670 metres. Beebe vividly described his visit to another world, three decades before the televised Moon landings.

Most modern grant proposals require applicants to describe the wider benefits of their work to society. Those studying the deep sea can point to examples of medical treatments, industrial enzymes and even tips for making better optical fibres based on the glass skeletons of deep-sea sponges. Rozwadowski describes how early workers highlighted the benefits of seafloor dredging for cable surveys when lobbying for the use of HMS *Lightning*, HMS *Porcupine* and HMS *Challenger*. But Gould and Matsen show that Beebe got funding by promising a payback in the joy of knowledge itself. At the age of 16, he wrote that "to be a Naturalist is better than to be a King". Taken together, these books reveal how far we have come in understanding the largest habitat on our planet — and how much further we have to go. ■

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SCIENCE IN CULTURE

The music of life

Composer Thilo Krigar seeks to represent the flow of genetic information.

THILO KRIGAR

Juliane Mössinger

Music and science seem irreconcilable to many, but there is a close and long-standing relationship between them. Since antiquity, music has been categorized as *scientia mathematica*, together with arithmetic, geometry and astronomy. In the eighteenth century, Johann Sebastian Bach composed some almost mathematically constructed canons as part of his *Musical Offering*. And Karlheinz Stockhausen used the Fibonacci series to determine the durations of the 33 Moments in *Mikrophonie II* in 1965. More recently, the sciences have offered patterns in data, such as those arising from genomics, as inspirations for musical composition.

But previous attempts to portray DNA, the icon of twentieth-century science, in musical terms have been limited to the computerized conversion of nucleotide sequences into audible patterns. The composer Thilo Krigar, however, is not interested in simply representing the structure or sequence of the DNA molecule itself, but in a musical exploration of the flow of genetic information. He is fascinated by the idea that the dynamic and continuous renewal of our cells relies on the information coded in our DNA. He perceives this process of 're-creation' as the ultimate form of creativity — a metaphor for composition.

The Berlin-based cellist and composer has been working on *DNA in Concert* for the past five years, using the atoms that compose the DNA molecule as a starting point. He converts the number of outer valence or total electrons of hydrogen, carbon, nitrogen, oxygen and phosphorus into an equivalent number of semitone steps. These then form five different musical intervals, which, in turn, are the basis for the melodic and harmonic structure of the composition.

Krigar then uses other musical tools to represent the biochemistry of the cell. Stability in the harmonic architecture of the music, expressed by a double octave, for example, represents the chemical stability of hydrogen bonding. Although Krigar is interested in a close musical portrayal of biochemical processes, he realizes that a representation of all of the atoms, molecules and chemical bonds is virtually impossible and, musically, may not be desirable. Above all, he wants the resulting music to be aesthetically appealing and demanding.

DNA in Concert begins with a prelude that depicts the archaic process of reverse transcription — the mechanism thought to be involved in the transition from RNA into DNA on the early Earth. The main body of the work, 'Seasons4life', is then divided into four parts: Transcription, Translation, Metabolism and Replication.

During Transcription, the music reflects the physical tension in the DNA caused when RNA polymerase, the enzyme that copies DNA into RNA, unwinds and rewinds the template DNA helix. Saxophones represent the three-dimensional structure of the double helix, and the strings the actual generation of RNA molecules.

The music of Translation is focused on the activity of the ribosomes, complex biochemical machines that catalyse the translation of a nucleic-acid message into a protein sequence. Interjections of percussion, for example, represent amino acids as a building material. Live electronic sound embodies the energy consumed during protein assembly.

In Metabolism, the chemical signals that connect the activities of the cellular proteins are transformed into musical signals that are passed on from one musician to another. Different groups of instruments compete with one another through intensifying motifs to illustrate the polymerization of the two DNA daughter strands during replication.

Newly developed harmonies then portray the processes involved in cell division in the concluding passage, Proliferation, before the music retreats back to the structure of DNA.

The music is modern but not atonal. It is reminiscent of minimalism but has elements that resemble the dramatic romanticism of a Mahler symphony. The piece is written for a chamber ensemble, and the musicians are expected to move around the room, giving the audience the feeling of being surrounded by the double helix and the biochemical processes in the cell. Loudspeakers projecting computer-generated sound add to the surround effect. Digital movies of cellular processes bring a visual component to the performance.

The composition is not limited to repeating sequential tones, nor does it simply attempt a one-to-one representation of the molecular reality in the cell. The composer's work is based instead on biological concepts, stressing the parallels between biological processes and human creativity. He wants to give the listener a musical experience of the biochemistry in the cell and to become progressively aware of the life process taking place within ourselves.

DNA in Concert is a work in progress. Its world premiere — minus an unfinished coda — will be performed by the Pythagoras Strings on 28 and 29 May 2005 at TESLA im Podewils'schen Palais in Berlin, Germany.

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➧ **www.dna-in-concert.de**