Alchemy in Art by **Thomas Duggan** on 19 February 2021

The title of Mr Thomas Duggan's talk was apt. He spoke at speed, darting from one topic to another, ranging from art to medical science, and displaying both a prodigious aptitude as a designer and an entrepreneur.

He has established the Thomas Duggan Studio in Cornwall - a research studio exploring design, material science and sculpture. The picture shows a six-axis KUKA robot, which had been on a six month loan to the Studio, where it was mounted on a pillar of his own design.

His starting point was a curiosity into nature, and in those of its forms which can be re-expressed artistically. This curiosity extends to reverse engineering to see how things are produced.

Primitive natural plant forms can be captured on computer and then manipulated to produce new patterns. Some patterns, if repeated, form 2D or 3D structures. He designed display cases to be made in wood, some quite elaborate – involving him in studying strength of materials, and how they would break if overstressed (he showed a bamboo bicycle frame – and went on to try compressed bamboo to see if it was stronger – it was). One installation, for a prestigious museum, had an entry spanned by a 10 metre wooden truss. Another study was into the use of charring to bring resins to the surface of a piece of wood, and how this might enhance its properties. This led to the design of portable sheds in which artistic displays could be mounted.

An intriguing experiment was to watch the pattern formed by sodium acetate crystals precipitated from an aqueous solution as it cooled from an initial temperature of 54^{O}C. He looked into what pattern would emerge from a simple algorithm using the robot to drive a printer head.

3D printing is a process of printing one 2D layer on top of another until the desired thickness is achieved. 4D introduces the time element – printing something that will change shape in the future, depending on changes in, for instance, temperature or pressure.

Silk – there is silk from spiders and silkworms – Mr Duggan described their studies into the latter. It consists of a Protein with Serosin (the glue). The silkworm will produce a continuous fibre a kilometre long to make its cocoon. The protein is biopolymer (biological and biodegradable) both desirable properties. Boiling silk in water will separate out the serosin – degradation will be low after 5 min, but it becomes malleable after ½ hour and more so after 1 hour. The biodegradability and other properties of this reverse engineered silk will depend on how long it has been boiled, or conditions are controlled. It is edible.

It can be used to coat a bodily implant, for instance for drug delivery, after which it will dissolve away in the body. Or a whole (porous) bone can be made of it, and act as a scaffold in which new bone can grow while the implant dissolves. It is also possible to coat, for example, a Covid 19 vaccine until it is needed, then dissolve it off; this has been tried with the Pfizer vaccine – then kept

at room temperature for a few weeks after which the vaccine was unimpaired. The Eden Project sought Mr Duggan's advice on encapsulating seeds before being put into cold storage. A model of a winged seed pod was made as means of dispersal – and a real seed inserted (not necessarily of a plant that would use this method of dispersal).

Reverse engineered silk can, with difficulty, be formed into tubes in solutions of methyl or ethyl alcohol. One can then use them to make optical components such as microlenses, diffraction gratings etc. It is also possible to put thin films on an insulating substrate etched with a circuit pattern, incorporating a low proportion of gold, to make conductors. Even transistors can be made, by applying another film incorporating a low proportion of magnesium. Such circuitry would have limited performance, but be adequate to make, for example, blood sugar level sensors. Enzyme batteries are being designed.

If reacted with HVIP, silk fibres will cross-link, giving a strong water resistant material with very low surface friction. Cross-linked silk is not biodegradable, at least not in the short term. The sculptural pillar which supports the KUKA robot was made of this. Another application is for orthopaedic hardware. Miniature cog wheels, as used in a wrist watch, were essayed – made at three times full size (to ensure the tooth shape was correct) then shrunk to size.

In another form a block can be made incorporating polystyrene spheres, then dissolving out the spheres – leaving a strong, lightweight material with a shiny (very low friction) surface. They made 'Santos' crystals for Cartier by this method.

Mr Duggan closed by saying that energy flows and efficiencies were an important part of this work.

Thomas Duggan Studio is a collaborative and multidisciplinary research studio exploring design, material science and sculpture. The studio works on a consultancy basis within innovation and research and has a fully equipped workshop including advanced robotic fabrication supporting collaborative projects with individuals, companies and institutions. The studio has published work in journals including Proceedings of the National Academy of Sciences and Nature Nanotechnology as well as exhibiting at the V&A Museum, Tate and MoMA.