CRISPR/Cas9-NHEJ: Action in the Nucleus

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ABSTRACT

CRISPR/Cas9-NHEJ: Action in the Nucleus (2017) is derived from an interdisciplinary creative process. This paper discusses the creation of this 210° scientific visualization, the usage of data from the worldwide Protein Data Bank, and the audio-visual presentation in an interactive dome setup. Since the topic is significant for the future of humanity, immersive experiences should be considered to convey tacit knowledge of gene-editing processes to make them approachable for the general public.

CCS CONCEPTS

• **Human-centered computing** → **Scientific visualization**; • **Computing methodologies** → *Scientific visualization*; Animation; • **General and reference** → *Design*;

KEYWORDS

Scientific Visualization, Gene-Editing, CRISPR, Immersive

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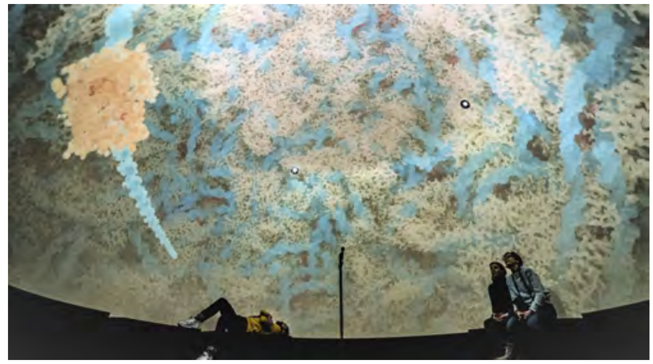

Figure 1: Presentation of CRISPR/Cas9-NHEJ: Action in the Nucleus in a full-dome setup, Copyright by the authors.

1 INTRODUCTION

Genetic engineering is thought to be one of the most influential technologies for the future of humanity. The newly viable editing of biochemical processes that are underlying all life may simultaneously solve and create problems for humankind. Scientific visualization offers a great opportunity to create visual representations of such advances in modern science. The abbreviation "CRISPR" stands for Clustered Regularly Interspaced Short Palindromic Repeats and can be used to modify the genetic code of organisms effectively, especially since the process with the nuclease Cas9 [Hendel et al. 2015] was discovered. The CRISPR/Cas9 process was recently recorded [Shibata et al. 2017], yet visualizations incorporating sophisticated design decisions are powerful tools to increase comprehension, visual thinking and common understanding of this topic. We seek to encourage more designers to engage in interdisciplinary communication processes with research teams to facilitate projects to impart research results.

Due to gene editing's current popularity, there are already several visualizations of CRISPR/Cas9 available, see for instance [Hendrich 2014], however, none of them depict the organic structures and chaotic organization of the CRISPR/Cas9 process, nor the NHEJ repair pathways as described herein. In referencing famous visualization masterpieces, like [Berry 2003] and pictures in [Goodsell 2009], our goal was to develop an organic approach while still obtaining a comprehensible insight into the actual biological processes in action. Cell biology is a particularly complicated field for visualization. The actual density of proteins and the proximity of the chemical reactions that take place inside cells are as intriguing as they are difficult to understand. Abstractions and reductions are necessary to make processes comprehensible.

2 OUR APPROACH

The Science Visualization Lab's main goal is to create computer animations based on various scientific imaging techniques. Accordingly, we wanted to realize the idea of an animation of the CRISPR/Cas9 process respective to our established quality standards. This resulted in the usage of data from the worldwide Protein Data Bank [Berman et al. 2003], combined with an interdisciplinary creation process between gene-editing scientists and the Science Visualization Lab at the University of Applied Arts Vienna. We designed the protein parts akin to jelly clouds with floating locomotion behavior in order to present the organized chaos of life as visible and tangible. We experimented with ways to add dynamics to the atomic models of the various macro molecules. There are two approaches visible in the presented video. One approach uses the point clouds of the pdb file format as emitter for particles. The other experiment uses the pdb Blender importer to generate geometry and animates it with random noise patterns to deform the animation curves. We developed artistic representations of the movements, none of the available simulation tools for calculating chemical reactions were used. Instead we focused on the visual

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process of the Cas9-complex and the NHEJ repair pathway. The application of color coding in scientific visualizations, see for instance Figure 2, helps distinguish between various components. A pinch of noise and flicker indicates the density of the visible atoms and their movements. The visual style was developed using the Cycles render engine.

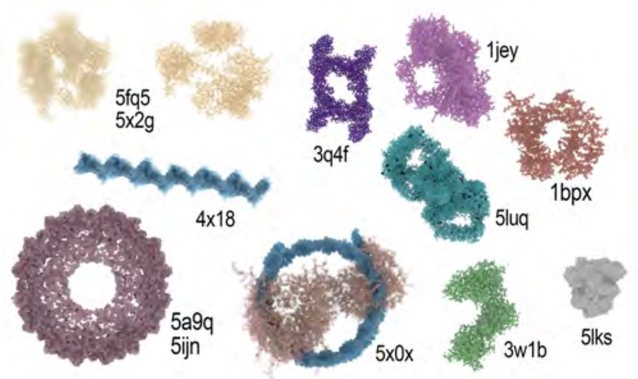

Figure 2: Structures of the worldwide Protein Data Bank [Berman et al. 2003], used in the discussed project; 5a9q and 5ijn: Human Nuclear Pore Complex, 1jey: Nuclease Ku, 1bpx: Polymerase, 5lks: Human Ribosome, 3q4f: XRCC4/XLF-Cernunnos Complex, 3w1b: Ligase IV-Artemis Complex, 4x18: DNA Structure, 5fq5 and 5x2g: Cas9-sgRNA-DNA Complex, 5luq: PKcs, 5x0x: Nucleosome Complex, Graphics by the authors.

The background soundtrack of the scientific visualization serves primarily as ambient sound to enhance immersion and is a composition using pink noise and in a binaural manner generated frequencies. The noise is deliberately chosen in order to indicate the connection between chaos, organization, and life, as well as to communicate omnipresent intricacy. In the animation, complexity was reduced to increase comprehension, while remaining noticeable in a subliminal manner through sound. The philosophical voice overlays play a crucial part in conveying the importance of the topic. The generated voices enable speculative glimpses into the future and invite the viewer to think about gene-editing. The concept of the scientific visualization does not provide captions or explanatory texts as many educational videos do because nothing should distract from the aesthetic-abstract processes and the complete experience of being inside a cell nucleus. Nevertheless, a scientific animation should be able to convey the underlying research results. Therefore, a folder could accompany the animation describing the processes in detail as well as explaining the color codes of the crystal structures used in the animation. Comparable to a program folder for a ballet, both the undisturbed experience of the animated CRISPR/Cas9 "dance" and the possibility to obtain information about the scientific background could be achieved.

3 CONCLUSIONS AND FUTURE WORK

Our visualization was initially commissioned as part of an immersive audio-visual presentation in an interactive dome setup. The

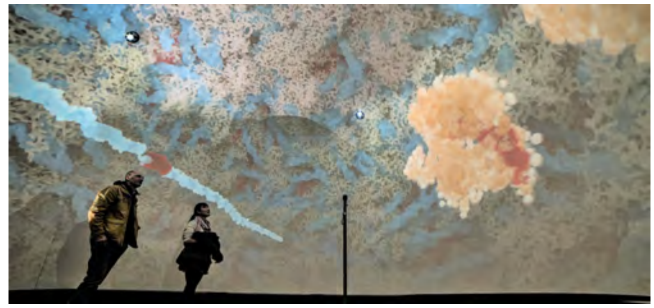

Figure 3: Visitors approaching the microphone, Copyright by the authors.

audience reactions were throughout positive, although understanding of the processes could not be fully conveyed as the scientific visualization was part of a callable program of less narrative visuals and should not stand out for the sake of consistency. For interested visitors we gave an evening talk in the museum describing the scientific content and the design process. We did not conduct an official survey, nevertheless, after each showing, audience participants seemed fascinated and asked follow-up questions. Photographs of the exhibition can be seen in Figure 1 and 3. Entering through a small gate and sitting in a domed "cave" increases the feeling of actually being in a sort of spherical environment like a cell nucleus, while also increasing the possibility to convey tacit knowledge. Scientific visualizations give rise to the possibility that complex processes, which are determining for the future of humanity, become generally more understandable. Therefore, we want to pursue experiments with visual and artistic communication of bio-chemical processes in cells. We plan to iterate the project and had already very inspiring talks with notable institutions and artists.

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