17th February 2024

An Introduction to BSF Enterprise

Well, I have failed miserably over the past five months in sticking to the promise I made to myself to write more regularly in blog format…!

To get the ball rolling once more, I have written an introduction to ***BSF Enterprise (9.75p, £10.1m)***, an early-stage, pre-revenue biotech company focussed on cell-based tissue engineering. I will discuss the technology a little more in depth overleaf, but in short BSF has developed a unique method of engineering living tissues – such as muscle, skin and corneas. In contrast to competing technologies, that require synthetic 'scaffolds' to assist in tissue growth, the tissues that BSF produces grow without assistance, self-structuring exactly as they would in a living organism. This could potentially open up immense commercial opportunities for BSF in a wide array of industries, including in *cultivated meat*, *high-end fashion*, and *healthcare*.

As a disclaimer: I have been holding the stock in varying size for fifteen months, since November 2022, having traded it only moderately successfully (whilst I bought initially at 8-9p, I subsequently purchased a large block in the 17p placing in April 2023!). However, it was in October and November last year that I really started upping my position back in the 8-9p range, and declared a TR1 position on 30 November (my current average is a shade under 11p).

I have selected BSF as my first subject of choice in 2024 in this short blog format, because up until this week I had been disappointed with – and frustrated by – the Company's efforts to really connect with its investor base in recent months. On 31 January, BSF published its audited results for the financial year ending 30 September 2023. Whilst there were no real surprises in the financial statements, I was dismayed that management failed to provide quality commentary on its various activities, either from a technical and operational perspective, or from a commercial outlook. There was a lack of structure to the commentary provided, that was difficult to follow.

Many shareholders were left second-guessing about just how far the various proof-of-concept trials that BSF is involved in have progressed; about when product sales will commence in earnest; about when the first licensing agreements will be signed, etc. Moreover, many non-holders who I have spoken to about the Company, do not quite understand the technology and thus the investment proposition – and so have no interest in buying the shares.

This week, however, BSF released a well-written strategy update that addressed many of the shortcomings of the Final Results. The Company clearly articulated that it is developing an 'umbrella strategy', in which it is launching a handful of subsidiaries to focus on developing and commercialising BSF's IP suite within specific target market verticals.

In this narrative, I set out the investment case for BSF. I provide my own commentary on the core technologies and products within the Company, and why various industries may desire to use them. I then cover the various divisions and ongoing activities within each. I subsequently examine the balance sheet and the possible near-term cash flow generators. Finally, I touch upon possible valuations – and why I feel the current share price of 9.75p provides such an attractive investment opportunity. [Alas, I have utterly failed to stick to my self-imposed three page limit, for this new blog format!]

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An Introduction to BSF and to Tissue Engineering

BSF listed on the Main Market of the LSE in July 2019, as a special purpose acquisition company, raising £0.77m at 5p per share. In May 2022 BSF completed its first deal, when it acquired 3D Bio-Tissues ('3DBT'), a tissue engineering business based in Newcastle, for a total consideration of £2.5m that was paid entirely in consideration shares at a price of 7.37p. In tandem, the Company raised £1.75m cash (also at 7.37p) from new investors.

3DBT was spun out from the University of Newcastle by its founders, Professor Che Connon and Dr Ricardo Gouveia. They are now BSF's Managing Director and Chief Scientific Officer, respectively, and hold almost 15% of the company between them. Professor Connon is a world leading expert in the field of *tissue engineering*. At 3DBT, they have developed a proprietary tissue engineering platform, named *Tissue Templating*, which boasts unique properties that give it a major competitive advantage over conventional tissue engineering processes.

So then, what actually is 'tissue engineering'? In short, it is a multidisciplinary field that combines principles from engineering and life sciences to create *functional, biological tissues*. These could range from muscle tissue; to cartilage; to heart, liver, lung or kidney tissue; to skin; to corneal tissue. Use cases for such biomaterial are wide-ranging and increasing rapidly. For example, engineered skin tissue could be used in the healthcare setting, such as for skin grafts for burn victims; but it could also be used in the fashion industry, for tanning into leather to be used to make luxury items such as designer handbags. Similarly, engineered muscle tissue could be used in muscle repair or reconstructive surgery; but it could also be used in the food industry, to produce *cultivated meat*.

The process of creating tissue usually involves several key steps. Firstly, initial cells are sourced from the tissue that is intended to be developed. Using an example from the cultivated meat industry – such as producing a beef steak: through a biopsy, a small sample of muscle tissue is taken from a living cow. From this sample, relevant cell types are selected to develop an 'immortalised cell line' – essentially, a stable, self-replenishing bank of cells which can be drawn from repeatedly, so that animal biopsies to collect new cells are not required all the time.

The cells are then 'seeded' onto a three dimensional scaffold, which serves to mimic the structure of natural meat. The scaffold plays the role of the "extracellular matrix" – providing support for cell attachment, growth, and tissue organization. Scaffolds are made of synthetic or plant-based material. The seeded scaffolds are placed in a *bioreactor* (not too dissimilar to a stainless steel beer fermenter, in appearance!), and fed with a *cell culture medium*. In layman's terms, a cell culture medium is essentially a liquid 'broth' – comprised of basic nutrients such as amino acids, glucose, vitamins, and inorganic salts, and supplemented with growth factors and other proteins. This encourages cell growth and proliferation (i.e. when a cell divides to produce two daughter cells). Through changes in the cell culture medium composition that is fed into the bioreactor, as well as through cues from the scaffolding structure, immature cells are also triggered to *differentiate* into skeletal muscle, fat cells, and connective tissues that make up meat.

In essence, the bioreactor attempts to *replicate*, as closely as possible, the optimal conditions for cell growth that is found in living animals. Cultivated meat matures in the bioreactor over a period of 3-6 weeks.

It's important to have a basic grasp of the above process of normal tissue engineering, in order to be able to appreciate the unique technology that 3DBT has developed. The *Tissue Templating* platform – which is essentially a methodology, as opposed to a physical product – works by providing a *natural*

structure for the engineered tissue, so that a scaffold is no longer required in the process. The technology is based on applying physical and biochemical cues to direct and organise cell growth, using the inherent power of cells so that they self-assemble to form highly structured, natural tissue.

Now, this may not sound like such a big deal, for many readers. But the nuance has huge ramifications. If engineered tissue does not have a structure, it does not have proper function. The biomass would simply be – in layman's terms – soft and mushy. Every other tissue engineering company gets around this by using synthetic or plant-based scaffolds (they could be made from biodegradable polymers; collagen; alginate; cellulose; lignin; vegetable protein; etc.). Nevertheless, whilst their engineered tissues will have structure, they will not have a truly natural feel or content. Tissue engineered with 3DBT's Tissue Templating technology, however, has a proper, recognisable and natural function. In the case of cultivated meat, for example, a beef steak produced by BSF's technology would be *100% beef content* – with the same texture, bite and taste as a beef steak produced from a farmed cow.

During its early R&D work, 3DBT also developed a booster supplement for cell culture media that is used in the tissue engineering process. This patented formulation – which BSF has branded ***City-Mix*** – is added at a concentration of 25:1 (i.e. 1 litre of the supplement, for every 25 litres of media being used). In short, the City-Mix supplement boosts biomass production, whilst simultaneously reducing the requirement for most of the expensive growth factors presently used in cell culture media. Whist the inclusion of City-Mix in the medium is a fundamental requirement when using the Company's proprietary *Tissue Templating* process (it was, after all, specifically designed to facilitate scaffold-free engineering), BSF has also commercialised the supplement as standalone product. It is beginning to sell it into both the life sciences sector – for example, to manufacturers of biologics such as antibody-based therapies; and into the nascent cultivated meat industry. Ultimately, customers will buy City-Mix in order to lower the cost of their media, which is the *largest* component of the overall cost of engineering tissue such as cultivated meat.

3DBT has also developed a second standalone product that is not directly related to its Tissue Templating platform. ***Etsyl*** is a lipopeptide – a molecule composed of both lipid (fat) and peptide (protein) components – that promotes cellular collagen production. These small molecules have potential cosmetic and pharmacological applications, namely as bioactive ingredients in skincare formulations for preventing and treating wrinkling due to collagen loss, as well as for enhancing wound repair. Currently BSF is working with one of the largest cosmetic companies in the world, under a proof-of-concept agreement, to test the suitability of Etsyl for use within skin cream cosmetic solutions.

BSF is a young and small company with only a dozen or so employees and limited financial resources. It is presently seeking to commercialise its Tissue Templating technology in (an initial) three fields: ***cultivated meat***, ***leather*** and ***corneas***. For each target industry, the Company is positioning itself as technology licensor. It does not intend to manufacture products in-house (at least, at large-scale), but rather to license out production line blueprints to meat companies, luxury fashion houses, medical devices companies, etc.

Over the past three months, BSF has begun to implement an umbrella strategy, in which R&D and commercial activities around each target market vertical, are housed in separate subsidiaries – with their own management teams, staff and accounting functions. A key benefit of this strategy will be that investors and/or partners will be able to invest at subsidiary level – thus limiting equity dilution at PLC level, going forward.

Kerato Ltd, a 100%-owned subsidiary, has taken over responsibility for the commercialisation of BSF's corneal products. ***Cultivated Meat Technologies Ltd*** – which BSF is in the process of establishing as a 50%-owned joint venture with a technology partner – will focus on cultivated meat. ***Lab-Grown***

Leather Ltd will be formed in the next several months, as another 100%-owned subsidiary, and will be involved in the commercialisation of cultivated leather. Finally the original subsidiary, ***3D Bio-Tissues Ltd***, will continue to focus on commercialising, as well as carrying out further R&D work on, the physical standalone products, namely City-Mix and Etsyl.

Cultivated Meat Technologies Ltd

Let's start with BSF's efforts in the *cultivated meat* industry. It would require dozens of pages to set out the rationale behind the significant effort and investment being poured into this nascent industry, around the world; but so as not to drive readers to abandon this note here and now, I shall do my best to summarise it in just a few paragraphs! So – why the strong interest in making cultivated meat a reality, from governments and from scientific, industry and investment communities across the globe? There are a plethora of reasons, that I have grouped into four broad areas below. For each area, I describe the problems caused by conventional farming, and how cultivated meat production may mitigate against each problem.

Environmental. It has been estimated that over 3.4 *billion* hectares of agricultural land (equating to some 70% of *all* agricultural land on Earth) are used to graze cattle and other livestock, and to grow the crops that feed them. This results in *colossal* volumes of deforestation, as well as destruction of natural habitats. Livestock rearing and feeding consumes immense volumes of fresh water (drinking, cleaning, and irrigation of the feed crops). It is also a major contributor to water pollution through runoff of manure, antibiotics and fertilizers into waterways.

Livestock rearing and feeding is also hugely energy intensive (feed production, processing and transportation; meat processing, packaging and transportation).

Finally, conventional meat (and dairy) production is a major global contributor to greenhouse gas emissions. Enteric fermentation (what most of would know as, "cattle belching"!) releases methane, which has a heat-trapping ability that is at least 30 *times* greater than that of carbon dioxide. Moreover, another greenhouse gas, nitrous oxide, is released during both fertilizer application and manure management.

The environmental benefits to be gained from switching to cultivated meat should be blindingly obvious to all. There are a number of forecasts out there for readers to peruse – which, whilst highly speculative, are helpful in understanding just how great of a positive impact on the environment, a switch to cultivated meat could be. Here are just a few of them, addressing each of the points above:

- Land use for livestock grazing and feed production could be reduced by 95% to 99% worldwide;
- Fresh water use could be reduced by 78%, and possibly by as much as by 96%;
- Water pollution from the industry would be eradicated (and moreover, water could actually be recycled in a cultivated meat-based industry);
- Energy use could be reduced by up to 45%;
- Due to a combination of reduced energy use, and eradication of enteric fermentation, fertiliser application and manure management, greenhouse gas emissions could be reduced by as much as 96%.

Ethical. Approximately *70 billion* farm animals are raised and killed for food every year, across the globe. A large majority of those animals are battery-farmed – which is, frankly, a disgusting and harrowing subject, and not one to detail at length here. I shall give just one analogy: in 1925, the average market weight of a chicken was 2.5 pounds. In 2015, it was 6.24 pounds, an increase of 150% – even though both sets of birds from ninety years apart, were fed *the same weight of food*. Furthermore, the birds in 2015 that were two and a half times the size of the 1925 group, had an "average days to market" of only 48 days – which is a 57% shorter time period than the 112 days to market for the 1925 birds.

I can't imagine anyone actually believes there will be a world (at least in this century) in which animal husbandry does not exist. But a core driver of many who advocate cultivated meat, is the desire to witness an eradication of *intensive battery farming* of animals. As the brilliant historian Yuval Harari once wrote:

The treatment of domesticated animals in industrial farms is perhaps the worst crime in history.

Health. In conventional farming, antibiotics are used extensively for disease prevention and growth promotion, which results in the emergence of *antibiotic-resistant bacteria* in reared animals. These resistant bacteria can pose serious health risks (notably, transmission through consumption, leading to difficult-to-treat infections). *Foodborne pathogens* such as Salmonella and E.coli, which can contaminate meat products during slaughter and processing; and *zoonotic diseases* such as influenza viruses and coronaviruses, which can be transmitted to humans from close contact with animals in intensive farming systems – are likewise significant public health concerns. With regards to seafood, the ingestion of *microplastics* is also a rapidly growing threat to global public health.

Cultivated meat (and seafood) production would safeguard against all four of these threats to public health:

- Production does not require the use of antibiotics, thus minimising the possibility of antibiotic resistance in humans;
- Production systems would have strict sanitary controls and sterile conditions in place, reducing the risk of foodborne pathogens in cultivated meat products;
- No intensive farming would mean that zoonotic disease could no longer be transmitted to humans;
- Ingestion of microplastics through seafood consumption would be eradicated.

Economical. Cultivated meat production has the potential to be far more economically attractive than conventional meat production. The reason for this primarily stems from more *efficient resource utilisation.* Consider nutrient utilisation. Animals raised for meat production typically convert feed into muscle tissue inefficiently, with a significant portion of the feed's energy lost in maintenance activity (such as maintaining body temperature and organ function); physical activity (such as walking and grazing); digestive inefficiencies; metabolic processes; etc. In contrast, in cultivated meat production, nutrients can be delivered directly to cells in a highly controlled environment, resulting in more efficient conversion of nutrients into meat.

Compounding on the above: in traditional animal farming, the portion of the feed's energy that *is* left over for tissue growth, must be used to grow *the entire animal* – including the inedible parts such as hide, hair, hooves and internal organs, which, in the case of a cow, usually amount to a little over 50% of the animal. Cultivated meat production has the potential to optimize resource utilisation by focusing *exclusively* on the production of *edible* meat tissue.

In the meat industry, the above two concepts are measured with *Feed Conversion Ratios ('FCR')*. The lower the FCR, the less feed it takes to create a pound of edible meat. Typically, the FCR for beef is 6.0-10.0. For *cultivated* beef – once the nascent industry has matured and its technology advanced and scaled up – the FCR should theoretically drop to close to 1.0. This could drastically improve the economics of the novel industry over the incumbent.

Finally, it is also important to note that cultivated meat production sites could be located near to urban centres around the world, including in regions where conventional livestock rearing is unfeasible due

to the climate, the terrain, or simply to lack of physical space. This could likewise dramatically improve the economics of the industry, with regards to transportation costs. It could also address the major issue of *food security* for numerous regions.

So there we have it – the basic arguments for why there is huge interest across the globe in building out a cultivated meat industry. At present, the industry essentially remains at a pre-commercialisation stage. Only two companies worldwide have received approval from regulatory bodies to sell cultivated meat to the public – East Just received approval to sell its chicken bites in Singapore, in December 2020, and in the US in June 2023; and UPSIDE Foods also received approval to sell its chicken product in the US in June 2023. Although both companies partnered with high-end restaurants to serve their products on taster menus, those restaurants (in both Singapore and the US) have all stopped serving cultivated meat.

As with any new revolutionary technology, there are significant hurdles for the fledgling industry to overcome. For cultivated meat, there are five key challenges:

- ***Cost and contents of media***. The production cost of cultivated meat remains many multiples more than that of farm-raised meat. A core component of the cost (estimated to be as much as 90%) is the cell culture medium – the liquid broth that feeds the tissues' growth. This is in large part due to the use of foetal bovine serum ('FBS') in the media, which is astronomically expensive. FBS is derived from the blood taken from a bovine foetus at a slaughterhouse. Any use of FBS in the production process of cultivated meat is, frankly, absurdly counterintuitive.

- ***Structure, texture, taste***. The current major players in the cultivated meat industry have reportedly struggled to create products that truly replicate the texture of meat. Eat Just's chicken product is comprised of actually only 70% chicken cells, with the balance being a blend of plants and other proteins. UPSIDE's product, whilst over 99% chicken, has also been reported by numerous critics to lack a real, meat-like texture.

- ***Difficulties in scaling up***. Technology transfer from lab-scale bioreactors to *industrial*-scale bioreactors will be fundamental in making cultivated meat production an economic reality. It has been reported that the existing leading cultivated meat companies are struggling to achieve this. Frequent contamination of the larger bioreactors is a major issue. The capital costs of currently planned cultivated meat factories are also economically unfeasible.

- ***The "ick factor"***. A large majority of people are currently revolted by the idea of cultivated meat. Derogatory terms used include "lab-grown meat" and "Frankenstein meat". The ick factor will only be eroded with time, and significant education. Personally, I think if every child in every school in the world were forced to sit down and watch an hour of video footage taken from the worst battery farms and abattoirs, and witness the astonishing cruelty that billions of animals endure every day… Then that education process could be fast-tracked marvellously. Alas, we can only dream…!

- ***Resistance from incumbent powers***. Many (most?) farmers and meat companies will naturally fear the concept of cultivated meat, as they view it as an existential threat. It is abundantly clear that large corporations and unions have already been lobbying aggressively all over the world to slow down the progression of the nascent industry – or even halt it dead in its tracks. Whilst some states in the US have embraced cultivated meat, others are fighting it. Nebraska and Texas have restricted its labelling, and Florida is shortly to ban it altogether – as Italy has already done.

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It sounds like a bloody tough industry to try one hand's in, right? Why on earth would BSF seek to get involved in it, readers might ask, when there are lower hanging fruits to pick? Well, firstly, BSF's combined technologies of Tissue Templating and City-Mix address the first two points listed above. The inclusion of City-Mix as a supplement drastically reduces the cost of cell culture media, whilst simultaneously removing the requirement for FBS in it. However, even more importantly, the use of the two technologies in combination facilitates the production of cultivated meat *with structure*.

In November 2022, only six months after the acquisition of 3DBT had completed, BSF successfully produced three prototype fillets of cultivated pork. Whilst these first prototypes were very small – weighing only 5 grams each – they exceeded management's expectations.

"*In their raw state the lab-grown fillets exhibited structural integrity and resistance to breaking when being manipulated and compressed. The fillets resembled conventional farm grown meat to touch with similar consistency and elasticity and no obvious aroma.*

Two of the fillets were then pan fried, cooking rapidly and throughout while maintaining integrity and shape and exhibiting only minimal shrinkage, as would be expected during the preparation of high-quality farm grown meat. The fillets seared easily, showed heavy caramelisation with charring and crisping on the surface, and the aromas were identical to those of barbecued meat."

Two months later, BSF produced a number of larger prototypes, approximately 9cm by 6cm. These steaks were actually eaten by management. The results were again hugely encouraging.

"*In its raw state the cultivated steak fillet was very similar in appearance to conventional meat with fibres clearly visible. On cutting the fillet, it displayed similar structural integrity to raw conventional meat, including resistance to breaking and compression…*

When eating the cooked meat, it was found to exhibit very similar texture, consistency and flavour to that of traditional pork. In summary, the test results exceeded expectations in all respects. The testers agreed that both the texture and the taste in the mouth was indistinguishable from pork steak."

Finally, in May last year, BSF produced full-size pork fillets, and invited select shareholders and company insiders to a tasting event. Once again, the results were overwhelmingly positive.

Now. BSF doesn't intend to be an actual producer of cultivated meat. It is a biotech company focussed on building out a licensing model in multiple industry verticals in which its technologies can make a real difference. Whilst City-Mix and Tissue Templating address the first two of the cultivated meat industry's challenges that I noted on the previous page, the third issue remains: scaling up production. To that end, BSF is teaming up with CellularRevolution ('CellRev'), which happens to be another spinout from the University of Newcastle, founded by Professor Connon.

CellRev is a next-generation bioreactor company that is focussed on continuous cell culture processing, as opposed to traditional batch culture. In short, its patented bioreactor system enables continuous growing of cells (for as long as 60 days, uninterrupted), which dramatically increases productivity whilst significantly reducing labour costs (as there is less work to do in management of the bioreactor). Moreover, the media can be recycled, thus cutting input costs substantially.

CellRev and BSF are in the process of creating a joint venture, ***Cultivated Meat Technologies Ltd ('CMT')***. By combining their technologies, they believe that CMT could address *all* of the first three technological issues that I listed on the previous page. In management's words:

"*The aim of CMT is to provide the market with the premier platform for manufacturing cultivated meat in a scalable and cost-competitive manner.*"

Whether or not CMT will succeed in integrating the two companies' technologies… we shall discover in the next six months. However, given that that they share a founder and that they are based in the same building in Newcastle, I'd imagine they have a good idea of what is achievable (I also don't doubt that the two companies have already done considerable work on the project together already).

But just consider the possibility of it being a success. Both UPSIDE and Eat Just are failing to get to grips with the cost and contents of their cell culture media; with creating a *structured* product (that is 100% actual meat, without the need for a plant or synthetics scaffold); and with getting their industrial-scale bioreactors to actually work.

Both UPSIDE and Eat Just have achieved valuations in excess of $1 billion, and have raised hundreds of millions of dollars in new capital… But both are still unable to deliver a structured, 100% meat product, yet alone deliver such a product at commercial-scale output.

"*CMT will seek to deliver this through licencing agreements with established meat-producers that can provide production know-how, capital allocation and supply chain relationships*."

From the above quote, I imagine that CMT will raise funds privately, perhaps in H2 this year. My impression is that interested investors could also become customers – namely, the established meat producers of the world, such as Cargill, Tyson Foods and JBS. And for those readers who might automatically think, "No way would the industry leaders of conventional meat farming, get involved in cultivated meat!" – well, both Tyson and Cargill have invested in UPSIDE; Cargill has invested in another leading cultivated meat company, Aleph Farms; and JBS is in the process of constructing its own $62m cultivated meat research facility in Brazil, which is slated to open this year.

The incumbent powers of the global meat industry all have more than one eye on developments in the cultivated meat space.

And CMT is aiming to become *the* pick-and-shovel play in the nascent industry.

To put the long-term commercial opportunity into perspective, the combined global meat, poultry and seafood market was valued at circa $1.3 trillion in 2022. Various works of market research suggest annual sales of cultivated meat and seafood could reach as much as $25 billion by 2030, and increase exponentially thereafter.

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Lab-Grown Leather Ltd

BSF's Tissue Templating and City-Mix technologies can be used together to produce cultivated animal (or human) skin. Animal skin can be tanned into leather, and human skin could be used for medical applications such as skin grafts. At present, BSF is focussing its efforts on cultivated leather for the fashion industry. Besides the potentially substantial commercial opportunity available within that target industry vertical, cultivated leather moreover would not face regulatory scrutiny in being brought to market – in contrast to the strict regulatory environment that cultivated skin products (for medical use) and cultivated meat products would be forced to navigate.

In May last year, BSF announced that it had produced samples of animal skin tissue, measuring up to 10cm by 10cm in size, and between 0.5mm to 1.0mm in thickness. It also stated in the announcement:

"*BSF has engaged with a number of companies within the leather industry in the UK and abroad regarding potential Proof-of-Concept engagements to establish the suitability of the skin product as a sustainable, ethical alternative to traditional leather goods. Once established, BSF will seek to develop plans to scale up production of animal skin products*."

A week later, BSF announced that it had "*entered a contract with a leather company to test and develop lab-grown animal skin for leather production, although the terms of the contract are highly confidential at present.*" In subsequent investor interviews and presentations, management has hinted that the customer is a leading fashion house in Europe. For me, the obvious names are LVMH (with brands such as Louis Vuitton, Christian Dior, Fendi and Givenchy); Hermes; Kering; Prada; or Chanel.

The proposition for cultivated leather in the fashion industry is founded on the same ethical and environmental reasons that I detailed in the previous section, on cultivated meat.

Furthermore, there are several *practical* benefits of cultivated leather over cow-derived leather. Firstly, the latter will always be limited in size (by the size of the animal it was taken from!). Secondly, animal-derived leather will have imperfections (natural defects from birth, or by scarring in life). Thirdly, cultivated skin will require very little preparation work, prior to tanning – unlike with animal skins, which require washing and liming in order to remove hair, bits of flesh, and other unwanted material.

The global leather goods market was valued at $253bn last year and is expected to grow to $405bn by 2030. Hermes alone spent $300m on animal hides in 2018; I imagine that that figure has more than doubled by now, in line with the growth in Hermes' total cost of sales over that 5 year period.

VitroLabs is one standout competitor that produces cultivated leather. Founded in 2016 and headquarter in the San Francisco Bay Area, the company completed a Series A financing round in 2022, raising $46m. It is now valued at circa $114m. VitroLabs counts French luxury powerhouse, Kering, as both a shareholder and strategic partner (the two companies have worked together confidentially on product development and tanning since 2018). So we can probably rule out *that* name from BSF's possible luxury fashion partners that I listed above!

A key differentiator between VitroLabs' and BSF's technology platforms is that the latter does not require the use of synthetic scaffolds to produce its cultivated leather. VitroLabs currently uses polyester scaffolding, which has to be separated from the cells at time of harvest; although it has been reported that the company has been looking to replace the polyester with cellulose, for a more sustainable scaffold. It was also suggested that there was some wastage in the process, as not every cell was sticking successfully to the scaffold. I have not been able to determine if these issues were fixed by VitroLabs, or if they even ever represented a significant cost burden. Either way, what I *am* sure of is

that BSF does not require scaffolds to produce its cultivated skin – which could not only reduce manufacturing costs, but could also arguably result in a more natural, 'purer' final product for the tanning process.

In any event, with a total addressable market for luxury leather items stretching into the billions of dollars (even after assuming a displacement of animal-derived leather by cultivated leather, of only 1% or 2% over the next five years), I am comfortable that there'll be space for multiple major winners.

In this week's Strategic Update RNS, BSF revealed that it will be forming a 100%-owned subsidiary, ***Lab-Grown Leather Ltd ('LGL')***, in the coming months. It is already in the process of hiring a dedicated CEO and management team, and furthermore is in talks with partners about financing the business at subsidiary level.

Of particular note was that the company is "*in the process of building a leather tanning capability within its laboratory at Newcastle*." My take on this is that this will provide LGL – in the first instance – with the capacity to produce sample products, for which to showcase to potential customers. Additionally, it will assist LGL in optimising an end-to-end solution that it could then license out to multiple major players in the leather goods industry.

Personally, I would like to see further proof-of-concept trials entered into with other major fashion houses – or perhaps automotive companies (leather seats in sports cars)? – so as to reduce the operation's (seemingly) current heavy reliance on the first European fashion house with which BSF is working under a PoC agreement. In fact, I believe that this move to diversify is already occurring, with the first step being the decision to build out in-house tanning capacity.

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Kerato Ltd

BSF's Tissue Templating and City-Mix technologies can also be used together to produce human corneas. When BSF came to market in 2022, the Company was only focussing on using the product in the corrective vision market, as a direct replacement for donor tissue used in cornea transplant procedures. Last year however, BSF entered into a proof-of-concept agreement with "*America's leading consumer goods company*" (I think we can safely assume, Procter & Gamble) to develop lab-grown corneas for improved testing of chemical and pharma products.

Kerato was established as a 100%-owned subsidiary of BSF in October last year, as a dedicated unit to develop the R&D and commercial workstreams for the lab-grown corneas. An experienced managing director, Sarah Greenhalgh, who has led the design and delivery of early-stage clinical research projects and clinical trials – was appointed at the outset.

In Thursday's Strategy Update, BSF gave a bit more colour as to Kerato's plans and objectives:

"*Two applications are being developed, an* ***Implantable Medical Device*** *and an* ***Ocular Toxicity Testing Platform****, which will be launched in 2028 and 2026, respectively*."

It also referenced an intention to advanced towards clinical trials.

In short, BSF can produce lab-grown corneas in varying levels of *quality* (in terms of how closely it replicates an actual human cornea). The highest quality – and inevitably, most expensive – line of corneas that can be developed, will be used in a healthcare setting, i.e. as an ***implantable medical device***. Consider that the waiting list for corneal transplants has recently been estimated to be in excess of 10 million people worldwide (as there is a chronic shortage of donors, relative to the number of patients in need of the surgical procedure) – and you can begin to understand why lab-grown corneas could become of interest to the leading players in the corrective vision industry. Although nothing has been mentioned in the subsequent 22 months, BSF did state the following in its 2022 Admission Document:

"*3DBT has entered into a Material Transfer Agreement with a large medical device company. Although the commercial terms have not been agreed upon, 3DBT is anticipating the implementation of a licence model for access to the means of production for 3DBT corneas and associated intellectual property*."

Clearly then, there has *already* been interest in BSF's corneas from the medical devices industry.

With regards to the ***ocular toxicity testing platform*** referenced in Thursday's RNS, this is evidently building on the work that Kerato has already carried out under the PoC agreement with Proctor & Gamble. These lab-grown corneas are substantially lower grade (and resultantly, substantially cheaper to manufacture) than those produced for clinical use.

On the other hand, because of both ease of manufacture, and the removal of significant regulatory hurdles that the corneas for *clinical* use will face, the corneas for *industrial* use should almost certainly be generating revenues for Kerato in a much shorter time horizon.

As with both CMT and LGL, I expect that Kerato will raise capital (at the subsidiary level) from specialist investors (and/or perhaps industry partners) over the next 12 months.

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3D Bio-Tissues Ltd

With the three types of structured tissue that BSF is focussing on each having been re-homed in a subsidiary, the original business that was acquired by BSF in 2022 – ***3D Bio-Tissues ('3DBT')*** – is left with the Company's standalone products, namely *City-Mix* and *Etsyl*.

City-Mix

City-Mix is a supplement for cell culture media – the liquid 'broth' of nutrients which feeds the cells, in a cell culturing process such as tissue engineering. The supplement is a patented formulation, which is added at a concentration of 25:1 to the media (i.e. 1 litre of the supplement, for every 25 litres of media being used). In short, the formulation facilitates a process called "macromolecular crowding" in the media in which it is mixed. A cell culture medium supplemented with City-Mix has four key advantages over traditional (non-supplemented) media:

- increases cell proliferation rates and thus production yield;
- reduces (or even completely removes) the need for expensive recombinant growth factors;
- eliminates the need for foetal bovine serum ('FBS');
- facilitates the production of *structured* tissue via establishing an extracellular matrix (thus reducing or removing the need for scaffolds).

The first three points in combination drive a dramatic reduction in media costs. BSF estimates that its customers are enjoying a reduction in media costs of as much as 75%, by using the City-Mix supplement.

Additionally, the third point is highly significant for customers who wish to remove animal-derived products entirely from their cell culturing processes, for ethical reasons.

Finally, it is important to note that the fourth point is why the City-Mix supplement plays a key role in BSF's Tissue Templating process for engineering *structured* meat, skin and corneas.

The cell culture media market is currently worth approximately $6 billion per annum, and has been forecast to double to $13 billion over the next 5 years. End-users are primarily comprised of pharmaceutical and biotechnology companies, who utilise cell culture processes to produce monoclonal antibodies and other proteins for use in vaccines, immunotherapies, antibody-drug conjugates, etc; and to produce key biologic components in both gene and cell therapies (such as viral vectors and MSCs). Media are also used by pharmaceutical and medical devices companies in numerous diagnostics applications, as well as drug screening and development.

Of course, tissue engineering going industrial-scale – notably, if/when the cultivated meat industry really kicks off – could provide a step change for the cell culture media market. Consider: media comprises the *majority* of the cost of production for a cultivated meat producer. Assuming a 20% gross margin (in line with animal-farmed meat companies), then as much as 50% of revenue might be spent on media. If the global cultivated meat industry reaches $100 billion by 2035, then we're looking at a market of $50bn pa for cell culture media, *just* for cultivated meat production.

3DBT formally launched City-Mix as a stand-alone product at the end of 2022. Over the past year, over 30 prospective customers – ranging from cultivated meat companies, to biotech businesses, to universities – have been carrying out product evaluations. No major customers or out-licenses have yet been secured, although in the RNS this week management stated that results from the evaluation to date have been "*overwhelmingly positive*."

Despite the lack of revenue generation to date, 3DBT is continuing to ramp up its City-Mix production lines. Having doubled capacity last year to 2,500 litres per annum, 3DBT is in the process of expanding this by a further 5x, to 12,500L pa. Personally, I think this is a hugely encouraging sign of what is to come.

On 3DBT's website, which acts as an in-house direct sales channel, City-Mix is priced at £400/L, or £200/100ml. If maximum capacity is achieved next year, then revenues would be in excess of £5m per annum (and theoretically, as high as £25m(!), if all product was sold in 100ml batches – which of course it won't be).

3DBT's strategy is to sell to the cultivated meat industry directly; and to the life sciences sector through distributors. In my view however, the two key routes for creating material sales volumes are:

1) ***Partnership with one of the major suppliers of cell culture media***. A handful of players dominate the existing market, selling media to the life sciences sector: Cytiva (a division of US conglomerate, Danaher Corp); Sigma-Aldrich (a division of Merck KGaA); Thermo Fisher Scientific; Sartorius.

   These players cornerstone the media market, and each have rosters of hundreds of end-customers (biotech companies, university laboratories, etc.). Ideally, 3DBT would out-license the City-Mix formulation to these key players, who would manufacture the supplement in-house, and include it in their product range.

2) ***Supplying (the customers of) BSF's other subsidiaries, CMT and LGL***. City-Mix is a key ingredient in BSF's Tissue Templating process. If/when CMT and LGL secure direct customers or licensees who will be producing cultivated meat or leather at commercial-scale, City-Mix sales should enjoy a tremendous uplift.

Provided that BSF's Tissue Templating processes is successfully adopted on a commercial sale by the cultivated meat and/or leather industry, then there will be *guaranteed* significant demand for City-Mix. Cross-selling is likely to become a very important aspect of BSF's umbrella strategy: the greater the commercial successes of CMT, LGL and Kerato, the greater the cashflows generated by 3DBT.

However, 3DBT is one of at least a dozen companies that is focussed on developing FBS-free and low cost media / media supplements. Moreover, the leading cultivated meat companies are all developing their own custom media in-house, for their product lines. Frankly, I don't know just how well City-Mix stands up to these competing products coming to market. Only licensing deals and substantial sales orders over the next year, will prove its quality and competitive advantages. We shall see!

Etsyl

Etsyl is a lipopeptide – a molecule composed of both lipid (fat) and peptide (protein) components – that promotes cellular collagen production. These small molecules have potential cosmetic and pharmacological applications, namely as bioactive ingredients in skincare formulations for preventing and treating wrinkling due to collagen loss, as well as for enhancing wound repair.

At the time of BSF's IPO in 2022, the Company suggested that:

"*3DBT aims to become the sole distributor of Etsyl to established cosmetic companies, to be used as an active ingredient in skin cream and other topical dermatological products. Such products are expected be formulated by 3DBT's B2B customers into final consumer skincare products*."

Last November, 3DBT provided its first update on Etsyl since its IPO – and slowly but surely appears to be delivering on that IPO statement.

It announced that it had entered into a proof-of-concept contractual agreement with one of the largest cosmetic companies in the world, which will test the suitability of Etsyl for use within its skin cream cosmetic solutions. A bit of online sleuthing suggests that this company could be FTSE 100 constituent, Croda International – which primarily operates a B2B model, supplying specialty chemicals and ingredients into various industries, such as personal care, healthcare, crop care, and industrial markets. In the *personal care* sector, Croda provides ingredients to manufacturers of cosmetics and skincare products, amongst other product types.

Clearly, Croda were to give Etsyl its seal of approval and begin offering it within its product range to the likes of Estée Lauder Companies, Johnson & Johnson, L'Oréal and Unilever… then the revenue opportunity for 3DBT could be very substantial.

As it is currently in only a single PoC trial, however, I place Etsyl firmly on the backburner, within the overall BSF investment proposition.

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The Investment Thesis

It has taken BSF 21 months since IPO, to work out, put in motion, and articulate an ambitious yet sound strategy for commercialising its tissue engineering technologies in multiple industry verticals. However, now that it has done so, I believe the Company offers an excellent investment opportunity – especially given that the share price, at 9.75p, has only appreciated a measly 32% since IPO.

The investment thesis is founded on BSF's patented technologies in tissue engineering that enable the production of scaffold-free tissues – a process that no one else is able to replicate. Although this may sound nuanced, such a technology platform potentially has huge ramifications for the nascent cultivated meat industry, which could possibly become one of the fast growing industries of the next two decades – as well as for the luxury leather goods industry and for the corrective vision industry.

BSF currently has over £1.6m in net cash (there is zero debt on the balance sheet), which provides it with a cash runway until early 2025. That assumes nil income from either City-Mix sales or upfront payments in licensing deals throughout 2024, which I think is highly unlikely.

There are £1.8m of warrants outstanding, exercisable at 15p, that expire in May next year; and a further £3.0m, exercisable at 34p, that expire in March 2026. I suspect that BSF management will be looking to unlock a significant portion of at least the first lot of warrants, throughout this calendar year.

The umbrella structure that BSF is putting in place is a clever move. It will facilitate equity financing at subsidiary level, which brings three key benefits:

- It minimises dilution at PLC level;
- It enables specials investors to participate (who may want exposure to only one particular business line, or who may not be mandated to invest in publicly listed companies);
- Pre-new money valuations are not dictated by BSF's prevailing share price, but by precedent transactions within the particular industry that the subsidiary operates in.

The final point is key to understanding how BSF as a group could become dramatically undervalued, on a Net Asset Value basis, relatively quickly. Consider the direct competitor to the LGL subsidiary that I commented on earlier, namely VitroLabs. Its $46m fundraise was achieved at a pre-new money valuation of around £55m. If we assume LGL successfully raises cash this year at an *80% discount* to the valuation at which VitroLabs recently did, then BSF's diluted shareholding in LGL alone would *still* be valued at circa £11m – which is greater than BSF's current market capitalisation.

The competitive advantages that Tissue Templating and City-Mix provide in the tissue engineering process, are even *more* compelling in the cultivated meat industry than in the cultivated leather space. The provision of structure and texture to the meat products that BSF's joint venture, CMT, intends to develop, could ultimately become a *critical* differentiator in a competitive field. So too would be the ability to successfully scale up production in industrial-sized bioreactors – again, a target that CMT believes it can achieve as a result of CellRev's proprietary bioreactor technology. As such, I believe that CMT will not struggle to raise cash from major investors over the next 12 months, at a valuation that could also *dwarf* BSF's market cap. Recall that both Eat Just and UPSIDE Foods have achieved billion dollar valuations – yet are struggling not only with product structure, but with transferring its production lines into industrial-scale bioreactors.

With regards to Kerato: as it is further from commercialisation than CMT and LGL, and moreover the total addressable market for its products is smaller than that for cultivated meat and leather, I believe an initial pre-new money valuation will be more modest (at a guess, perhaps £2m to £4m, if it were to raise say £1m?). Even so, even that would cover 20% to 40% of BSF's current market cap.

3DBT's cash generating ability is difficult to quantify, until it secures major customers / licensees for City-Mix as a standalone product, or until CMT and LGL (or their own customers) begin producing cultivated meat and leather in significant volumes. That said, by investing in an expansion programme that will increase production capacity by 400% by next year – despite negligible sales to date – 3DBT evidently believes that City-Mix will be purchased in substantial volumes over the next 24 months. As a reminder, hitting 100% of 2025's planned production capacity would generate revenues well in excess of £5m per annum – and that is just from *in-house* production.

How to value City-Mix? It's tricky, without any sort of sales track record yet established. The leading cell culture media companies – Danaher, Merck KGaA, Thermo Fisher Scientific, Sartorius – trade on current year EV/Sales ratios of around 4x to 8x. Assuming City-Mix sales hit £1m this year, then we could attribute a very conservative valuation of £4m to £8m to 3DBT by year end. However, consider that the in-house production lines for City-Mix are being increased by *five times* for next year, and you can understand how that valuation could increase by many multiples over the next 24 months.

Personally, I am finding it difficult to calculate a fair value for BSF at this point in time. Over the next 12 months however, this exercise should be facilitated by certain announcements:

- Equity raises at subsidiary level, thus creating solid NAVs;
- Commercial licensing deals;
- Increase in size and frequency of sales orders for City-Mix;
- Technology advancements in each industry vertical (e.g. successful pilot testing of a proprietary production line).

Of course, each of the above type of RNS would also likely act as a material share price catalyst.

Only one City analyst covers BSF at present, and he has put a fair equity value of *at least* £50m (approximately 50p+) on the stock – a 400% premium to where BSF's shares are currently trading.

Why the massive disconnect? Firstly, we've got to acknowledge that – predominantly as a result of various macro drivers (not least, the roofing of interest rates across the world) – nano- and micro-cap equities have been *smashed*, these past two years. Yet whilst growth companies listed on overseas exchanges have enjoyed strong rallies in recent months, the UK micro-cap space continues to be shunned by most investors, and is starved of both trading liquidity and access to fresh capital. Only very stark, very tangible valuation disconnects, or else very sizeable distributions to shareholders, are forcing share price rerates for those companies on the lower tiers of the LSE.

BSF also operates in one particular market vertical – cultivated meat – that is under sustained attack by incumbent powers. Despite the industry not even having reached the commercialisation stage yet, it is under heavy fire from numerous angles, as I described earlier. I believe this has also been somewhat detrimental to BSF's share price.

Finally, as I remarked on the first page of this note, BSF has not done itself any favours with the vague wording in its reports and RNSs. However, I am hopeful that this week's clear and concise Strategic Update marks the start of a positive shift in shareholder communications.

BSF is a pre-revenue nano-cap stock. It should be abundantly clear to all readers that it represents a very high risk investment. The business will likely have to rely on equity raises in the near-to medium-term, to fund the growth of its portfolio companies.

Moreover, it may be that its structured tissue products are *not* in fact such an important differentiator as management (and I myself) believe them to be. Additionally, it may be that a superior supplement product to City-Mix is developed by a competitor, thus dramatically reducing its revenue generating capacity.

There are dozens more risks to consider, and readers should do so carefully as part of any due diligence they may wish to undertake into BSF.

That said, at a share price of 9.75p, a market capitalisation of £10.1m and an enterprise value of £8.5m, I personally think the risk-reward profile is incredibly attractive.

Disclosure

The author of this paper, Myles McNulty, is a private investor. He and his family hold ordinary shares in BSF Enterprise.

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