Integrative workshop: Avian eggshell biomineralization and innate immunity

Joël Gautron

LE STUDIUM

CONFERENCES

Innate immunity in a biomineralized context: trade-offs or synergies?

Integrative workshop:

Avian eggshell biomineralization and innate immunity

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INRAE science for people, life & earth

université de TOURS

The calcified avian eggshells

Physical protection

- Ultrastructure and genetic variations,
- Genetic traits inherited under the environnmental pressure

A biomineral full of antimicrobial molecules

- Distribution in the shell and roles during egg life cycle
- Dual role of matrix proteins (eg ovot, lyz and OCX-32)

Shell/skeleton dialog

- Molecular, vesicular and cellular mechanisms

Metabolite and immunity in biominerals

The physical protection

Ultrastructure and genetic variations,

- Strong evidences that the structural organization of avian eggshell is under genetic control

- Polymorphisms of specific shell proteins (ovalbumin, ovocleidin-116, ovocalyxin-32) partially explain variations in certain eggshell properties (i.e., eggshell thickness, crystal size, crystal orientation, eggshell mechanical properties)

- A total of 118 QTLs associated with shell strength

ANIMAL GENETICS Immunogenetics, Molecular Genetics and Functional Genomics

doi:10.1111/j.1365-2052.2011.02280.x

Genetic variation in eggshell crystal size and orientation is large and these traits are correlated with shell thickness and are associated with eggshell matrix protein markers

I. C. Dunn*, A. B. Rodríguez-Navarro†, K. Mcdade‡, M. Schmutz§, R. Preisinger§, D. Waddington*, P. W. Wilson* and M. M. Bain‡

ANIMAL GENETICS Immunogenetics, Molecular Genetics and Functional Genomics

doi:10.1111/j.1365-2052.2010.02131.x

Quantitative trait loci affecting eggshell traits in an F_2 population

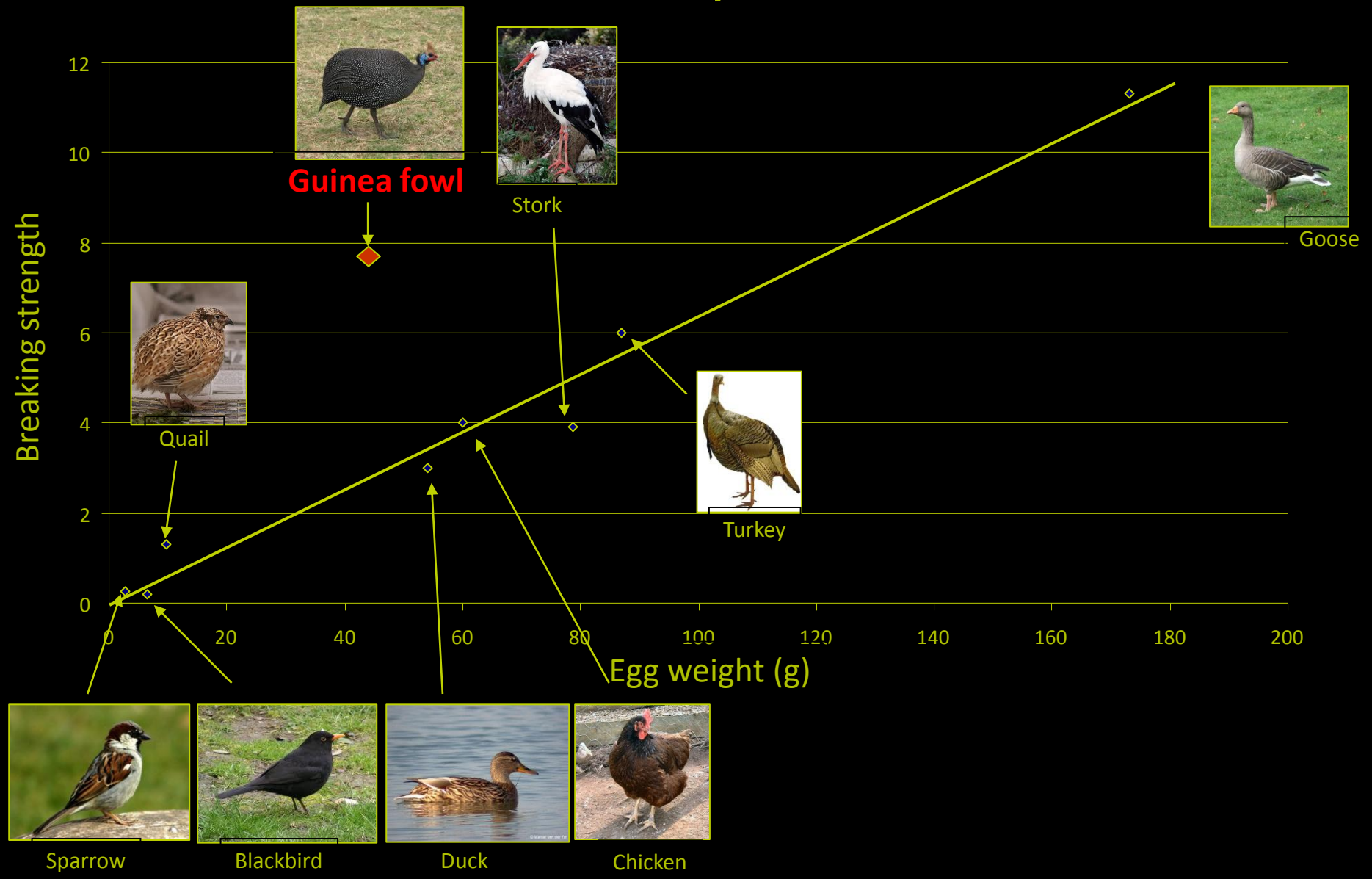
M. Tuiskula-Haavisto*, M. Honkatukia*, R. Preisinger†, M. Schmutz†, D. J. de Koning‡, W. H. Wei§ and J. Vilkki*

*MTT Agrifood Research Finland, Biotechnology and Food Research, 31600 Jokioinen Finland. †Lohmann Tierzucht GmbH Am Seedeich 9-11, PO Box 460, 27454 Cuxhaven, Germany. ‡Genetics and Genomics, The Roslin Institute and R(D)SVS, University of Edinburgh Midlothian EH25 9PS, UK. §MRC Human Genetics Unit, Western General Hospital Crewe Road, Edinburgh EH4 2XU, UK

Toward a selection of haplotypes with higher strength quality (genomic selection, candidate gene approach) ?

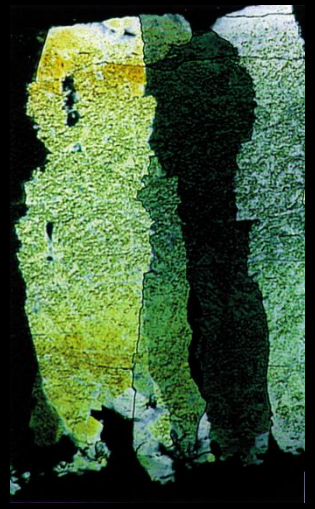
The physical protection

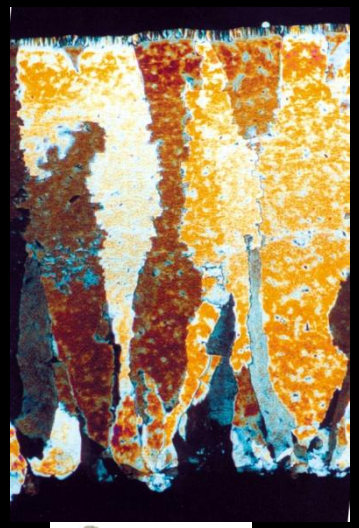
Genetic traits inherited under the environnmental pressure

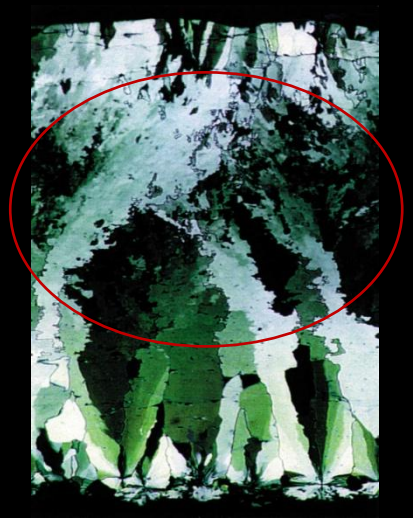


The physical protection

Genetic traits inherited under the environnmental pressure







Gallus gallus

Meleagris gallopavo

Numida meleagris

Sankofa pyrenaica

The physical protection

Genetic traits inherited under the environnmental pressure

JOURNAL OF Evolutionary Biology

doi:10.1111/j.1420-9101.2010.02010.x

SHORT COMMUNICATION

The evolution of host-specific variation in cuckoo eggshell strength

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†DST/NRF Centre of Excellence at the Percy FitzPatrick Institute, University of Cape Town, Rondebosch, South Africa

Behavioral Ecology Vol. 15 No. 1: 109–119
DOI: 10.1093/beheco/arg102

Phylogenetic analysis of life-history adaptations in parasitic cowbirds

Myriam E. Mermoz and Juan Francisco Ornelas
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Cowbirds (*Molothrus*) are obligate brood parasitic birds, that lay their eggs in nests of other bird species. The hosts provide all parental care to the parasitic eggs, chicks and fledglings.

Obligate brood parasitic birds are known for their greater eggshell thickness

* Intraspecific competition amongst parasite birds (frequently peck and puncture of other eggs laid into the nest)
* limit shell damage when rapid lay on elevated position
* Prevent damage from attempts by hosts to pierce-eject parasitic eggs

Increased thickness, but also variability in shell microstructure → Increased eggshell mechanical properties.

The physical protection

Genetic traits inherited under the environnmental pressure

Eggshell cuticles containing vaterite nanospheres have been noted (but not studied) on eggshells of six species including the double-crested cormorant (*Phalacrocorax auritus*), emperor penguin (*Aptenodytes forsteri*), great frigatebird (*Fregata minor*), hamerkop (*Scopus umbreta*) and smooth-billed ani (*Crotophaga ani*) (Mikhailov, 1997). The majority of these species incubate eggs in wet environments, where microbial abundance is likely high (D'alba et al., 2014)

Available online at www.sciencedirect.com
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Comparative Biochemistry and Physiology, Part B 149 (2008) 640–649
CBP
www.elsevier.com/locate/cbpb

Antimicrobial activity of the Anseriform outer eggshell and cuticle

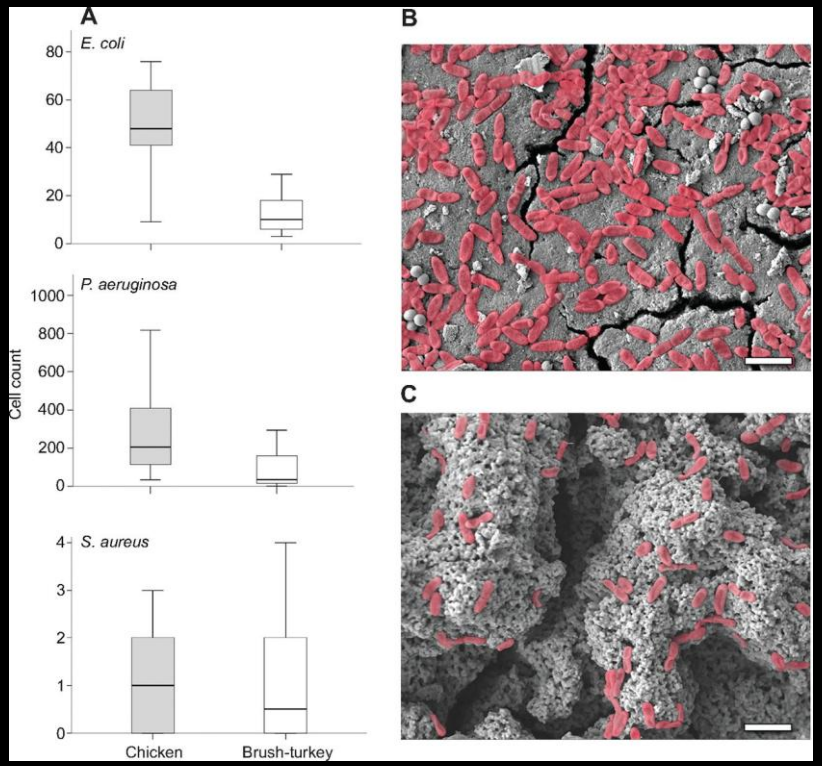
Olivier Wellman-Labadie, Jaroslav Picman, Maxwell T. Hincke *
Department of Biology, University of Ottawa, 30 Marie Curie, Ottawa, Ontario, Canada K1N 6N5

Received 28 October 2007; received in revised form 4 January 2008; accepted 4 January 2008
Available online 12 January 2008

… the presence of more potent antimicrobial proteins in the eggshells of cavity-nesting versus open cup-nesting Anseriform species

The physical protection

Genetic traits inherited under the environnmental pressure



© 2014. Published by The Company of Biologists Ltd | The Journal of Experimental Biology (2014) 217, 1116-1121 doi:10.1242/jeb.098343

RESEARCH ARTICLE

Antimicrobial properties of a nanostructured eggshell from a compost-nesting bird

Liliana D'Alba[1,*], Darryl N. Jones[2], Hope T. Badawy[3], Chad M. Eliason[1] and Matthew D. Shawkey[1]

"The presence of nanoscale spheres composed of calcium phosphate, renders the eggs hydrophobic, decreases bacterial attachment and is most likely the major component preventing trans-shell penetration

This modified surface also appears to limit bacterial adhesion…"

A biomineral full of antimicrobial molecules

Anti-microbial activity observed in eggshell extracts (Mine et al. 2003)

JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY

J. Agric. Food Chem. 2003, 51, 249–253 249

Eggshell Matrix Proteins as Defense Mechanism of Avian Eggs

YOSHINORI MINE,* CEDRIC OBERLE, AND ZEINA KASSAIFY

Department of Food Science, University of Guelph, Guelph, Ontario N1G2W1, Canada

Connective Tissue Research, Vol. 42(4), pp. 255-267

Ovotransferrin is a Matrix Protein of the Hen Eggshell Membranes and Basal Calcified Layer

J. GAUTRON[a], M.T. HINCKE[b], M. PANHELEUX[a], J.M. GARCIA-RUIZ[c], T. BOLDICKE[d] and Y. NYS[a,*]

Identification of antimicrobial proteins into the shell

ELSEVIER

Matrix Biology 19 (2000) 443–453

MATRIX BIOLOGY

www.elsevier.com/locate/matbio

Identification and localization of lysozyme as a component of eggshell membranes and eggshell matrix

M.T. Hincke[a,*], J. Gautron[b], M. Panheleux[b], J. Garcia-Ruiz[c], M.D. McKee[d,e], Y. Nys[b]

THE JOURNAL OF BIOLOGICAL CHEMISTRY Vol. 276, No. 42, Issue of October 19, pp. 39243–39252, 2001

Ovocalyxin-32, a Novel Chicken Eggshell Matrix Protein

ISOLATION, AMINO ACID SEQUENCING, CLONING, AND IMMUNOCYTOCHEMICAL LOCALIZATION*

Received for publication, May 18, 2001, and in revised form, August 6, 2001
Published, JBC Papers in Press, August 7, 2001, DOI 10.1074/jbc.M104543200

Joël Gautron‡, Maxwell T. Hincke§¶, Karlheinz Mann‖, Marina Panhéleux‡, Maureen Bain, Marc D. McKee‡‡, Sally E. Solomon**, and Yves Nys‡§§**

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Comparative Biochemistry and Physiology, Part B 147 (2007) 172 – 177

CBP

www.elsevier.com/locate/cbpb

Recombinant eggshell ovocalyxin-32: Expression, purification and biological activity of the glutathione *S*-transferase fusion protein

Jun Xing [a], Olivier Wellman-Labadie [a], Joel Gautron [b], Maxwell T. Hincke [a,*]

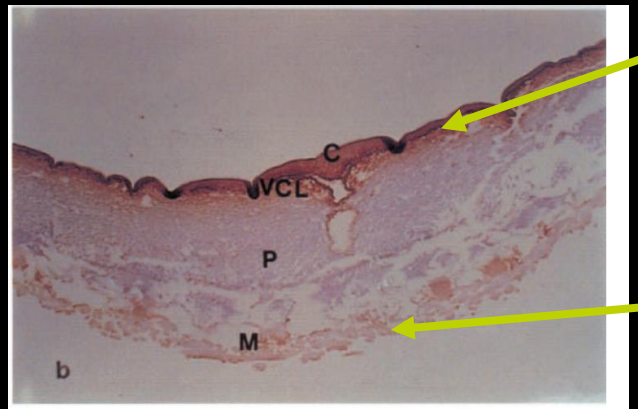


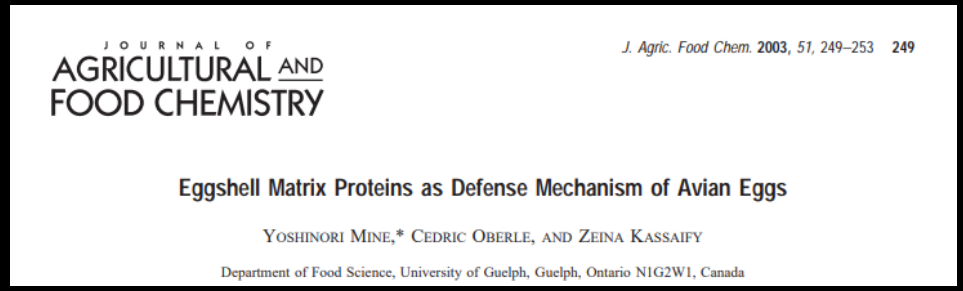
FIG. 2. **Immunohistochemistry to localize the 32-kDa protein n eggshell matrix.** Shell was decalcified/fixed and paraffin-embedded

Highly concentrated in the cuticle → to avoid bacterial penetration during eggshell formation?

Highly concentrated in the lower part of the shell (membranes and mmmillary layers) → to protect the developing embryo when shell components are made soluble?

A biomineral full of antimicrobial molecules

Anti-microbial activity observed in eggshell extracts (Mine et al. 2003)


JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY

J. Agric. Food Chem. 2003, 51, 249–253 249

Eggshell Matrix Proteins as Defense Mechanism of Avian Eggs

YOSHINORI MINE,* CEDRIC OBERLE, AND ZEINA KASSAIFY

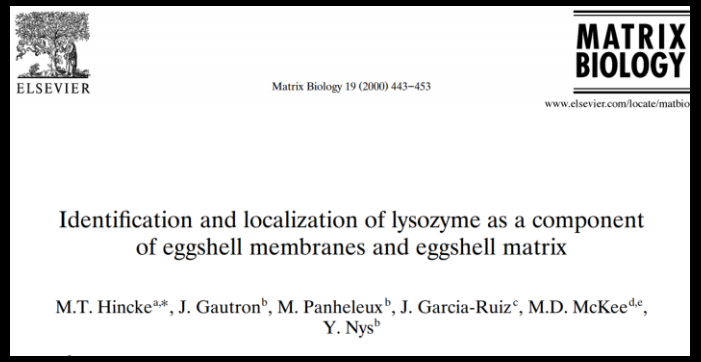
Department of Food Science, University of Guelph, Guelph, Ontario N1G2W1, Canada


Connective Tissue Research, Vol. 42(4), pp. 255-267 © 2001 Taylor and Francis Inc.

Ovotransferrin is a Matrix Protein of the Hen Eggshell Membranes and Basal Calcified Layer

J. GAUTRON[a], M.T. HINCKE[b], M. PANHELEUX[a], J.M. GARCIA-RUIZ[c], T. BOLDICKE[d] and Y. NYS[a,*]

Identification of antimicrobial proteins into the shell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Matrix Biology 19 (2000) 443–453

MATRIX BIOLOGY

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M.T. Hincke[a,*], J. Gautron[b], M. Panheleux[b], J. Garcia-Ruiz[c], M.D. McKee[d,e], Y. Nys[b]

Multi purpose roles

Biomineralization Ultrastructure and mechanical properties

Antimicrobials 1

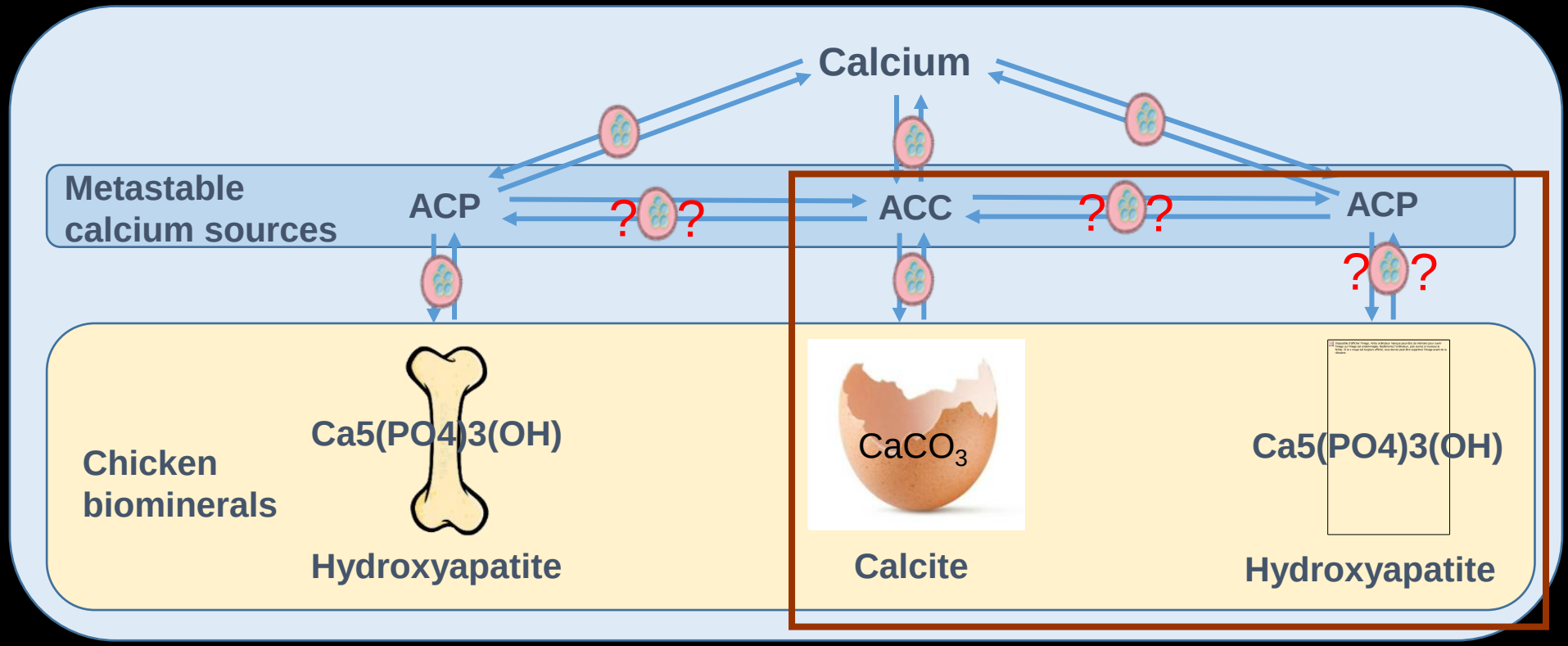
In soluble form during shell formation (keep the egg free of pathogens)

Antimicrobials 2

Solubilisation during chicken embryo development and skeleton formation

Shell/skeleton dialog

Molecular, vesicular and cellular mechanisms



Role of CAM to solubilize the shell

CAM and osteoblasts ?

CAM and immune cells ?

Metabolite and immunity in biominerals

Fish and Shellfish Immunology 106 (2020) 645–655

Contents lists available at ScienceDirect

Fish and Shellfish Immunology

journal homepage: www.elsevier.com/locate/fsi

Full length article

Immune-responsive gene 1 (IRG1) and dimethyl itaconate are involved in the mussel immune response

M. Sendra, A. Saco, M. Rey-Campos, B. Novoa *, A. Figueras

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Metabolomics (2019) 15:97
https://doi.org/10.1007/s11306-019-1556-8

ORIGINAL ARTICLE

Targeted metabolomics to investigate antimicrobial activity of itaconic acid in marine molluscs

Thao Van Nguyen[1] · Andrea C. Alfaro[1]

Received: 6 April 2019 / Accepted: 15 June 2019 / Published online: 22 June 2019

SCIENTIFIC REPORTS

OPEN

Itaconic acid inhibits growth of a pathogenic marine *Vibrio* strain: A metabolomics approach

Thao Van Nguyen[1], Andrea C. Alfaro[1], Tim Young[1], Saras Green[2], Erica Zarate[2] & Fabrice Merien[3]

Received: 7 December 2018
Accepted: 29 March 2019
Published online: 11 April 2019