A single teaspoon of productive soil generally contains 1 BILLION BACTERIA.

This means that the soil covering the farmed area of the earth (50 million km²) contains 12.5 BILLION TONS OF BACTERIA with $2.6 \times 10^{29}$ bacterial cells.

Therefore, every acre of soil contains ONE TON OF BACTERIA.

Bacterial biofilms are involved in essential plant processes. THEY COLONISE PLANT ROOTS, STIMULATE GROWTH, RECYCLE NUTRIENTS AND CONTROL PATHOGENS.

Biofilms are therefore an integral part of the WORLD'S $3,700BN OF AGRICULTURAL ACTIVITY.

Bacteria can also cause diseases of plants leading to the use of ANTIBACTERIAL PRODUCTS IN AGRICULTURE particularly fruit and vegetables and can be applied to foliage, the soil or even injected into trunks.

The global market for these materials is estimated to be $10.4BN.
ORAL PLAQUE is a biofilm that forms between teeth and along the gumline.

Without removal by cleaning, it leads to the demineralisation of teeth and the formation of cavities as well as inflammation of the gums.

The global oral care/hygiene market totals $47bn.

Drivers for growth include rising awareness among consumers of dental treatments as means to improve aesthetics.

This includes routine oral hygiene products such as:
- Mouthwash
- Toothpaste
- Dental floss
- Toothbrushes

The toothbrush and mouthwash segment is expected to exhibit the highest growth due to innovative products such as electric toothbrushes.
Living in Harmony with your Skin Microbiome

You have just as many bacterial cells living on your body as human cells inside it.

3.0 x 10^13 human cells in the body

3.0 x 10^13 bacteria in the human body

10^10 (100 billion) bacteria on human skin

1000 different bacterial species on human skin

What areas do we consider biofilms present and why it is important to consumers?

Consumer desire to manage their skin for aesthetic and functional reasons

Personal care products provide prevention and control of skin conditions for:

- Scalp health
- Face care
- Underarm health
- Feminine care
- Foot care
- Body care

Aesthetics arising from:
- Grooming
- Personal appearance
- Aroma

Functionality arising through:
- Hygiene
- Protection
- Odour control

The global personal care market in 2019:

- $339bn
- $91bn

Amount of which was attributable to biofilms:

- 20% Skincare
- 20% Baby & Child
- 25% Hair Care
- 50% Bath & Soap
- 100% Deodorant

A global industry
Biofilms have a **significant impact** on human health. This is estimated to be:

**$7.2bn in the UK and $387bn globally**

### Cystic Fibrosis
**UK: $493m**  **GLOBAL: $7.5bn**

The mucus produced in the lungs of cystic fibrosis patients is colonised by biofilm forming pathogens. In the UK cystic fibrosis accounts for 9,500 **hospital admissions** and over 100,000 **hospital bed-days** every year. More than 70,000 people worldwide are living with cystic fibrosis.

### Central Venous Catheter Bloodstream Infection
**UK: $38.7m**  **GLOBAL: $11.5bn**

Biofilms colonise catheters and can lead to infection. A European study in 2009 estimated that 210,000 central venous and arterial catheters were placed annually in the UK leading to 8,940 bloodstream infections.

### Prosthetic Cardiac Valves and Pacemakers
**UK: $3m**  **GLOBAL: $220m**

The risk of infection is around 1% for a new device and 3% for a replacement device. Over one million pacemakers are implanted globally. This infection is typically in the form of a biofilm on the artificial surfaces of the pacemaker. These can only be treated by surgery removal and replacement.

### Catheter—Associated Urinary Tract Infection
**UK: $99m**  **GLOBAL: $1bn**

Biofilms colonise catheters and can lead to infection. Around 150 million people globally experience a urinary tract infection (UTI) every year; it is the most common bacterial infection among women. In England, 17.2% hospital acquired infections are UTIs; they are the most common type of hospital acquired infection.
In 2019, the global household cleaning product market reached $212bn with a growth of 5% per year.

**Rapid Growth Due To:**
- Consumer shift towards natural and clean-labelled, eco-friendly products (away from perceptions of harsh chemicals)
- Reduction in non-biodegradable waste, particularly plastics
- Less time on domestic housework
- More time on leisure activities
- Rising incomes

**Technology of Product Formulations**
- Detergents & surfactants
- Water softeners
- Bleaches & enzymes
- Polymers (fillers)
- Foaming agents
- Colour & fluorescence additives
- Fragrances
- Antibacterials & preservatives

**Air Fresheners**
- Global $13.3bn
  - UK £340m

**Powder Detergents**
- Global $11.1bn
  - UK £286m

**Liquid Detergents**
- Global $26.1bn
  - UK £667m

**Polishes**
- Global $3.7bn
  - UK £95m

**Detergent Tablets**
- Global $9.6bn
  - UK £245m

**Manual Dishwashing**
- Global $9.6bn
  - UK £245m

**Toilet Care**
- Global $10.1bn
  - UK £259m

**Laundry Aids**
- Global $14.9bn
  - UK £381m

**Fabric Conditioners**
- Global $13.8bn
  - UK £354m

**Home Insecticides**
- Global $4.8bn
  - UK £122m

**Surface Care**
- Global $24.5bn
  - UK £626m

**Automatic Dishwashing**
- Global $14.9bn
  - UK £381m
ANTIMICROBIAL TEXTILES are specialist textiles with an ANTIMICROBIAL COMPOUND.

This compound helps resist contamination from bacteria, viruses, protozoans and fungi and control odours.

They are frequently used for applications in:

- Medical & Military uniforms
- Shoes
- Sportswear
- Upholstery
- Outdoor clothing
- Curtains
- Medical bedding

The global textiles market reached $9.5BN in 2019 with a growth of 5.4% per year.

Key drivers behind market growth in Asia Pacific (region with highest growth rate):

- Prevention of hospital acquired infections growing per capita incomes
- Rising population
- Increased health awareness

In the UK, the market is £250M.
50,000 registered merchant ships are responsible for transporting:

- **80% of global trade by volume**
- **70% of global trade by value**

**Global shipping capacity** is growing by 2.7% per year.

**Increased fuel costs related to drag caused by marine biofouling**: £10,000m

**Total value of marine vessel antifouling**: £28,700m

Shipping is reported to account for 2% of all global carbon dioxide emissions with the largest emissions from the container ship, bulk carrier, and oil tanker fleets.

**Marine biofouling** can increase drag by up to 34%.
Marine biofilms are a huge issue for aquaculture and can form on:

- Surfaces of fish including the surface of shellfish
- Natural surfaces exposed to organisms that live on waste food and fish waste from aquaculture
- Infrastructure such as nets, floats, cages and ropes

Aquaculture has seen significant growth in recent decades.

**Inland** production in 2018 was **51.3M tonnes** whilst **Marine** production was **30.8M tonnes**

This is in contrast to commercial fishing, which has not significantly changed in the period 1986 to 2018 with annual production typically between **80 & 90M tonnes**

Marine biofilms are a huge issue for aquaculture and can form on:

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The management of these biofilms accounts for **5—10% of production costs**

**Biofouling in Aquaculture** has a global cost of **£4,000M - £8,000M**