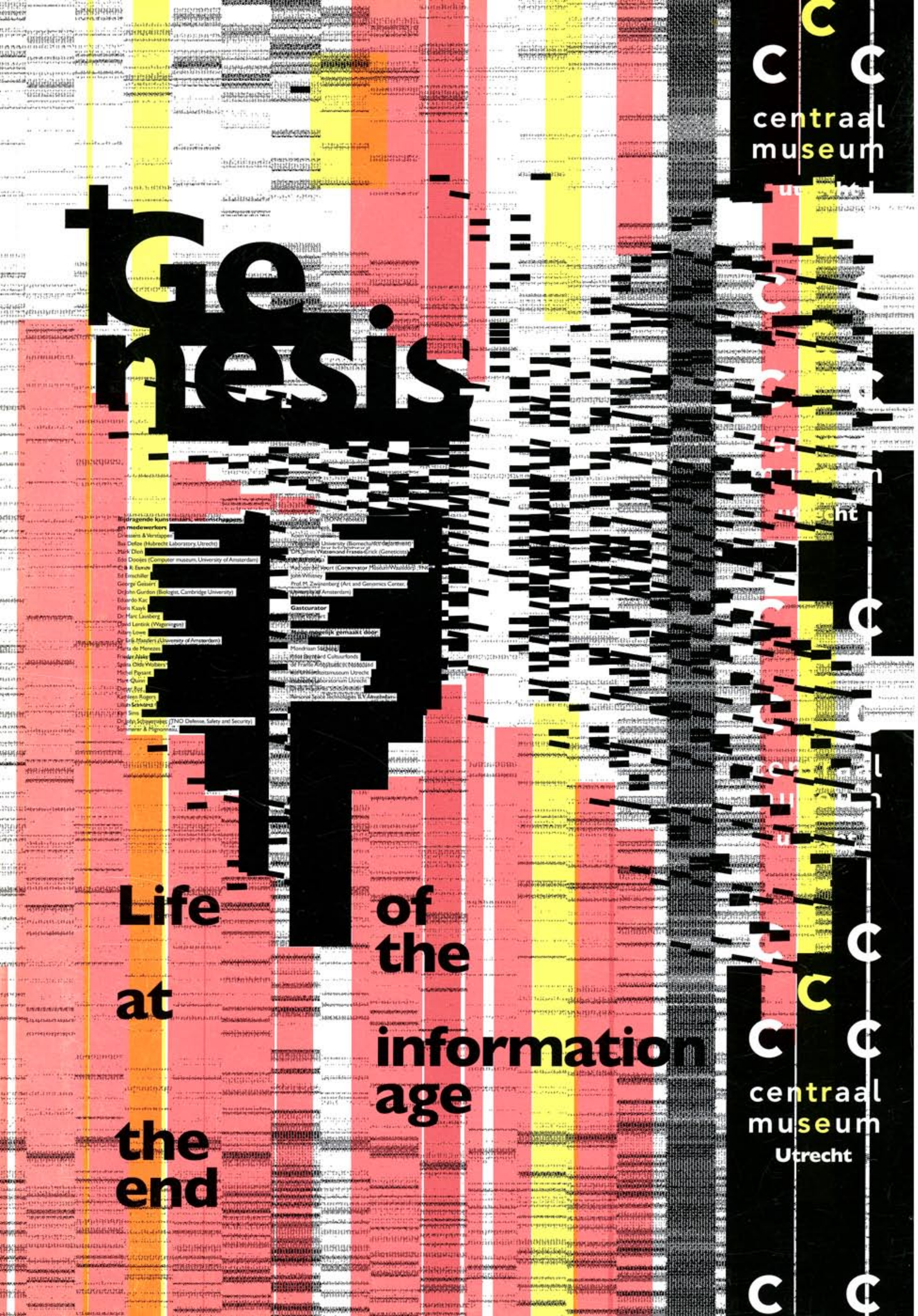


Moulding wet materials into replicas of themselves

Adam Lowe

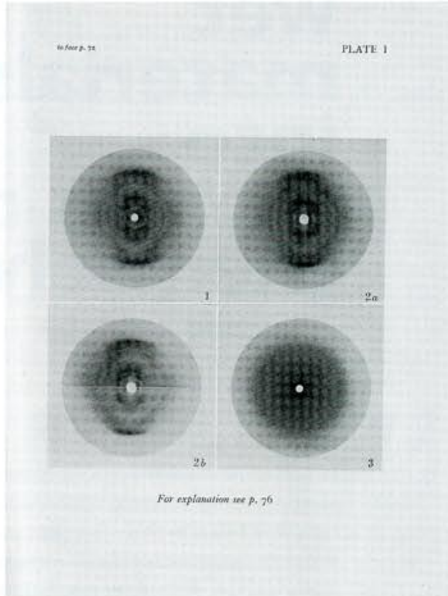
I believe that the same process of moulding of plastic materials into a configuration complementary to that of another molecule, which serves as a template, is responsible for all biological specificity. I believe that the genes serve as the templates on which are moulded the enzymes that are responsible for the chemical characters of the organisms, and that they also serve as templates for the production of replicas of themselves.

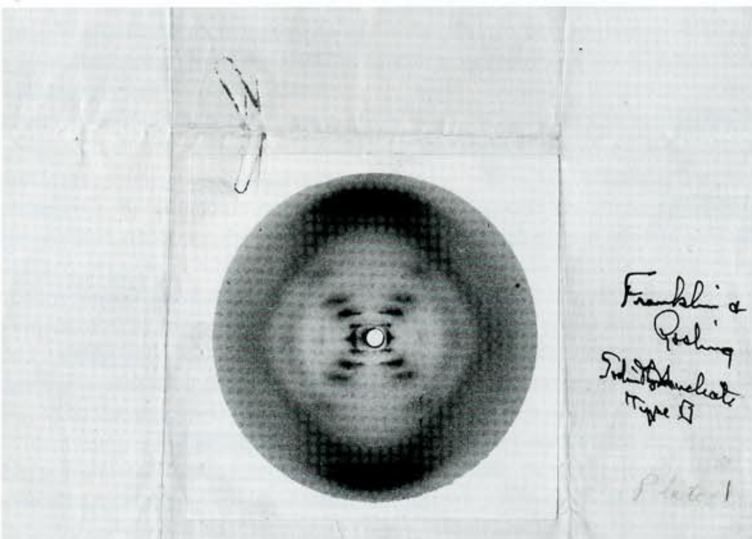
Linus Pauling, Sir Jesse Boot Foundation Lecture, May 28, 1948

Linus Pauling lost the race to discover the structure of DNA, mainly because he had the wrong photographs. He was working from x-ray diffraction photos taken in the late 1930s (with one new photograph from 1947) by William Astbury. In the x-ray diffraction technique a crystal is exposed to x-rays in order to produce a diffraction pattern. The electrons that surround the atoms, rather than the atomic nuclei themselves, are the entities that physically interact with the incoming x-ray photons. Unless the crystal is pure the results contain too much information and cannot be read. Astbury's photos of nucleic acids are beautiful, blurred circular patterns, resembling out-of-focus Chladni figures or one of the photographs that Margaret Watts Hughes took of her eidophone. In 1951 Pauling requested to see some DNA photos that he had heard were being taken at Kings College, London. He was refused access to these images. The photos he needed to see were taken by Rosalind Franklin, a very skilled x-ray crystallographer. After training in physical chemistry at Cambridge she spent three years at the Laboratoire central des services chimiques de l'Etat in Paris, learning the technically demanding process of x-ray diffraction photography. From 1951 to 1953 at 53 King's College she produced what J.D. Bernal has called, "the most beautiful x-ray photographs of any substance ever taken".

At the start of her research she was working with a mixture of the A and B forms of DNA, which produced a 'muddy' diffraction pattern that seemed almost impossible to interpret. However, from these photographs she realised that DNA was a thirsty molecule and that the phosphates in the molecule must be encased in water on the outside. She then succeeded in developing an ingenious and laborious method to separate the two forms, providing the first DNA crystals pure enough to yield 'interpretable' diffraction patterns. Photos 51 and 52 are in focus and show the pattern of the B Structure of DNA in its pure, extended, wet form. These photographs, clear to those who can read them, show twofold symmetry and a helical structure.

Since 1953 our understanding of DNA has been clarified, cleaned up, theorised, packaged and patented. This development has been parallel to the development of the computer. It is therefore not surprising that the language used to describe both the computer and genetics gets mixed up. It seems





Top:
William Astbury's X-Ray Studies of Nucleic Acids, 1947. Courtesy Ava Helen and Linus Pauling Papers, Oregon State University Libraries

Bottom:
Sodium deoxyribose nucleate from calf thymus, Structure B, Photo 51, taken by Rosalind E. Franklin and R.G. Gosling, 1952. Courtesy Ava Helen and Linus Pauling Papers, Oregon State University Libraries

it is now safe to assume that DNA is a 'program' carrying genetic 'information' in a 'coded' and 'sequenced' form. It is therefore logical that these 'instructions' can be 'stored' and 'accessed' at the appropriate time and made manifest using 'compatible software' and the right 'output device'. This reductive view concentrates on the byte-sized units being discrete and with a pre-programmed desire to replicate. But what if they are not? Brian Cantwell Smith has already demonstrated that digital systems are digital only as an abstraction. In the physical world they are actually analogue systems with enough redundancy for them to appear digital. Keeping things discrete takes a great deal of work. At the beginning of twentieth century, William Bateson, the inventor of the word genetics, preferred a messy, noisy model. He observed that, "the appearance of chromosomes is not suggestive of strings of beads of extreme heterogeneity, but rather with that seen for example in drying mud." He went even further to suggest that living things are not matter at all but a vortex through which matter passes.

If DNA is wet and plastic, why do the metaphors we use to describe it revolve around images of building blocks, chains, and links – dry rigid images based on a Lego world of assembling? This 'dry model' has had a profound effect on our world but what would happen if the metaphor were more about 'making'? If it were more fluid – like cement – with DNA partially taking on the shape and characteristics of the environment in which it forms? Within this 'cement' model there is less control, and as the random mutations churn away they generate not only the potential for disaster, such as cancers, but also the possibility of evolution and transformation.

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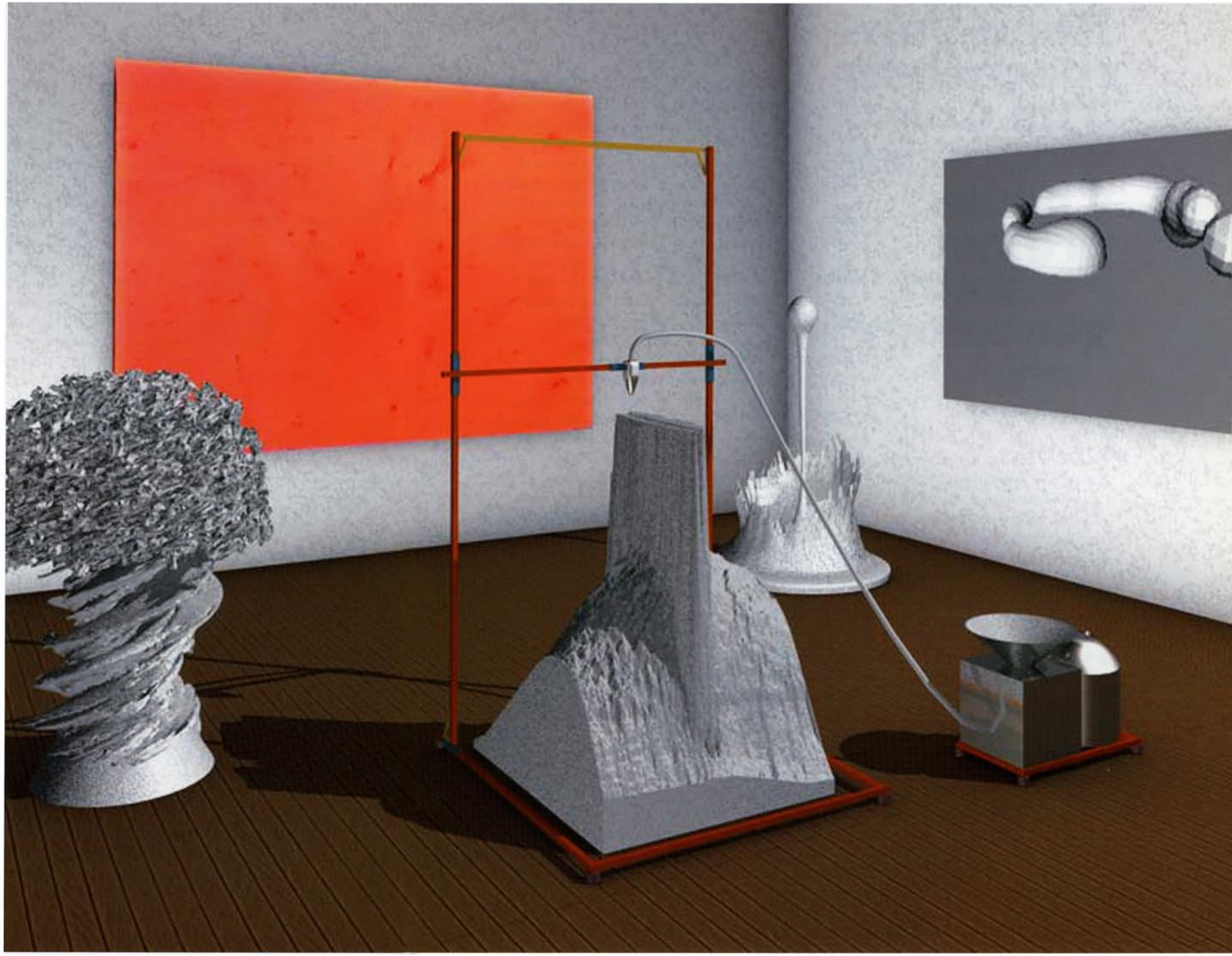

Above:
The Cement printer was designed and built by Dwight Perry and Adam Lowe. Virtual model of the printer was produced at Factum Arte by Gregoire Dupond