contrary to conventional electronics, the goal is not just high speeds.

"We are no longer pursuing the goal targeted by Len Adleman's original DNA computing experiment: to compete with silicon by using the massive parallelism of chemistry to solve combinatorial problems in mathematics," he explained.

"Instead, our goal is now - and has been for many years - to enrich chemistry itself so that molecular behaviours can be programmed.

"We'd like to make chemical systems that can probe their molecular environments, process chemical signals, make decisions, and take actions at the chemical level."

Tom Ran, a member of the research group that in 2009 **published on a DNA computer that could "answer" logical conundrums**, told BBC News that the DNA computer of the new work exhibited more "digital behaviour" than other molecular computing approaches and thus that "it may be more robust, reliable and scalable".

"The complexity of the presented work - together with the potential of scalability and of interfacing it with other molecular computers - make this paper important and interesting," he said.