

# Scalp microbiome gets to the root of dandruff

Dandruff is an extremely common cosmetic condition, but one that remains often difficult to treat. Research scientists Sally Grimshaw, Elaine Xu and Dr Barry Murphy, of Unilever R&D, have carried out a detailed genetic investigation of the scalp microbiome: the community of bacteria, fungi and other microorganisms that live on the scalp skin. Their findings suggest that both bacteria and fungi play an important role in the development of dandruff. This knowledge is being used to develop better treatments for the condition.

Dandruff can be irritating, uncomfortable and unsightly. It is also extremely common. The condition, which typically causes a dry, itchy and flaky scalp, affects up to half the world's population. Surprisingly, for such a prevalent condition, for some people dandruff remains very tricky to treat.

One explanation for the difficulties in treating dandruff is that the causes are often elusive. While some traits – such as age, gender and underlying health conditions – are linked to a greater likelihood of dandruff, the precise reasons why some people develop the condition and others do not are unclear. Much of the previous research has focused on a possible fungal cause for dandruff, with the result that cases are often treated with antifungal shampoos. However, there is another potential group of culprits: bacteria. Until recently, there has been relatively little consideration of the possible role of bacteria in dandruff.

## THE SCALP MICROBIOME

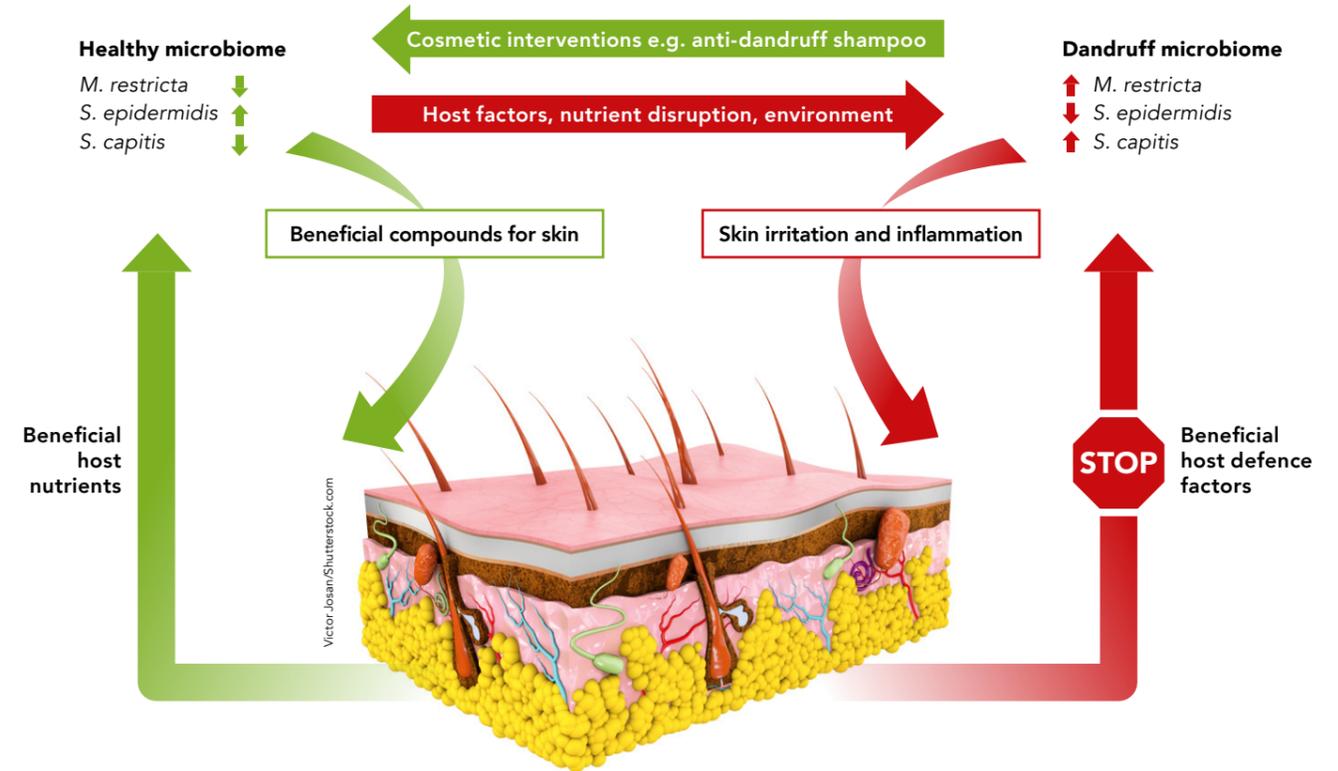
Like every other part of the human body, the scalp has its own unique microbiome. A microbiome is the sum of all the micro-organisms, including bacteria, viruses and fungi, that inhabit a particular place. Time after time, research has shown that the microbiome plays a complex and vital role in human health; a healthy microbiome means a healthy body.

Common conditions such as acne, dermatitis and irritable bowel disease

have all been linked to disturbances in the microbiome. It would probably be safe to add dandruff to that list. Although no single definitive cause for dandruff has been identified, researchers generally agree that certain changes or conditions are significant. These include over-colonisation of the scalp by yeasts belonging to the genus *Malassezia* (yeasts are a type of fungus). Individuals may also be predisposed to dandruff due to changes in the activity of the sebaceous (oil) glands in the skin, and genetic factors that can result in a less robust skin barrier. Even the weather might play a role: many people find that their dandruff is worse in the winter months.

Fungi like *Malassezia* are normal residents of the skin's surface. Micro-organisms like this are commensal, which means they benefit from or depend on their host, while causing no harm. However, sometimes the balance of the microbiome is disturbed, causing normally harmless micro-organisms to become problematic. Multiple studies have found a link between the abundance of *Malassezia* and scalp health. When people with dandruff used an antifungal shampoo, the number of *Malassezia* on the scalp was reduced, and a decrease in skin flaking was seen – suggesting a relationship between the abundance of *Malassezia* and dandruff. However, *Malassezia* is sometimes also present in high numbers on healthy scalps. This suggests that both a large *Malassezia* population and a predisposition to dandruff are involved.

## The partnership between scalp skin and its microbiome – a balancing act



## A healthy scalp is the foundation of a balanced microbiome

### SEEKING THE CAUSES OF DANDRUFF

Recently, research interest has turned towards a possible role of bacteria in dandruff. This has been encouraged by one particular study which found that the link between bacteria and dandruff might actually be stronger than the relationship between fungi and dandruff.

Sally Grimshaw, Elaine Xu and Dr Barry Murphy, of Unilever R&D, are investigating the scalp microbiome at the genetic level, with a particular interest in bacteria.

Recently, the team used a method called next generation sequencing (NGS) to analyse the DNA of the complete scalp microbiome. Simply put, NGS is a quick, relatively cheap DNA sequencing technique that can sequence “barcoding” marker genes present in bacteria and fungi, the sequencing of which facilitates their identification. Thanks to these advantages, NGS has become an

invaluable tool in many areas of research. The team at Unilever used NGS to assess the genetic composition of the scalp microbiome, allowing them to define precisely which types of bacteria and fungi were present.

More than 100 people took part in the team's study of the scalp microbiome. First, the overall scalp health of the participants was assessed and they were divided into two groups, “Healthy” and “Dandruff”. Scalp skin washes were

## Neither bacteria nor fungi are solely responsible for dandruff; in fact, both are involved.

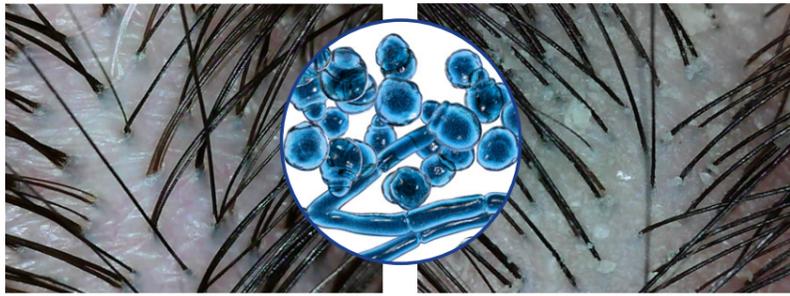
taken from two sites on the scalp of each person, one from the healthiest part of the scalp, and one from the least healthy. This allowed the microbiome to not only be compared between individuals, but also on the same person. DNA was extracted from the samples, processed and sequenced. The microbial DNA sequences were

then used to identify which species of bacteria and fungi resided on the scalps of the study participants. A technique called quantitative polymerase chain reaction (qPCR) was also used, to determine how many micro-organisms of each species were present.

### BACTERIA AND FUNGI: ARE THEY BOTH RESPONSIBLE?

The team discovered that, as they had predicted, the microbiome of a scalp with dandruff differs from that of a healthy scalp. Interestingly, it seems that neither bacteria nor fungi are solely responsible for dandruff; in fact, both are involved.

On both healthy and dandruff scalps, by far the most abundant fungal resident is the yeast *Malassezia restricta*. For people without dandruff, *M. restricta* is found in similar quantities on both the most and least healthy parts of the scalp. However, on dandruff scalps, the picture is different, with a much greater



A healthy scalp (left) versus a dandruff scalp (right) may be determined by the scalp microbiome (centre).

## The number of bacteria differed both between healthy and dandruff scalps, and between different areas on the same scalp.

difference in abundance of *M. restricta* between the healthiest and least healthy sites. This finding could indicate that not only are some individuals more susceptible to dandruff than others, but that, for the same person, some parts of the scalp might be more prone to dandruff than others.

The team's work identified a further four known species of *Malassezia* in the scalp samples. They also uncovered another, undefined species of *Malassezia*. Importantly, although this new yeast species was found in both groups of participants, it was far more abundant on the scalps of people with dandruff. Alone, this result is not enough to say that the mysterious *Malassezia* causes dandruff – but it does warrant more attention through future research.

So what about the bacteria? *Staphylococcus* and *Cutibacterium* proved to be the most abundant types of bacteria on both healthy and dandruff scalps. As with *Malassezia*, the number of staphylococci differed both between healthy and dandruff scalps, and between different areas on the same scalp. Significantly, this suggests that something local is happening to disrupt the microbiome, rather than a condition that affects the individual as a whole.

### A NEW APPROACH

Grimshaw, Xu and Murphy's work is the first time that these combined approaches have been used to study the scalp microbiome. The use of

NGS and other techniques, including qPCR, allowed the bacteria and fungi present on the scalp to be examined in intricate detail.

The next step will be to determine just how these changes in the microbiome might be linked to the development of dandruff. In a further result, the team found that, on a dandruff scalp, one



The Unilever team's work allows the development of targeted anti-dandruff products such as those pictured here.

species of *Staphylococcus*, *S. epidermidis* declines in number, while another species, *S. capitis*, greatly increases. The team suspect that the increases in both *M. restricta* and *S. capitis* seen in this study could be explained by both species having the ability to exploit changes in scalp biology. What these changes are – damage to the skin surface, or changes in skin oil production, for example – could be revealed by further research.

The microbiome is a complex and sometimes delicate community of micro-organisms. Successfully identifying the bacteria and fungi in the microbiomes of both healthy and dandruff scalps, as the team at Unilever have done, is the first step towards discovering why the microbiome can become unbalanced, leading to scalp problems such as dandruff, itch and dryness. With this knowledge it is possible to develop products such as the Clear Advanced Protection anti-dandruff shampoo, Clear Scalp Clinic range and Living Proof Restore Dry Scalp Treatment that target the root cause of these conditions and restore the equilibrium of the scalp microbiome.

# Behind the Research



Sally G Grimshaw

T: +44(0)151 641 3661  
E: [sally.grimshaw@unilever.com](mailto:sally.grimshaw@unilever.com)



Dr Barry Murphy

T: +44(0)151 641 1201  
E: [barry.murphy@unilever.com](mailto:barry.murphy@unilever.com)



Elaine Xu

T: +86 021 22125889  
E: [elaine.xu@unilever.com](mailto:elaine.xu@unilever.com)

## Research Objectives

The team at Unilever investigate the scalp microbiome to better understand the causes of dandruff.

## Detail

### Sally G. Grimshaw

**Barry Murphy**  
Unilever R&D Port Sunlight  
Quarry Road East  
Bebington  
Wirral  
CH63 3JW

### Elaine Xu

Unilever R&D Shanghai  
66, Linxin Rd.  
Shanghai 200335  
China

### Bio

Unilever has an established R&D global capability in Human Microbiomics. In partnership with leading experts in the field of Next Generation Sequencing (NGS) and Bioinformatics we have undertaken numerous clinical studies to obtain a deeper understanding of the role of the microbiome in consumer relevant conditions across our Beauty and Personal Care division, examining the microbiome associated with cosmetic skin conditions, axillary malodour and oral health.

### More information

[www.clearhaircare.com](http://www.clearhaircare.com)  
[www.livingproof.com](http://www.livingproof.com)

### Funding

The study was funded by Unilever R&D

### Collaborators

The University of Liverpool's Centre for Genomic Research (CGR), Liverpool, UK; Beijing Genomics Institute, Shenzhen, Guangdong, China; Eagle Genomics, Cambridge UK

## References

Grimshaw, SG, et al. 2019. The diversity and abundance of fungi and bacteria on the healthy and dandruff affected human scalp. *PLOS ONE* <http://doi.org/10.1371/journal.pone.0225796>



## Personal Response

### How might *S. capitis* interact with other aspects of the microbiome to cause dandruff?

Interactions between different species of bacteria and fungi are complex and require further investigation to be fully understood. Micro-organisms consume substances present on the scalp in order to flourish, provide the scalp with essential nutrients and also produce substances that can inhibit the growth of other microbes. However, the over or underproduction of these metabolites can have a detrimental impact on the skin of susceptible individuals. This "balancing act" is key to the maintenance of a healthy scalp. The increase in the levels of *S. capitis* and *M. restricta* is an important indication of microbiome imbalance necessitating an intervention with anti-dandruff technology.

CLEAR



Living proof.