ArrowBiome®

ARROWBIOME KNOWLEDGE HUB · ACNE SCIENCE SERIES — CHAPTER 3

# Your Skin Has an Ecosystem

## And acne is what happens when it tips

A premium guide to the living community on your skin — the residents that keep it in balance, what happens when that balance shifts, and why the science of acne has moved from *kill the bacteria* to *restore the balance*.

THE SKIN MICROBIOME, EXPLAINED

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A NOTE BEFORE YOU READ

# A garden on your face

Imagine your face as a garden. Not a sterile patch of soil, but a thriving, settled landscape — microbes instead of plants, each species suited to a particular plot. A healthy garden is not one that has been scrubbed clean. It is one that is **balanced**: the right species hold the right ground, helpful organisms crowd out invaders, and the soil itself stays fertile and protected.

WHAT THIS CHAPTER EXPLAINS

### From residents to rebalancing

› Who lives on healthy skin — and what they do
› Good balance vs. dysbiosis — the tipping point
› The counterintuitive truth about *C. acnes*
› Why you actually need *C. acnes* (some of it)
› The skin barrier — the ecosystem's foundation
› What inflammation really is
› From "kill it" to "balance it"

HOW TO READ IT

### One big idea per page

Written for a curious, non-specialist reader — cosmetic brand managers, R&D and retail teams, and anyone who wants the real science without the jargon.

Every claim is grounded in peer-reviewed evidence (2015–2026); full sources are listed at the back. No products are mentioned — this is science, not a sales pitch.

THE SHORT VERSION

### Acne is a story of balance, not invasion.

When a garden tips out of balance, you rarely get a new species arriving. More often the residents that were always there shift in proportion — one strain overtakes its neighbours, diversity collapses, and the ground beneath becomes inhospitable. Acne, the contemporary literature increasingly agrees, is a story of exactly this kind: **not an infestation, but a garden that has tipped.**

01

THE RESIDENTS

# Meet the community living on your skin

Billions of microorganisms, organised not by chance but by real estate — each region of skin a distinct habitat with its own residents, all of them working partners in skin health.

SECTION 1 · THE SKIN MICROBIOME

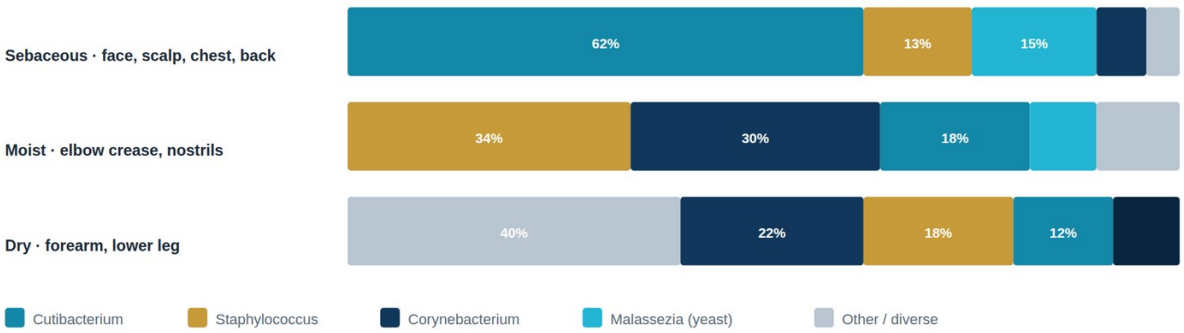
# Different neighbourhoods, different residents

Each region of skin is a microhabitat defined by its oiliness, moisture and exposure — and different microbes settle accordingly. This site dependence is one of the most reliably reproduced findings in skin microbiome research.

WHERE THE RESIDENTS LIVE

**WHO LIVES WHERE — COMMUNITIES SHIFT BY SKIN REGION**

Relative share of the dominant residents at each site type (illustrative, after Grice and Segre; Byrd et al.)




OILY ZONES

## Cutibacterium country

Sebaceous sites — face, scalp, chest, back — are dominated by *Cutibacterium*, especially *C. acnes*, which thrives in the lipid-rich, low-oxygen follicle. The yeast *Malassezia* is the most abundant fungal resident.

NOT PASSIVE LODGERS

## A working ecosystem

*C. acnes* makes acidifying fatty acids; *S. epidermidis* acts as a sentinel, releasing succinic acid and lipoteichoic acid that suppress pathogens and calm inflammation. Far from dirt — a working neighbourhood.

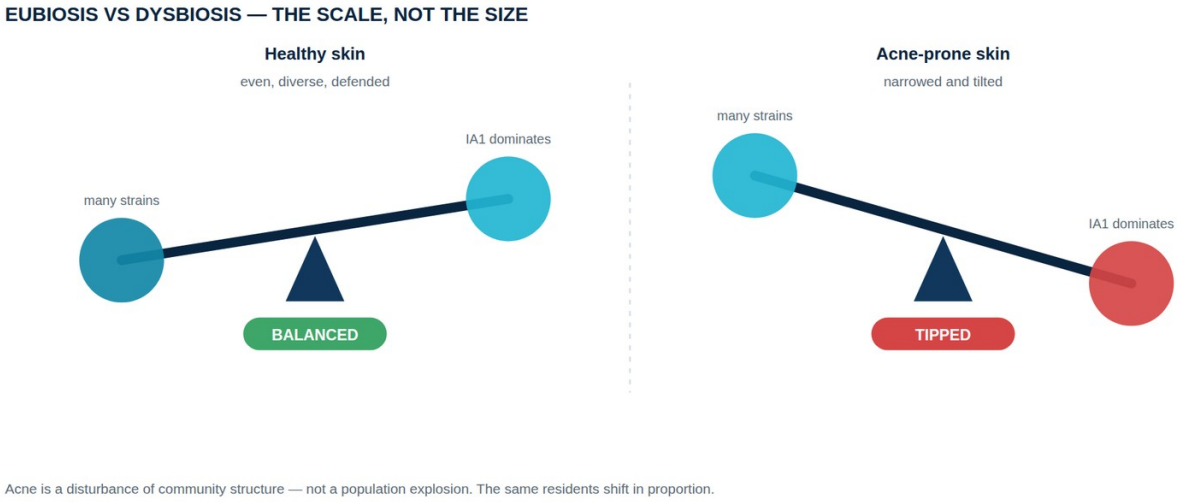
Sources: O'Neill & Gallo, *Microbiome* 2018; Grice & Segre, *Nat Rev Microbiol* 2011; Dagnelie et al., *Exp Dermatol* 2021. Shares illustrative.

SECTION 2 · BALANCE VS DYSBIOSIS

# What tipping the scale looks like

A healthy skin community has two signatures: it is **diverse** and it is **even**. Microbiologists call this balanced state *eubiosis*. Its opposite — the tipped garden — is *dysbiosis*: a disturbance of the community's structure, not necessarily its size.

THE BALANCE, NOT THE SIZE




Acne is a disturbance of community structure — not a population explosion. The same residents shift in proportion.

REMEMBER THIS

## Dysbiosis runs both ways with the barrier.

Acne-prone skin shows higher water loss, a higher (less acidic) pH and more sebum — and these barrier changes track closely with **lower microbial diversity**. A weakened barrier makes the ground less hospitable; an unbalanced community further weakens the barrier. The soil and the garden fall together.

Sources: Dréno et al., *Am J Clin Dermatol* 2020; Cavallo et al., *Sci Rep* 2022; Zhou et al., *CCID* 2022.

SECTION 3 · THE COUNTERINTUITIVE TRUTH

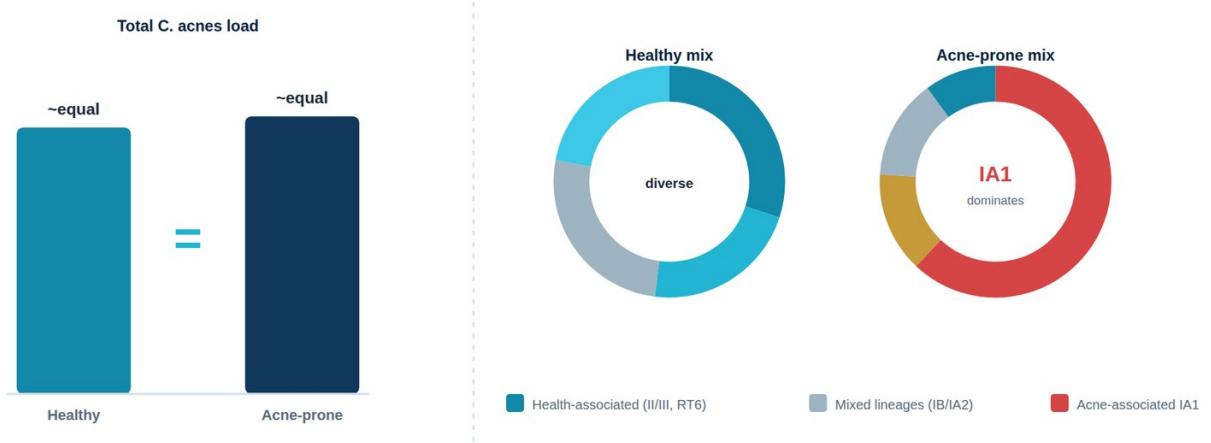
# It's not how many — it's which ones

If acne were simply an infection, you would expect far more *C. acnes* on spotty skin. It is not so. The total amount is broadly similar between healthy and acne-affected skin — so blaming the bacterium's presence explains nothing.

SAME QUANTITY, DIFFERENT FAMILY

SAME QUANTITY, DIFFERENT FAMILY

Total C. acnes is broadly similar on clear and acne-prone skin — the phylotype mix is what differs.




AN EXTENDED FAMILY

## Cousins, not clones

Within the species sit genetically distinct lineages — **phylotypes**. On healthy skin the family is mixed, including health-associated members like phylotype II and ribotype RT6.

THE TILT

## When IA1 takes over

On acne-prone skin the family narrows: phylotype **IA1** (carrying virulence-linked ribotypes RT4/RT5) comes to dominate, while the peaceable cousins recede.

Sources: Rozas et al., *Microorganisms* 2021; Mias et al., *JEADV* 2023; Cavallo et al., *Sci Rep* 2022. Composition illustrative of reported patterns.

02

The good guys & the ground beneath

# Why you need C. acnes — and why the barrier holds it all up

The same species can protect or provoke. And none of it works without an intact skin barrier — the ecosystem's living soil.

SECTION 4 · THE GOOD GUYS

# Why you need C. acnes (some of it)

If *C. acnes* were simply a villain, healthy skin would be better off without it. The opposite is true: a balanced population is one of the skin's most valuable assets. The species is often called **"Janus-faced"** — protective or provocative depending on which strains dominate.

FOUR JOBS A BALANCED C. ACNES DOES


AN HONEST NOTE ON THE EVIDENCE

## The principle is robust; the strain-level detail is a frontier.

That commensal *C. acnes* provides antioxidant protection, pH maintenance and colonisation resistance is **well supported**. The more specific claim that these benefits belong uniquely to phylotypes II and III — rather than to balanced populations broadly — remains more inferential, with limited strain-resolved human evidence so far.

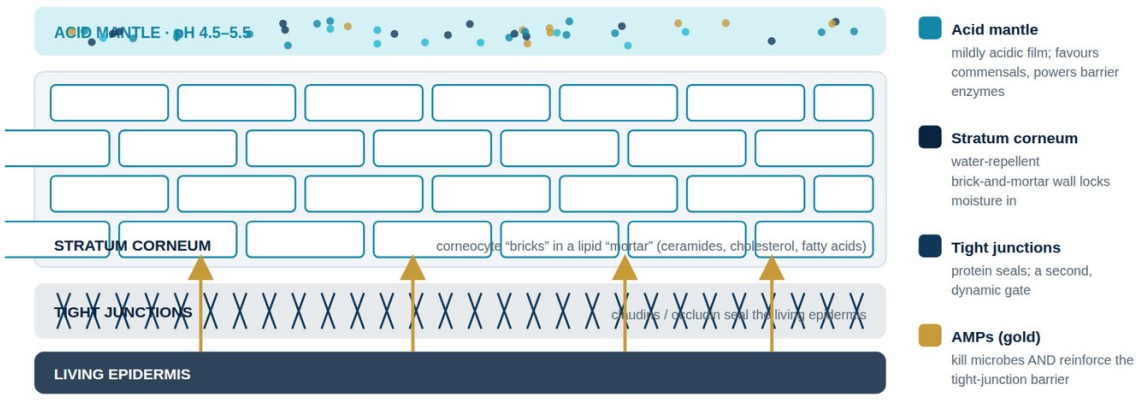
Sources: Brüggemann et al., *Front Microbiol* 2021; Andersson et al., *Sci Rep* 2019; Stødkilde et al., *Front Cell Infect Microbiol* 2022.

SECTION 5 · THE SKIN BARRIER

# The ecosystem's foundation

A garden is only as healthy as its soil. For the microbiome, that soil is the **skin barrier** — and barrier integrity and microbiome health are inseparable. The barrier is not one structure but several working in concert.

A CROSS-SECTION OF THE BARRIER




WHEN THE FOUNDATION CRACKS

## The consequences cascade.

Over-washing, harsh products or inflammation breach the barrier — water is lost, surface pH rises, antimicrobial-peptide defences falter, and the now-alkaline, leaky terrain favours the unbalanced communities seen in acne. Conversely, **repairing the barrier can help restore microbial equilibrium.**

Sources: Lee & Kim, *Int J Mol Sci* 2022; Bäsler & Brandner, *J Control Release* 2016; *J Integr Dermatol* 2025 (acid mantle).

03

INFLAMMATION & THE NEW SCIENCE

# Redness is a response — and the rules have changed

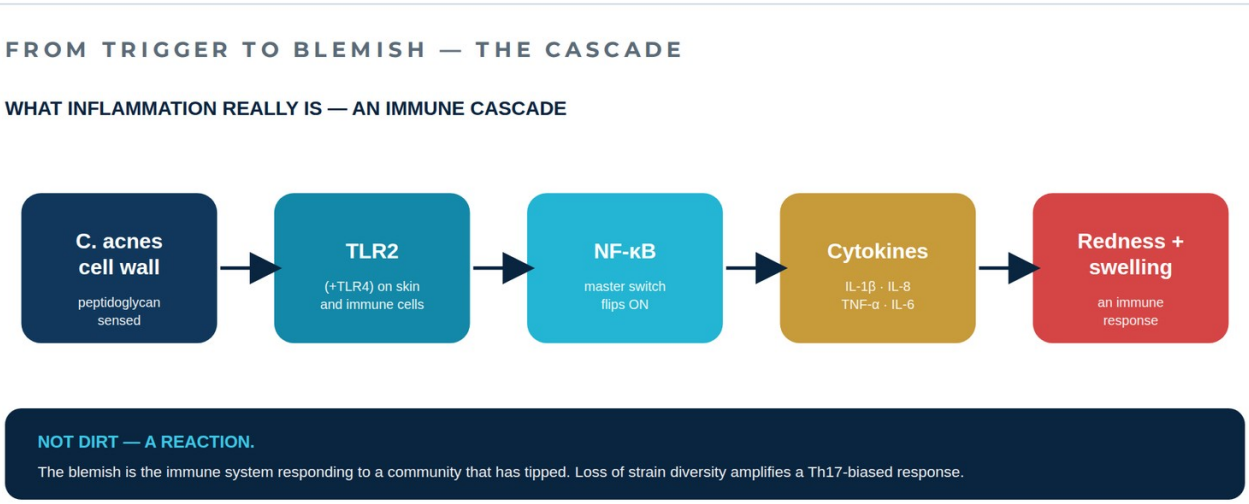
A blemish is the immune system reacting, not the bacteria doing visible damage. Understanding that has rewritten how dermatology approaches acne.

SECTION 6 · WHAT INFLAMMATION REALLY IS

# Redness is an immune response

The redness, heat and swelling of an inflamed spot are not dirt — they are your immune system responding. The skin's innate defences sense microbes through pattern-recognition receptors, and the reaction unfolds as a cascade.

FROM TRIGGER TO BLEMISH — THE CASCADE




THE SENSORS

## TLR2 reads the cell wall

Components of *C. acnes* — such as peptidoglycan — are detected chiefly by **TLR2** on keratinocytes, sebocytes and immune cells. When the balance tilts to IA1, this sensing becomes exaggerated.

THE AMPLIFIER

## A self-reinforcing loop

Sustained signalling skews the response toward the **Th17** pathway, linked to the loss of strain diversity — which is why calming acne is about quieting an over-reaction, not sterilising skin.

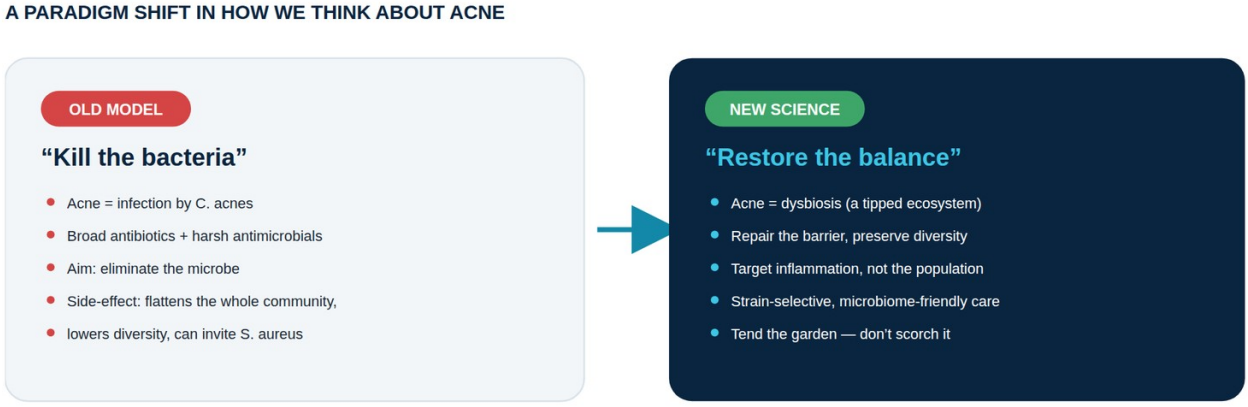
Sources: Qi et al., review in *Front Immunol* 2024; Kistowska et al., *PLoS ONE* 2014; Mias et al., *JEADV* 2023.

SECTION 7 · THE NEW SCIENCE OF ACNE

# From "kill it" to "balance it"

For decades, acne care rested on a simple premise: bacteria cause acne, so kill the bacteria. The microbiome revolution has dismantled the logic beneath it — if *C. acnes* is a normal, beneficial resident and its quantity is similar on clear and acne-prone skin, indiscriminate killing is biologically misguided.

A PARADIGM SHIFT




THE HEART OF THE MATTER

## Tend the garden — don't scorch it.

Broad antimicrobials flatten the whole community, lowering diversity and sometimes inviting *S. aureus* — the very dysbiosis the skin is trying to escape. The emerging philosophy is to repair the barrier, preserve diversity and target inflammation. **The most promising path is not war on a resident, but helping the community find its balance again.**

Sources: Oliveira et al., *Molecules* 2025; Dréno et al., *Am J Clin Dermatol* 2020; *Clin Exp Dermatol* 2025 (paradigm shift).

# Seven things to carry away from this chapter

1. **Your skin is a living ecosystem.** Bacteria, fungi and viruses form site-specific communities that, in health, stay diverse and balanced.
2. **Acne is dysbiosis, not overgrowth.** Total *C. acnes* is similar on clear and acne-prone skin — balance, diversity and barrier state are what change.
3. **It's which strains, not how many.** A narrowing toward the dominant IA1 phylotype is the hallmark — not a population explosion.
4. **C. acnes is largely beneficial.** Balanced populations supply RoxP antioxidant protection, hold the acid mantle and exclude pathogens.
5. **The barrier is the foundation.** Stratum corneum, tight junctions, acid mantle and AMPs are inseparable from microbiome health.
6. **Inflammation is an immune response.** Redness comes from TLR2 → NF-κB signalling and cytokines (IL-1β, IL-8, TNF-α) — not dirt.
7. **The science has moved to "balance it."** Repair the barrier and restore microbial balance rather than sterilise the skin.

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# Your Skin Has an Ecosystem

KNOWLEDGE HUB · ACNE SCIENCE SERIES — CHAPTER 3

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THE SKIN MICROBIOME, EXPLAINED

Scientific foundation: a Consensus.ai synthesis of the skin microbiome in acne (50 papers, 2008–2026), enriched and fact-checked against current peer-reviewed sources (2015–2026). Educational content — not medical advice or product claims.