A REFERENCE VOLUME

FIRST EDITION · 2026

The Chitosan Handbook

The molecule, its derivatives, and their industrial applications.

EDITED BY STEVE NICE · CHUCK COLLINS, PhD

The Chitosan Handbook

The molecule, its derivatives, and their industrial applications.

First Edition · 2026
Volume I of I
Printed in the United States of America

Shield Nutraceuticals, Inc.
chitosanglobal.com · shieldnutra.com
steve@chitosanglobal.com · chuck@shieldnutra.com
+1 423·202·6145

Foreword.

This handbook is written as a scientific reference for the industries confronting antimicrobial resistance, plastic pollution, and the reconstruction of modern agriculture. Chitosan is a powerful new tool that can solve problems with chemical pollution in all its forms. These chemicals can weaken our bodies and create premature limitations if left unchecked. Toxic load from forever chemicals, microplastics, heavy metals, etc., found in water, soil, and air, can be addressed with chitosan.

This work is presented as an introduction to the ways chitosan will be used to detoxify the environment, products, and our bodies. *Chitosan is something so good for us and the planet that, within ten years, we predict it will be on or in most products that go on or into pets and people.*

— Steve Nice

SHIELD NUTRACEUTICALS / CHITOSAN GLOBAL

A NOTE ON GLOBAL SUPPLY

As demand for chitosan explodes in late 2027, the worldwide supply of shellfish will be consumed very quickly unless a sustainable method of meeting that demand emerges. We believe we have seen that solution. Green-manufactured, well-characterized chitosan from mushrooms or insect shells makes possible a transition from a world using toxic ingredients to one that is safe, clean, and environmentally sound.

A NOTE ON FEEDSTOCK QUALITY

The majority of world chitosan production still originates from shellfish waste. That feedstock is variable, largely uncharacterized, and carries documented risk of residual heavy metals and mercury. Bulk imports from China and India require third-party characterization before they can be used for feed, dietary supplements, or medical applications.

THIS HANDBOOK IS A REFERENCE

After years of reading and research about chitosan and its uses, varieties, and sources, we decided to help shorten the path for anyone in this space. Enjoy the discovery and pass it on.

ACKNOWLEDGMENTS

With thanks.

This handbook is the product of contributions from a distributed team of scientists, agronomists, veterinarians, engineers, and operators working across the United States, India, and Latin America.

We thank the growers, herdsmen, plant managers, and municipal water engineers who let us test insect and mushroom derived chitosan against the working problems of their industries.

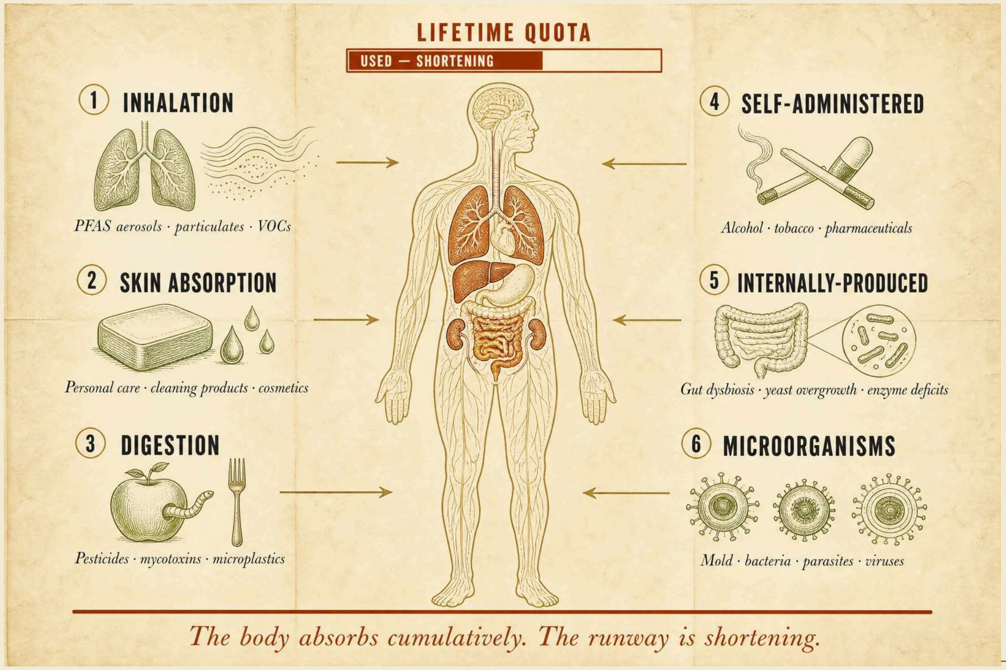
ETSU Innovation Lab

We are especially grateful to **East Tennessee State University** and the **ETSU Innovation Lab** for their sustained support of Shield Nutraceuticals and Chitosan Global, from the earliest characterization work on insect derived chitosan through the applied research programs that shaped the derivatives catalogue.

Their willingness to host a small biotech company inside a working academic environment provided the scientific foundation for this work.

Promecens Entosystems Pvt. Ltd., Pune, India, is the manufacturer of Chitosan FG, AG, IG, WS, AS and Native Chitosan from mushrooms and black soldier flies.

A fixed quota.
A shortening runway.



Every human body absorbs toxicants across its lifetime through the air we breathe, the water we drink, the food we eat, the skin we touch, and the medicines and habits we adopt.

The load is **cumulative**. **PFAS**, **microplastics**, **pesticides**, **mycotoxins**, heavy metals, industrial chemicals, and pathogenic microbes **stay in tissue** long after the exposure ends. Modern life is shortening the runway to overload.

THE CHITOSAN THROUGH-LINE

Chitosan binds and removes these cumulative toxins from **water, soil, and air** before they reach the body. Additionally, inside the body, it binds ingested microplastics, dietary fat, bile, acid-bound cholesterol, and heavy metals to make them ready for excretion.

It is the primary antimicrobial and adsorbent that closes the loop across every industry that touches humans and animals. *That is why we are in this business.*

AN INTRODUCTION · WHAT CHITOSAN IS, WHERE IT COMES FROM, WHY IT MATTERS

Chitosan — Wow.

Where chitosan comes from, why it carries a positive charge, and how that single property can lower environmental toxic load in people and pets.

SOURCES

Where chitosan comes from.

Chitosan (pronounced *KITE-o-san*) is made from chitin (pronounced *KITE-n*), the **second most abundant biopolymer on Earth**. Chitin forms the exoskeletons of insects and crustaceans and the cell walls of fungi. Enzymatic deacetylation of chitin yields chitosan.

SOURCE 01

Insects

Black soldier fly exoskeletons. Year-round biomass, farmed in controlled bioreactors on organic waste streams.

SOURCE 02

Fungi

Mushroom cell walls — especially *Agaricus* and *Lenzites betulina*. Vegan, kosher, halal, no shellfish allergens.

SOURCE 03

Crustaceans

Shrimp, crab, lobster shells — the traditional source. Widely used for industrial and agricultural grades.

SOURCE 04

Algae

Certain green and brown algae also contain chitin. An emerging, marine-friendly source under active research.

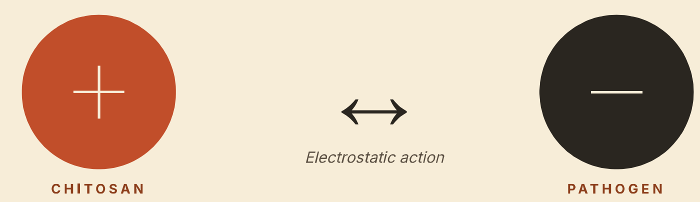
Chitin — exoskeletons of crustaceans, insects, fungi, and algae

WHY THE CHARGE MATTERS

Opposite charges attract.

Disease-causing microbes carry a **negative (−) charge** on the outside of their cells. Chitosan carries a positive (+) charge.

Opposite charges attract. The positive chitosan binds to the negative microbial surface and disrupts the cell wall through **electrostatic action**.



Most disease-causing microbes carry a negative surface charge.

- ***E. coli*** — gut infections, food poisoning
- ***Salmonella*** — poultry, eggs, produce
- ***Listeria*** — deli meats, cheese, fridge cold-tolerant
- ***MRSA*** — hospital & skin infections
- ***Pseudomonas*** — biofilm, wound infections
- ***Shigella*** — dysentery, waterborne
- ***Candida*** — yeast infections, oral thrush
- **Many more** — Gram-negative and Gram-positive bacteria, yeasts, and fungi.

Chitosan vs. Quats.

The traditional industry uses **quaternary compounds** — "Quats" — to kill microbes. They work, but they come with real trade-offs. Chitosan is the biopolymer replacement.

COMPARISON	TRADITIONAL QUATS · SYNTHETIC CHEMICALS	CHITOSAN · BIODEGRADABLE · BIOCOMPATIBLE · NON-TOXIC
Source *Where it comes from.*	Petrochemical feedstocks. Manufactured in industrial reactors from synthetic precursors.	Shells, mushrooms, or insect exoskeletons — produced by simple enzymatic deacetylation.
Health impact *Effect over time.*	Skin, lung, and long-term exposure concerns are documented. Rinsed residues persist.	**Biocompatible and non-toxic.** Safe for direct food, feed, and medical contact.
Resistance *Can microbes adapt.*	Yes. Bacteria mutate around chemical modes of action, and Quat resistance is now widespread.	No. The action is electrostatic; there is no biochemical target to mutate around.

KEY BENEFITS · FOUR REASONS CHITOSAN REPLACES QUATS

01 Selective binding.

Pathogens carry a negative surface charge. Positively charged chitosan binds them electrostatically, ignoring neutral tissue.

02 Physical mode of action.

The mechanism is electrostatic, not biochemical. The positive charge disrupts the microbial cell wall on contact.

03 No resistance pathway.

Because the action is electrostatic rather than biochemical, microbes have no target to mutate around and cannot develop resistance.

04 Biocompatible source.

Derived from shellfish, insects, fungi, and algae. GRAS-notified for food; biocompatible for medical use.

A NOTE BEFORE THE CHAPTERS · COMPLIANCE

Regulatory clearances.

Chitosan comes in many forms and has many applications. **Most of those applications are already approved** under the food, feed, cosmetic, water-treatment, and biopesticide frameworks of major markets. Some, however, still depend on **use-specific or product-specific** clearances — for example, an EPA-exempt biopesticide may still need brand-name registration in individual U.S. states.

It is **the customer's responsibility** to confirm and, where required, obtain the appropriate clearances for their finished product, use pattern, and territory. Chitosan Global supplies the raw material and its Certificate of Analysis; the buyer owns the finished-product registration.

DIVISION OF RESPONSIBILITY

Chitosan Global provides

Certificate of Analysis, technical data, GRAS-notified raw material, safety documentation, and formulation guidance.

Customer obtains

Finished-product registration, label review, brand-name state approvals, and any use-specific clearance for the target application and territory.

WHERE CHITOSAN IS ALREADY CLEARED · AND WHERE PRODUCT-SPECIFIC WORK MAY BE NEEDED

Food & feed

CLEARED FRAMEWORKS

U.S. FDA GRAS (GRN 170, GRN 397, GRN 443 for fungal chitosan); EU EFSA opinion on shrimp chitosan; OIV Resolution 336-2009 for wine fining; feed-additive listings in several jurisdictions.

CUSTOMER'S WORK

Finished-product label review, allergen statement, and any state-level food-contact filings.

Agricultural biopesticide

CLEARED FRAMEWORKS

U.S. EPA 25(b) minimum-risk exemption for chitosan and poly-D-glucosamine (40 CFR 152.25); EU biocontrol basic-substance status; approved plant defence elicitor in Japan and Korea.

CUSTOMER'S WORK

Brand-name state registrations (CA, NY, and others), efficacy dossier, label copy.

Cosmetics & personal care

CLEARED FRAMEWORKS

INCI-listed as "Chitosan" and its salts; EU CosIng entry; U.S. MoCRA cosmetic-facility framework applies to finished products.

CUSTOMER'S WORK

MoCRA facility registration, safety substantiation file, INCI-compliant labelling.

Water, medical, and novel uses

CLEARED FRAMEWORKS

NSF/ANSI 60 potable-water coagulant listings for qualifying grades; FDA 510(k) precedent for chitosan hemostatic dressings; drinking-water and swimming-pool clarifier allowances in most jurisdictions.

CUSTOMER'S WORK

Product-specific NSF or medical-device submission, novel-use consultation with regulator.

Introduction.

Chitosan is a global industrial asset. It is derived from shellfish, insects, fungi, and certain types of algae, and its measurable impact now runs from agriculture and water treatment through food safety, animal health, and medicine. This handbook is written for the CEOs, formulators, and investors who need actionable, scientific, and commercial intelligence.

- Real-world use cases, not laboratory abstractions.
- CAS-certified derivatives with batch-linked Certificates of Analysis.
- Regulatory alignment: GRAS, FDA, EFSA, REACH, ISO.
- Pilot-backed protocols from Shield Nutraceuticals and Promecens Entosystems.

Editors and team.

EDITORS

Steve Nice

CO-FOUNDER & CEO, SHIELD NUTRACEUTICALS / CHITOSAN GLOBAL

Entrepreneur focused on businesses that promote products and systems that help people. Co-Founder and former CEO of BedinaBox.com — originator of the first OekoTex-Certified mattress in U.S. history — and responsible for the removal of dibutyl tin and dangerous phthalates from polyurethane foam manufacturing.

Charles Collins, PhD

VICE PRESIDENT, SHIELD NUTRACEUTICALS

Dissolution chemist and professor of pharmaceutical sciences. Forty+ years as a pharmacist. PhD in Pharmacokinetics. Founding Member of the Shield Nutraceuticals Science Team and co-formulator of DigestShield.

CONTRIBUTING TEAM

Sheridan Nice
Co-Founder, Shield Nutraceuticals. Director, Serenity Knoll Farm & Cooking School. Graduate of La Varenne, Paris. 40 years as a professional chef.

Abhinav Chauhan
Partner. Founder & CEO, Promecens Entosystems Pvt. Ltd., India. Cross-disciplinary scientist across CSIR-IGIB, MIT, Cambridge, Pfizer, Novartis, and the Peter Doherty Institute.

Jorge M. Estrada
VP, Global Sales. M.S. Bovine Nutrition, Kansas State. Agrónomo degree, Zamorano. 34 years' experience in high-tech agriculture.

Dr. W. Andrew "Andy" Clark, PhD
Scientific Advisory Board. PhD Nutritional Biochemistry. Registered Dietitian Nutritionist. Emeritus Professor. Pioneer in chitosan as an antimicrobial. Co-formulator of DigestShield.

Dr. Audrey Depelteau, DC
Scientific Advisory Board. Chiropractor with 26+ years clinical experience. Director of a business incubation lab. Founding Member, Science and ESG team.

Herbert Herman Alvarado
VP, LATAM Agribusiness Ventures. 30+ years in coffee, cocoa, and produce trading across the U.S., Mexico, Ecuador, and Guatemala. Agronomy, Pan-American School of Agriculture; BS, Kansas State; MBA, Santa Clara University.

Mario Cabrera
VP, Pet Products. 20+ years across Nestlé, Shell, Sara Lee, Colgate-Palmolive/Hill's, Merck Animal Health, Boehringer-Ingelheim, Elanco, and Dechra.

Alvaro Corzo
VP, Latin American Joint Ventures. Agricultural Engineer with 35+ years in plant nutrition, biostimulation, soil health, and regenerative agriculture across Latin America and the Caribbean.

Julio Vásconez
VP, International Markets. Agricultural Engineer, MBA. 36+ years in sustainable agribusiness. Specialist in cocoa, cut-flower production, traceability systems, and EUDR compliance.

Mitchell Drake
U.S. Sales. Entrepreneur focused on regenerative agriculture. Specialist in produced-water remediation for oil and gas using chitosan and biochar.

Bart R. Dunsford, PhD
Director of Veterinary Health & Nutrition. BS Animal Science, Kansas State; MS Nutrition and PhD Veterinary Anatomy, Texas A&M. 20+ years across GTC Nutrition, Biowish, Penford, and Lallemand.

Dr. Clifford Wiegand, MD
Scientific Advisory Board. Retired Nephrologist.

Dr. Tom Rogers, MD
Scientific Advisory Board. Founder, Performance Medicine. Fellowship Trained and Board Certified in Integrative Medicine; Board Certified in Sports Medicine (A4M). MD, ETSU Quillen College of Medicine.

Dr. Noel Marshall, PhD
Scientific Advisory Board. Research and applied sciences.

Dr. John Hott, PhD
Regulatory Expert. PhD, Analytical Chemistry.

Robert Santos-Prowse, MS, RDN
Scientific Advisory Board. Registered Dietitian Nutritionist. MS, Clinical Nutrition, East Tennessee State University. Led the research and editorial guidance for Shield Nutraceuticals.

CONTENTS

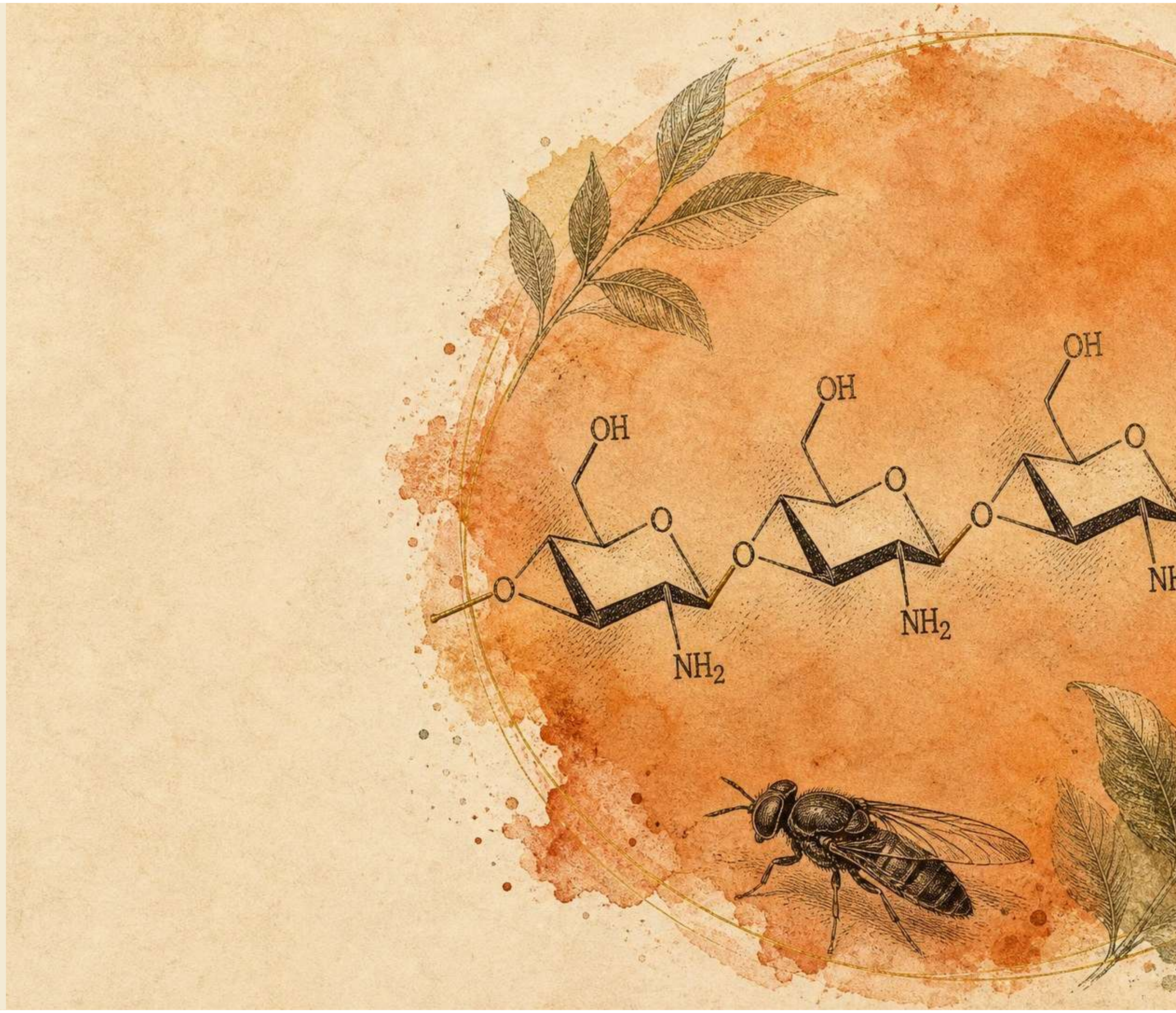
What's in this book.

Acronyms.

ACP	Amorphous calcium phosphate
AFB_1	Aflatoxin B_1
BRD	Bovine respiratory disease
BSF	Black soldier fly (*Hermetia illucens*)
CAS	Chemical Abstracts Service registry number
CMC / CMCS	Carboxymethyl chitosan
CoA / COA	Certificate of Analysis
COS	Chitosan oligosaccharide
DDA	Degree of deacetylation
DoQ	Degree of quaternization
DS	Degree of substitution
EFSA	European Food Safety Authority
ETEC	Enterotoxigenic *Escherichia coli*
FCR	Feed conversion ratio
FG	Food grade (Chitosan Global product tier)
FHB	Fusarium head blight
GRAS	Generally Recognized As Safe (US FDA)
GRN	GRAS Notice (FDA docket)
HCl	Hydrochloric acid / hydrochloride salt
IG	Industrial grade (Chitosan Global product tier)
kDa	Kilodalton (1000 daltons)
LMW	Low molecular weight
MBC	Minimum bactericidal concentration
MIC	Minimum inhibitory concentration
MW	Molecular weight
NAHMS	USDA National Animal Health Monitoring System
OIV	International Organisation of Vine and Wine
PFAS	Per- and polyfluoroalkyl substances
PFOA / PFOS	Perfluorooctanoic / perfluorooctanesulfonic acid
Q_{max}	Maximum adsorption capacity (mg/g)
RCT	Randomised controlled trial
TMC	Trimethyl chitosan (N,N,N-trimethylated)
TVC / TPC	Total viable count / total plate count
USDA	United States Department of Agriculture
w/v	Weight per volume (concentration)
pK_a	Acid dissociation constant

PART ONE

What chitosan is.

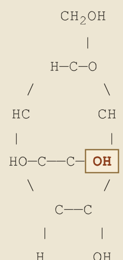


One amine group away from cellulose.

SIDE-BY-SIDE · THE ONE SUBSTITUTION THAT CHANGES EVERYTHING

CELLULOSE

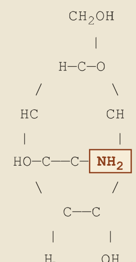
Poly β-1,4-D-glucose



Neutral. Structural. The C-2 hydroxyl group makes cellulose inert — the scaffolding polymer of all plant life.

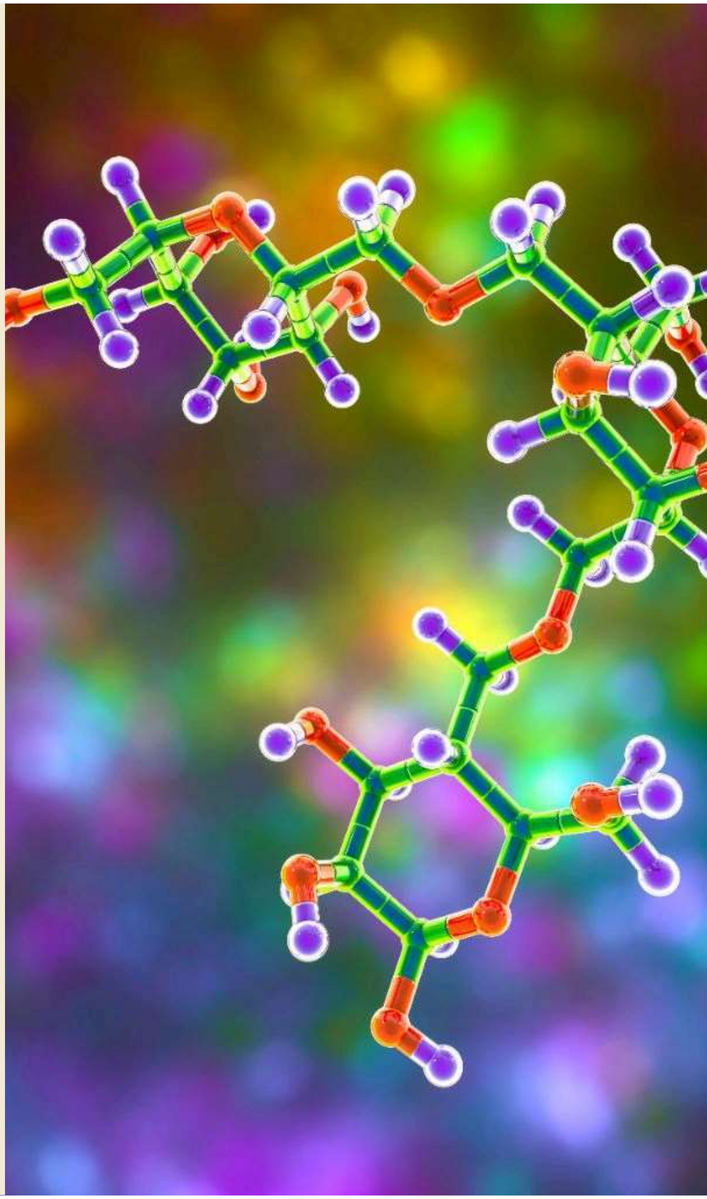
CHITOSAN

Poly β-1,4-D-glucosamine



Positively charged. Reactive. The amine (—NH_2) at C-2 is what lets chitosan bind pathogens, metals, and PFAS.

Cellulose and chitosan share almost the same backbone. Where cellulose carries a hydroxyl (**—OH**), chitosan carries an amine (—NH_2). That one substitution at C-2 turns an inert structural sugar into the only positively charged polymer in nature.



Naturally derived. Positively charged.

Chitosan is a naturally derived polysaccharide that carries a positive electrical charge. That charge is the origin of every functional application that follows — direct interaction with negatively charged microbial surfaces, contaminant particles, and plant, animal, and human tissue.

It is produced from chitin — one of the most abundant natural biopolymers on Earth, present in crustaceans, fungi, insects, and certain algae — through a deacetylation reaction that converts each acetyl group into a primary amine.

Chitosan is valued as a naturally derived, biocompatible alternative to harsher synthetic chemical approaches. Its versatile functional properties span R&D, biomedical and healthcare, food and agriculture, and environmental remediation.

Figure 1.1 · chitosanglobal.com

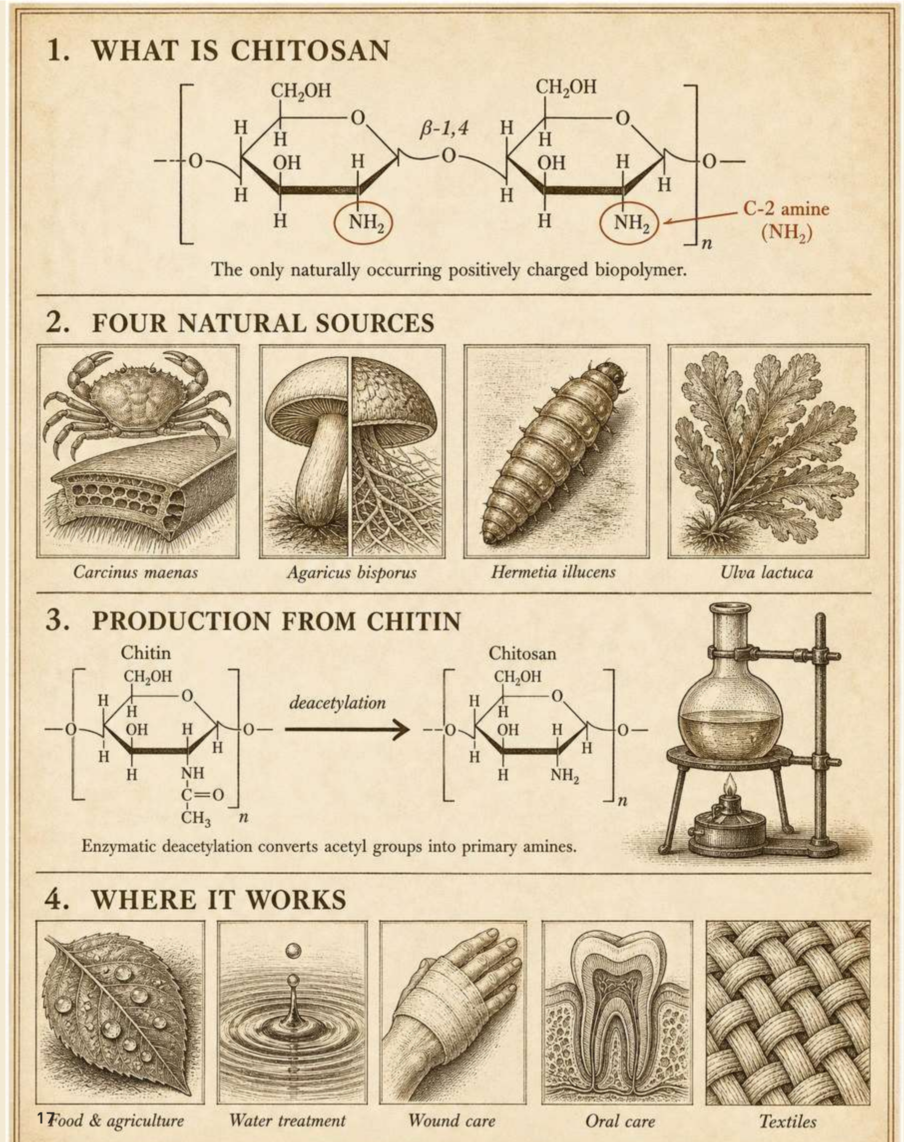


Figure 1.1 · Chitosan Global

Discovered in 1811. Industrialised in 2026.

1811	**Henri Braconnot** isolates fungin from mushroom cell walls — the first published record of chitin.
1859	**Charles Rouget** discovers that heating chitin in alkali produces chitosan — a soluble, positively charged polymer.
1878	The name *chitosan* is formally adopted; its structural relationship to cellulose is established.
1930s	First industrial-scale extraction from crustacean shells; early textile and water-treatment work.
1970s	Antimicrobial activity documented; wound-care applications begin in Japan and Scandinavia.
2003	Chitosan hemostatic dressings deployed by US military forces; battlefield use begins.
2009	OIV approves fungal-source chitosan for wine fining — first clean-label deployment in a regulated food category.
2013	FDA GRAS Notice 443 for shrimp chitosan (Primex ChitoClear) accepted for human food use.
2023	FDA GRAS Notice 997 for *Agaricus* mushroom chitosan + β-glucan — the first fully-vegan chitosan food-use pathway.
2026	Chitosan Global launches Chitosan FG (food), Chitosan IG (mycotoxin), and crown-ether lithium chemistry.

Nine categories, nine incumbents being replaced.

APPLICATION	INCUMBENT	WHY CHITOSAN WINS
Bakery preservative	Calcium propionate, sorbates, benzoates	Clean label
Wine fining	Isinglass, gelatin, casein, egg white	Vegan, no allergen
Water-treatment coagulant	Alum, ferric sulfate, PAC	No aluminium residual
PFAS remediation	Granular activated carbon	Higher capacity, lower cost
Poultry feed additive	Sub-therapeutic antibiotics	No AMR pathway
Wound dressing hemostat	Gauze + fibrin sealants	Bio-absorbable, non-animal
Antimicrobial textile finish	Silver nanoparticles, triclosan	No metal leaching
Lithium recovery	Evaporation ponds, DLE resins	Selectivity, water footprint
Mycotoxin binder	Bentonite, activated charcoal	Targeted charge affinity