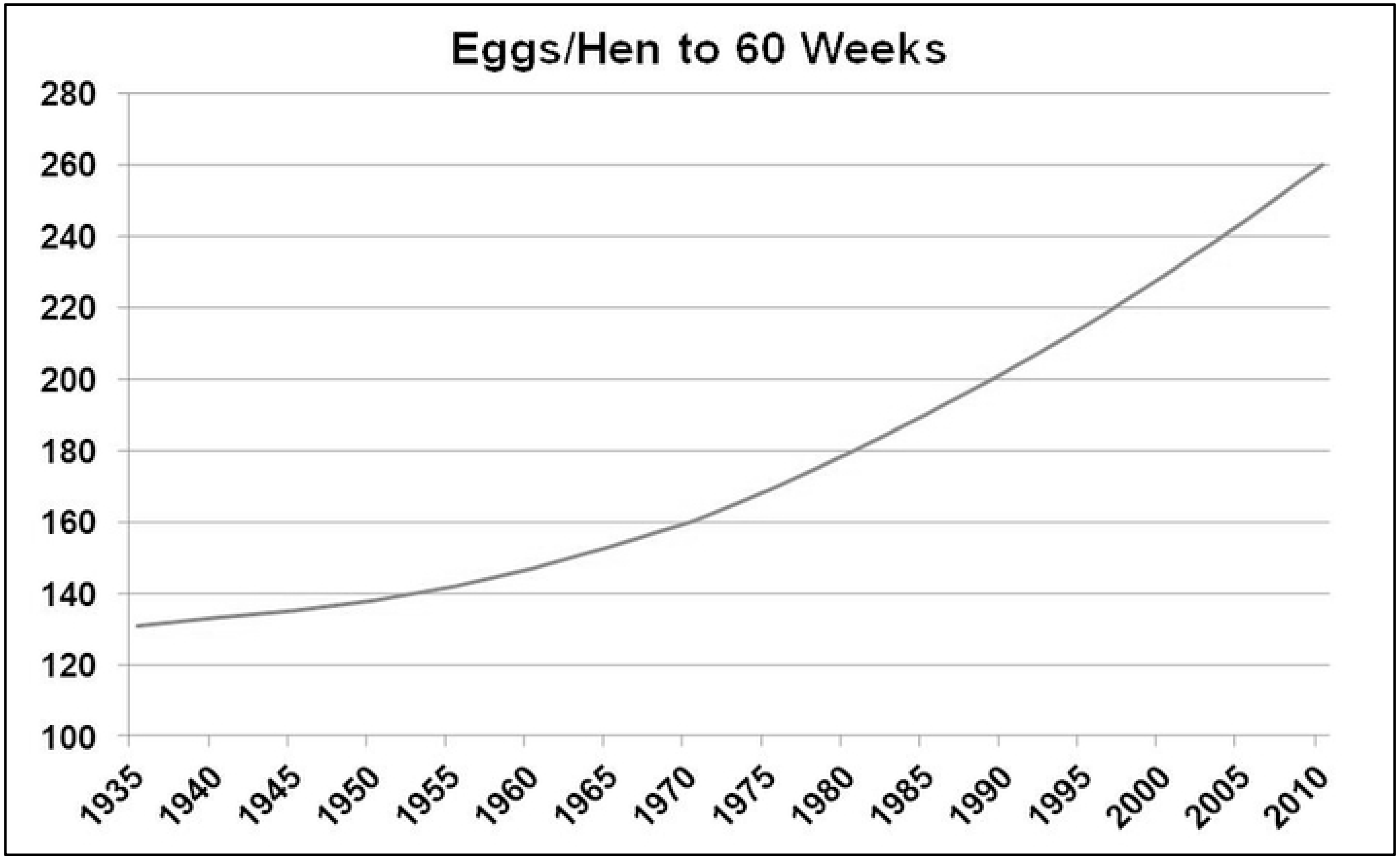
LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Ein Ei pro Tag:
Regulation, Reifung und Nährstoffbedarf

Bernd Kaspers – LMU-München

Department für Veterinärwissenschaften

Genetische Fortschritte bei der Eierproduktion



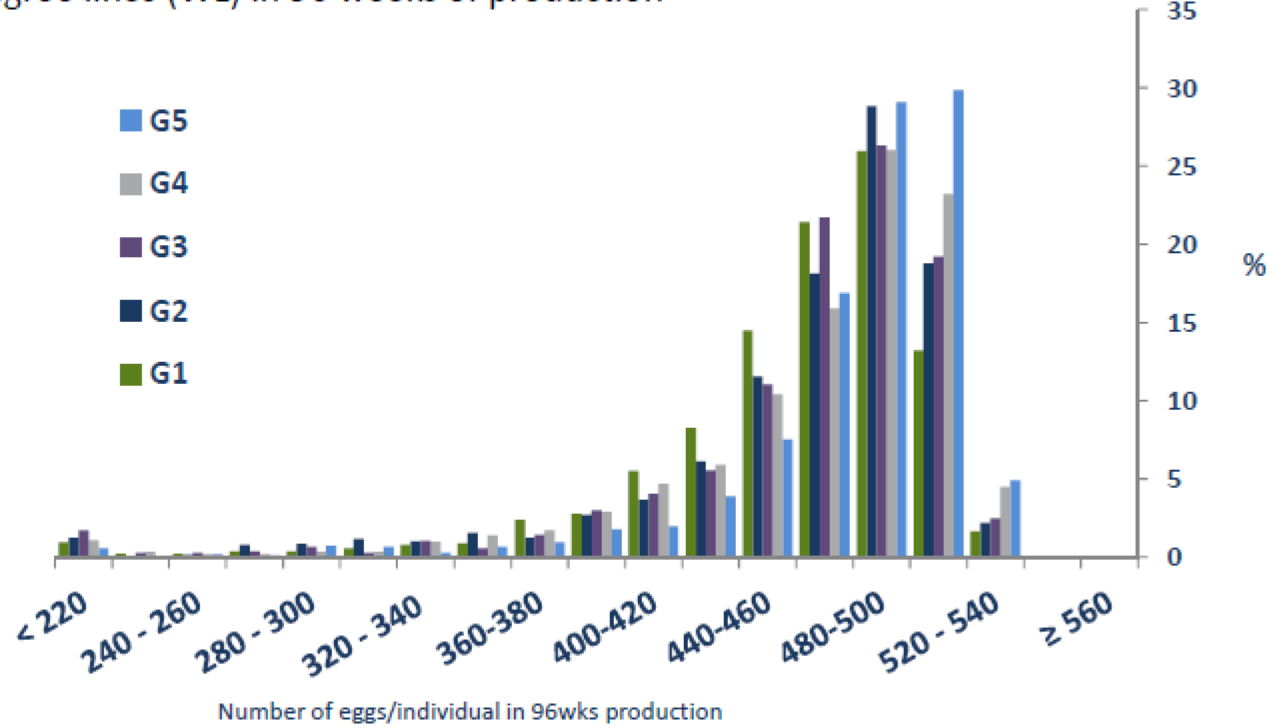
Anna Wolc, Iowa State University

Heute legen Hennen etwa 300 Eier in einer Legeperiode

Geht noch mehr?

The capacity to produce >500 eggs is present in existing pedigree lines

Range in number of eggs produced by individuals and their % distribution in 5 pedigree lines (WL) in 96 weeks of production



Data source -Institut de selection Animale

Das war nicht immer so!

By Dibyendu Ash ttps://commons.wikimedia.org/w/index.php?curid=38901184

Sun Chong Hong, Singapore

Selektion auf konstante Ovulation

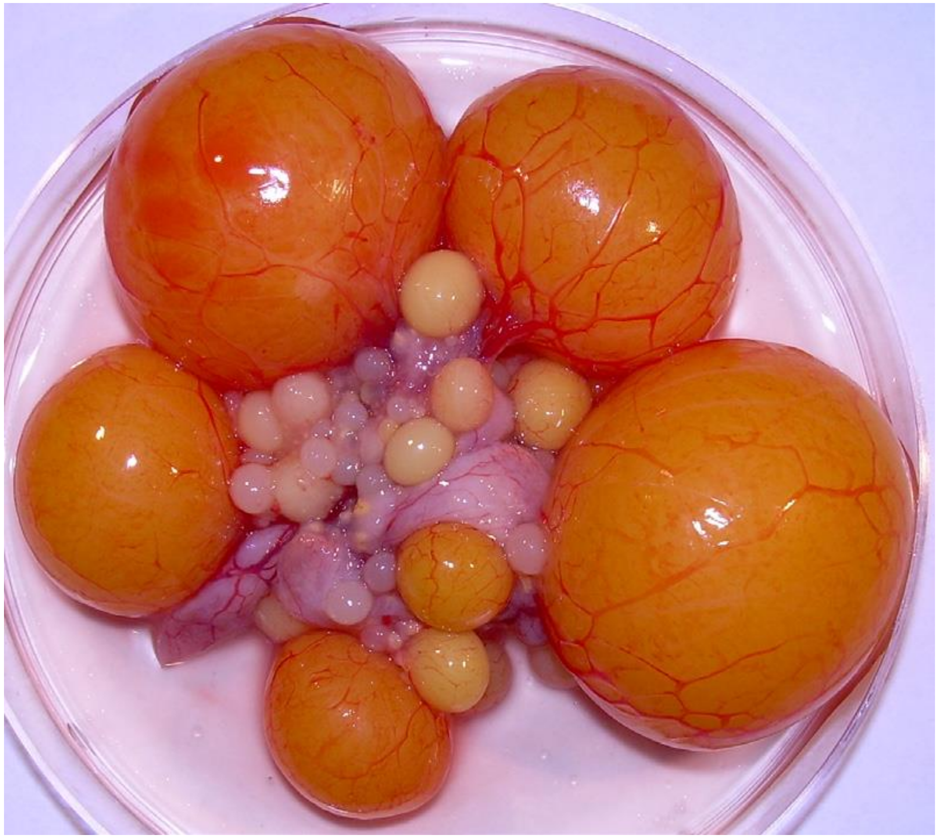
Das Brutverhalten wurde nahezu eliminiert

Ein großer Pool an Eizellen

Zum Schlupf finden sich ca. 12.000 Eizellen

Aber nur ein Bruchteil reift bis zur Ovulation heran

(250-500 bei den meisten domestizierten Spezies)



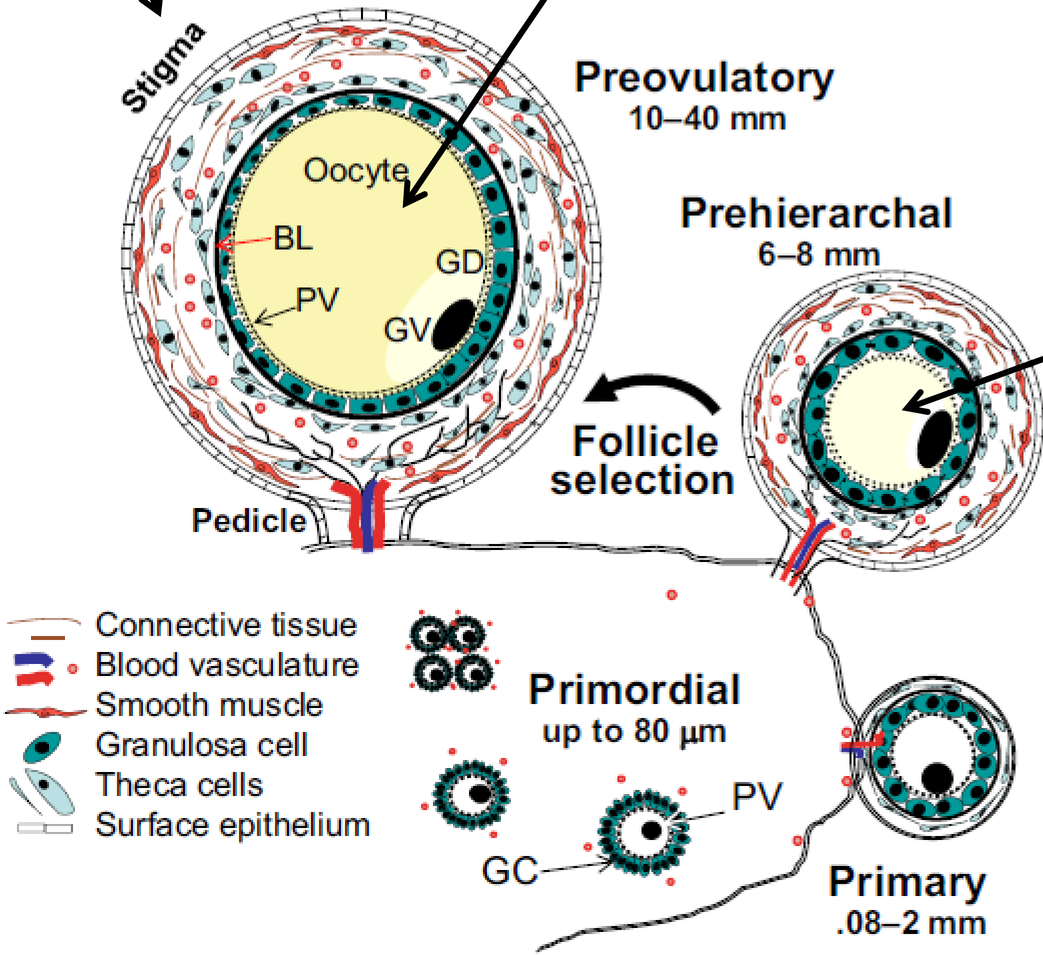
Johnson, 2015 in: Sturkie‘s Avian Physiology

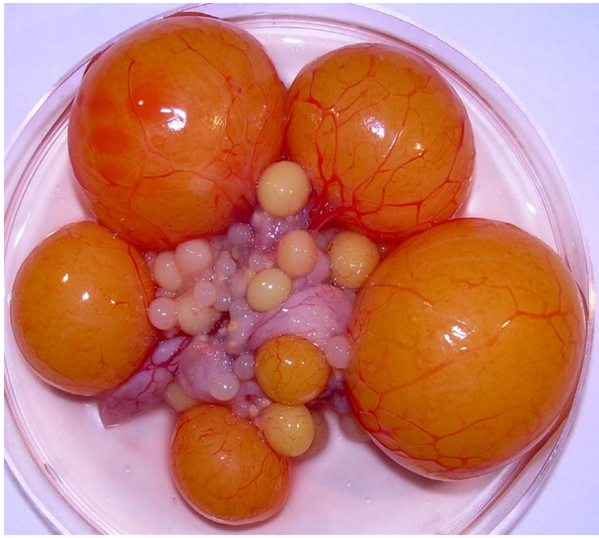
Hierarchische Entwicklung

Ort der Ruptur bei der Ovulation

Einlagerung von gelben Dotter (Vitellogenin, VLDL)

Einlagerung von weißem Dotter (reich an Lipoproteinen)

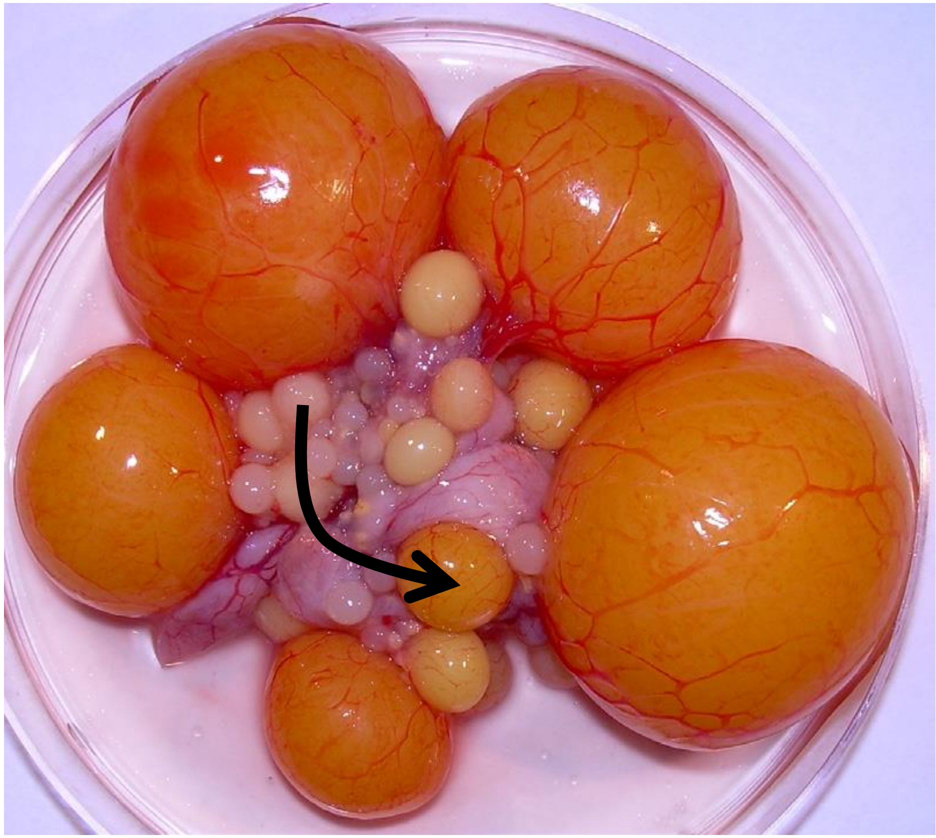




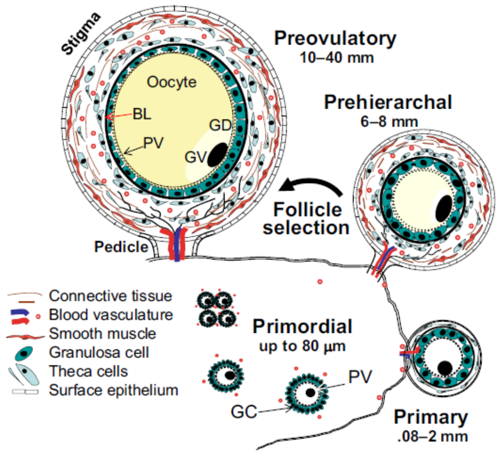
Johnson, 2015 in: Sturkie‘s Avian Physiology

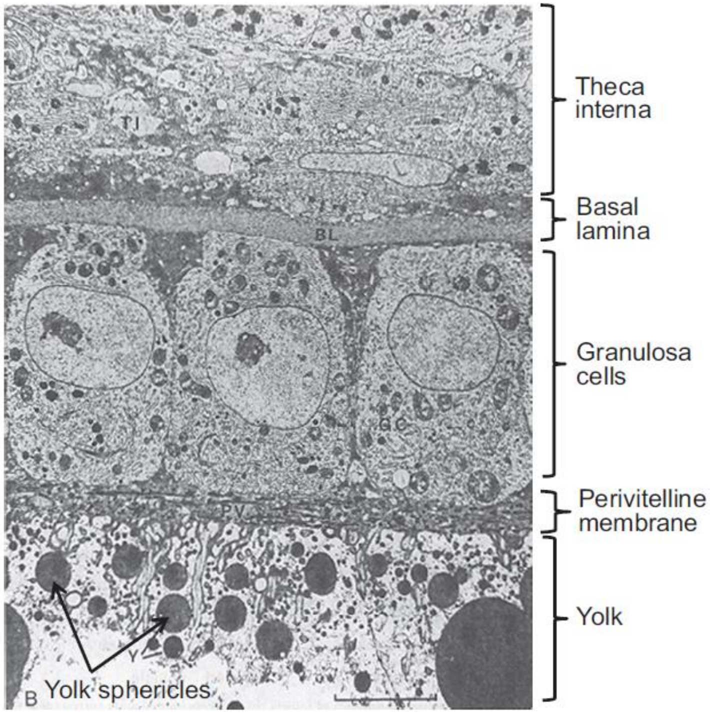
Hierarchische Entwicklung

Tägliche Selektion eines Follikels in den prä-ovulatorischen Pool



Hierarchische Entwicklung





Verlust der FSH-R Hemmung

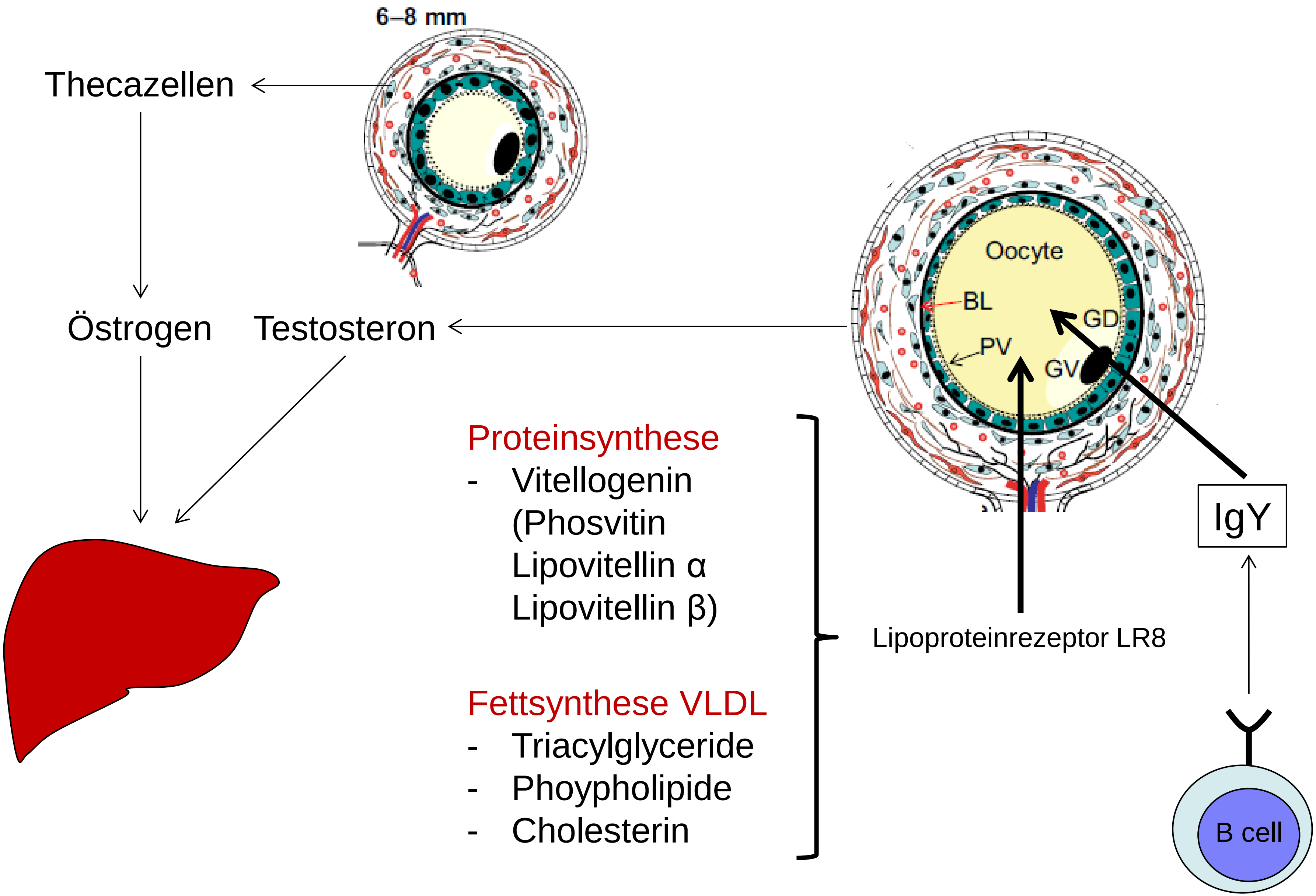
↓

Aktivierung des FSH-R und cAMP Signalwegs

↓

- Steroidhormon Synthese
- Induktion anti-apoptotischer Proteine
- Übergang von der FSH-R zur LH-R Dominanz
- Aufnahme von gelbem Dotter

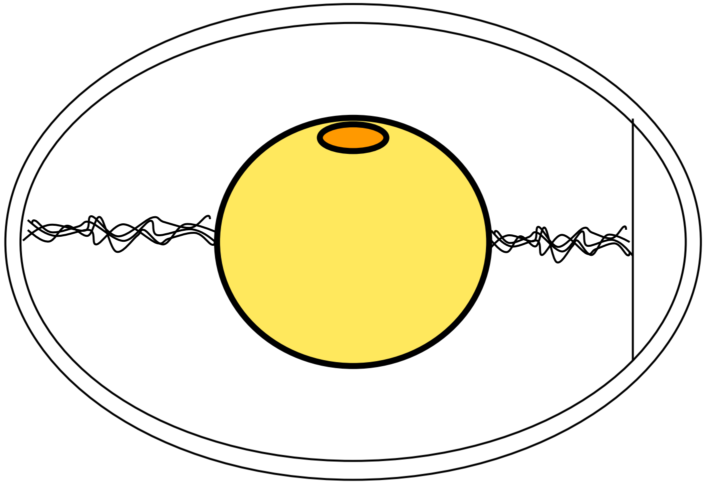
Dotterbildung

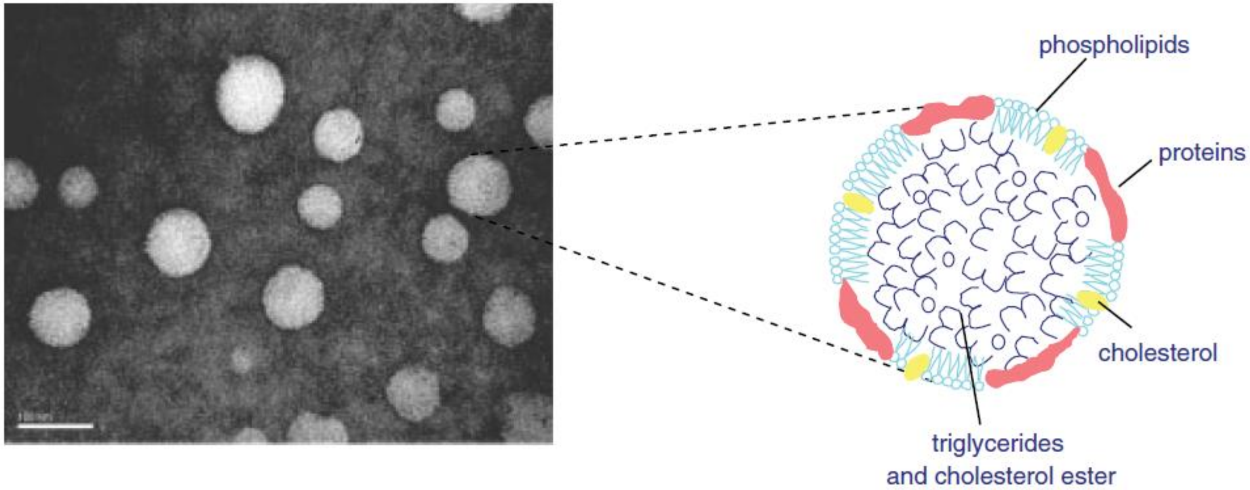


Dotterinhalt

36% Fett

- 65% Triacylglyceride
- 31% Phospholipide
- 4% Cholesterin





Jolivet P et al., Apoproteins: New research trends,
Nova Science Publisher, 2009

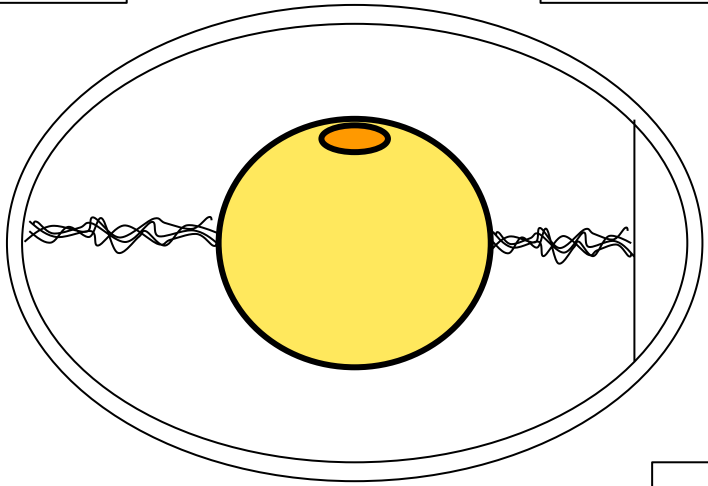
Dotterinhalt

36% Fett

- 65% Triacylglyceride
- 31% Phospholipide
- 4% Cholesterin

17% Protein < 119

- Serumalbumin 14% (= α-Livetin)
- Glycoproteine 41% (= β-Livetin)
- IgY 45% (= γ-Livetin)



Carotinoide - Xantophylle

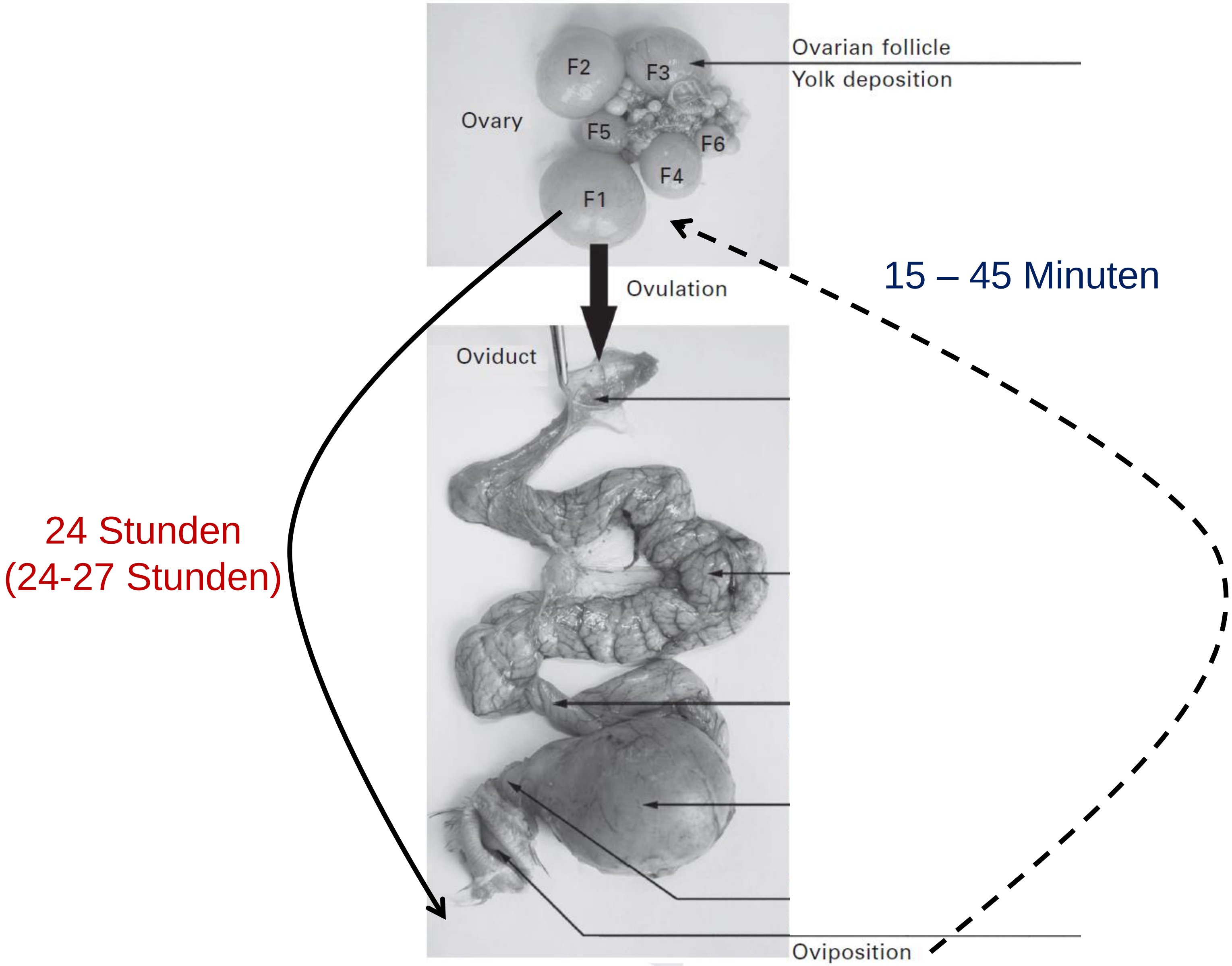
< 1% Kohlenhydrate

< 1% Vitamine

< 1% anorgan.

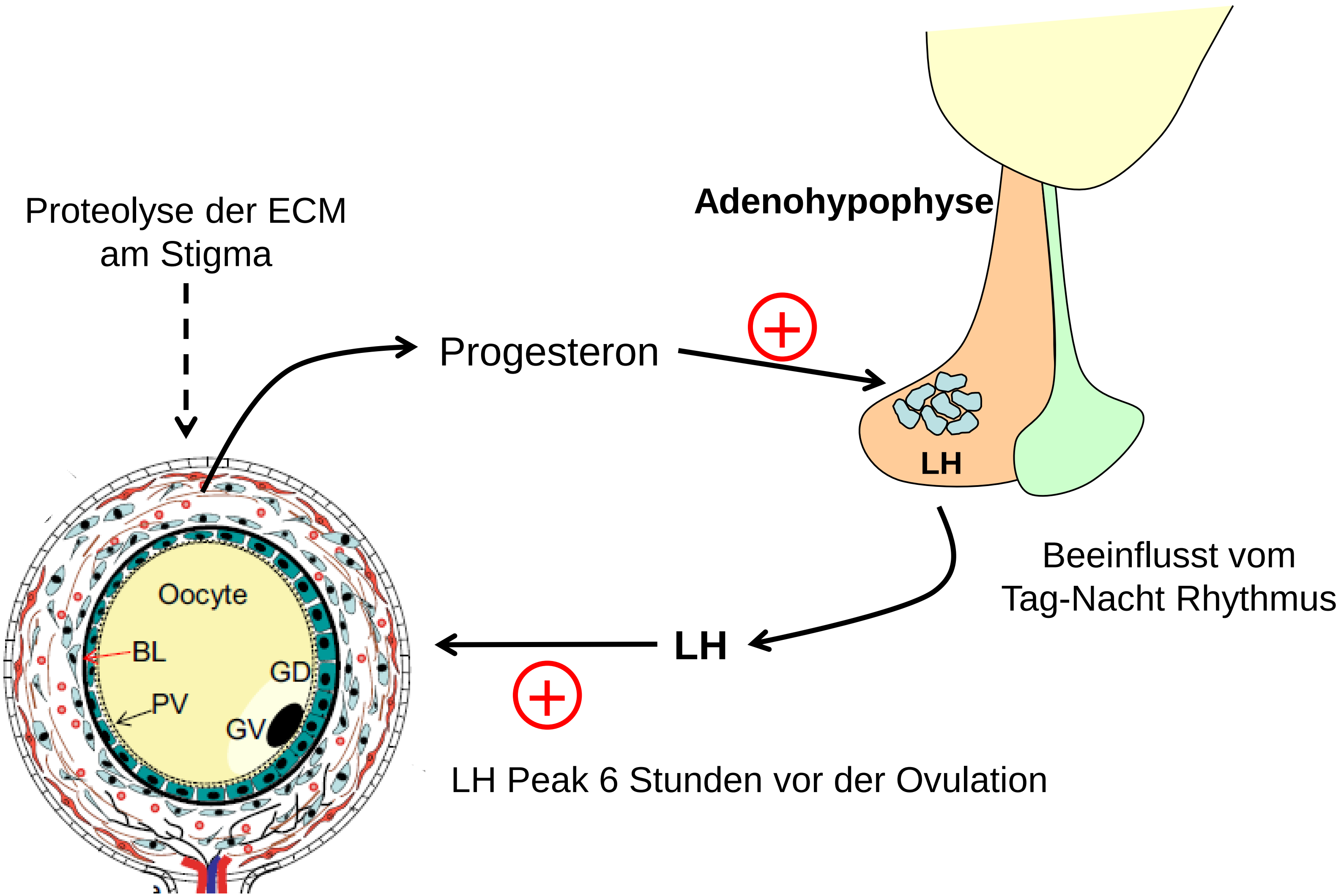
Bestandteile (P, Fe)

Ovulation



Ovarian follicle
Yolk deposition
F2
F3
Ovary
F5
F6
F4
F1
15 – 45 Minuten
Ovulation
Oviduct
24 Stunden
(24-27 Stunden)
Oviposition

Regulation der Ovulation



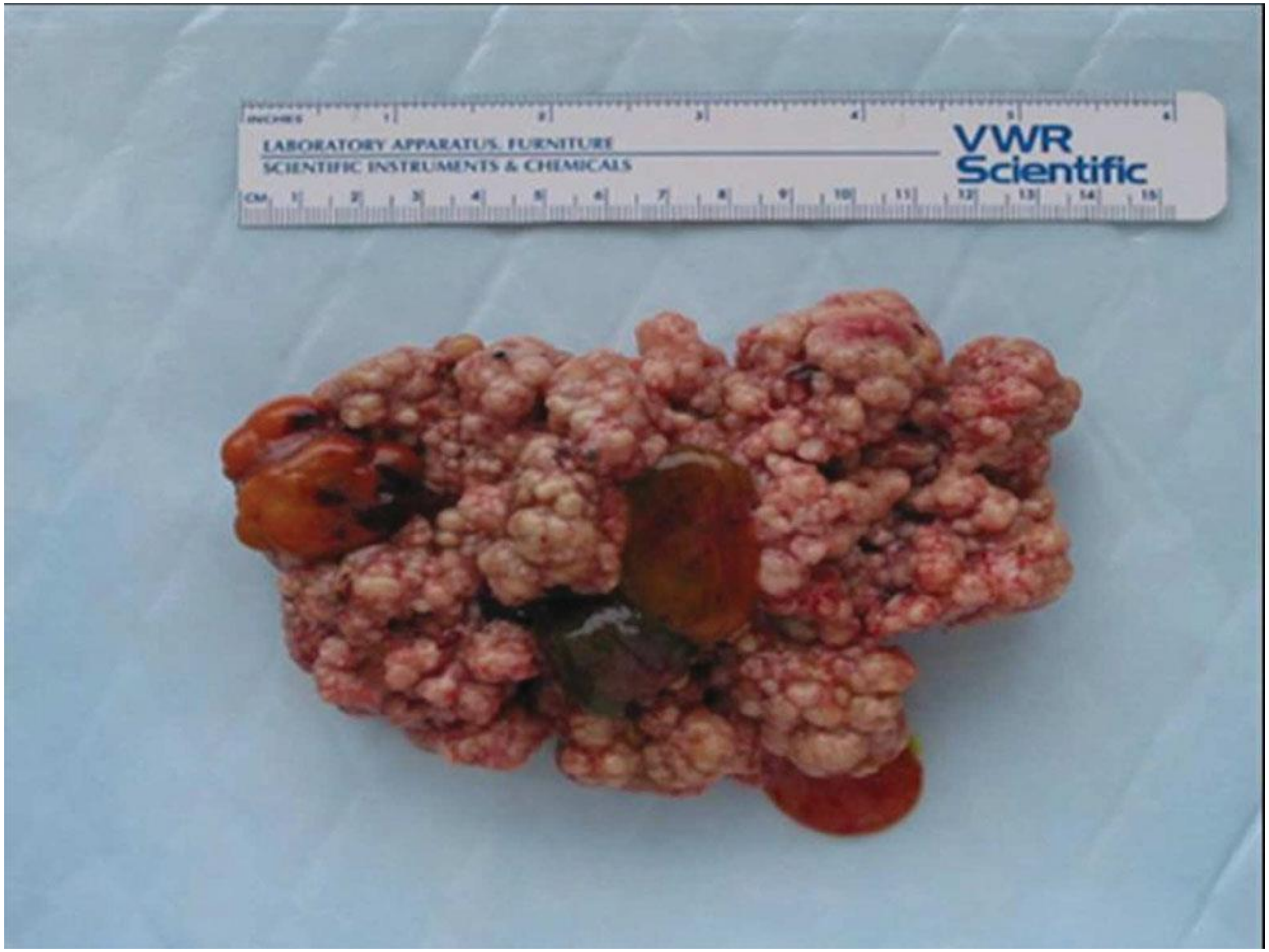
Hormonelle Regulation

TABLE 28.1 Partial List of Factors Reported to Be Expressed and/or to Act within the Avian Ovary

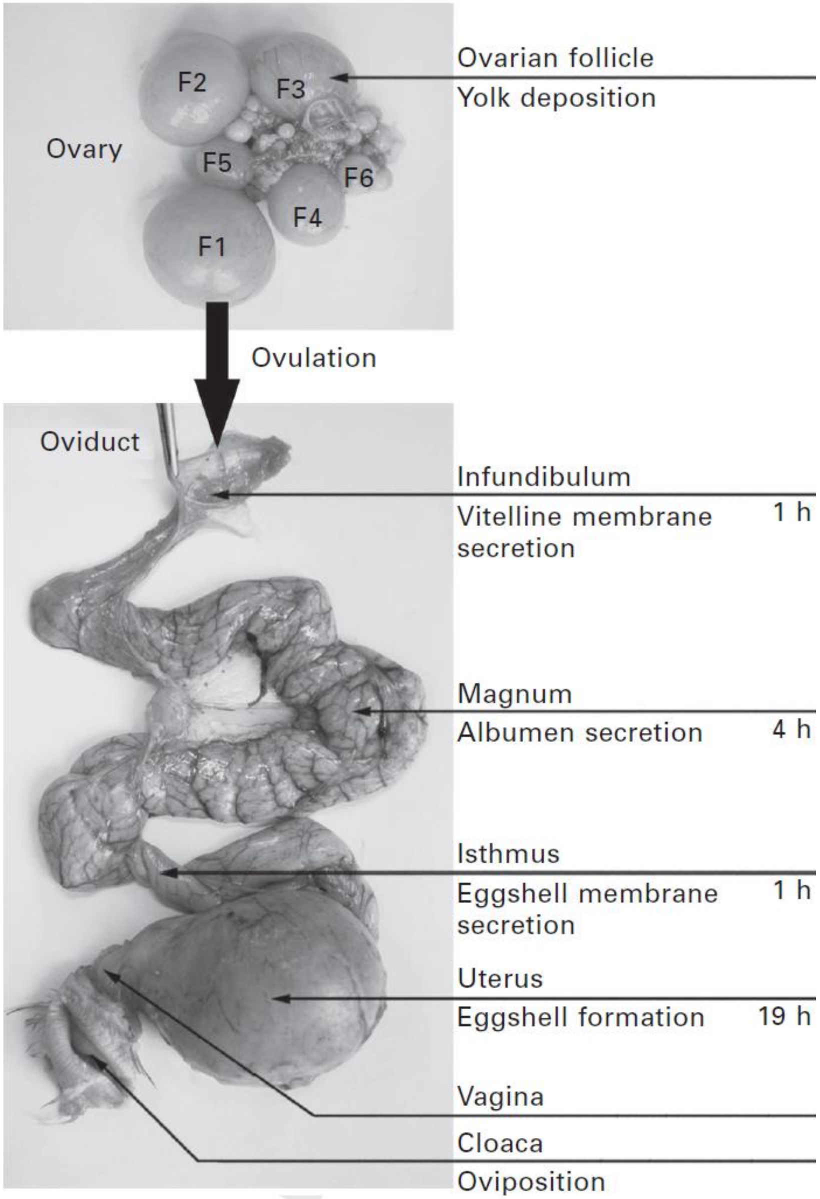
Factor	Proposed Function(s)	Reference(s)
Activins, follistatin, and inhibins	Follicle-stimulating hormone (FSH) secretion; FSH and luteinizing hormone receptor expression	Onagbesan et al. (2004)
Adiponectin	Steroidogenesis (?)	Chabrolle et al. (2007)
Anti-Müllerian hormone	Follicle recruitment; FSH responsiveness	Wojtusik and Johnson (2012)
Arginine vasotocin	Oviposition	Baeyens and Cornett (2006)
Bone morphogenetic proteins (BMPs)		
BMP2, -3, -4, -5, -6, and -7	FSH receptor expression; granulosa differentiation	Onagbesan et al. (2003)
BMP15	Steroidogenesis; cell proliferation	Elis et al. (2007)
Growth and differentiation factor-9	Granulosa cell proliferation	Johnson et al. (2005)
Calcitonin	Follicle maturation (?)	Krzysik-Walker et al. (2007)
Cytokines		
Tumor necrosis factor α	Regulates steroidogenesis; apoptosis	Witty et al. (1996) and Onagbesan et al. (2000)
Interleukins	Postovulatory follicle regression; innate immunity	Sundaresan et al. (2008) and Abdelsalam et al. (2012)
Epidermal growth factor (EGF) receptor ligands		
EGF, transforming growth factor α, betacellulin, and amphiregulin	Cell differentiation, proliferation, and apoptosis	Woods et al. (2005) and Woods and Johnson (2007)
Fibroblast growth factors	Granulosa cell proliferation	Lin et al. (2012)
Follicle-stimulating hormone	Granulosa cell differentiation	Johnson and Woods (2009) and Bruggeman et al. (2002)
Gonadotropin-inhibitory protein	Follicle differentiation (?)	Bédécarrats et al. (2009)
Ghrelin	Steroidogenesis, cell proliferation, and apoptosis	Sirotkin et al. (2006)
Growth hormone	Modulates steroidogenesis	Ahumada-Solorzano et al. (2012)
Insulin-like growth factors (IGF1 and 2)	Follicle growth and differentiation	Onagbesan et al. (1999)
Luteinizing hormone	Steroidogenesis, ovulation, and cell viability	Johnson and Bridgham (2001)
Melatonin	Gonadotropin responsiveness (?)	Sundaresan et al. (2009)
Neurotropins (nerve growth factor and brain-derived neurotrophic factor)	Steroidogenesis	Jensen and Johnson (2001)
Prolactin	Steroidogenesis	Tabibzadeh et al. (1995)
Prostaglandins (PGE and PGF2α)	Apoptosis; cell proliferation	Li et al. (1997) and Manchanda et al. (2001)
Transforming growth factors (TGFβ1)	FSH receptor expression	Woods and Johnson (2005)
Thyroxine and triodothyronine	Modulates steroidogenesis	Sechman (2013)
Vasoactive intestinal peptide	Granulosa cell differentiation; steroidogenesis	Johnson et al. (1994)
1,25-dihydroxyvitamin D_3	Regulates anti-Müllerian hormone expression	Wojtusik and Johnson (2012)

Sturkie's Avian Physiology, G. Causey Whittow, Ed., Academic Press.

Ovarielle Adenocarcinome



Vitellinmembran



Mann, K. Proteomics 2008, *8,* 2322–2332
Proteomic analysis of the chicken egg vitelline Membrane

- 137 Proteine identifiziert
- davon waren erst 13 als Bestandsteile bekannt

Vitellinmembran

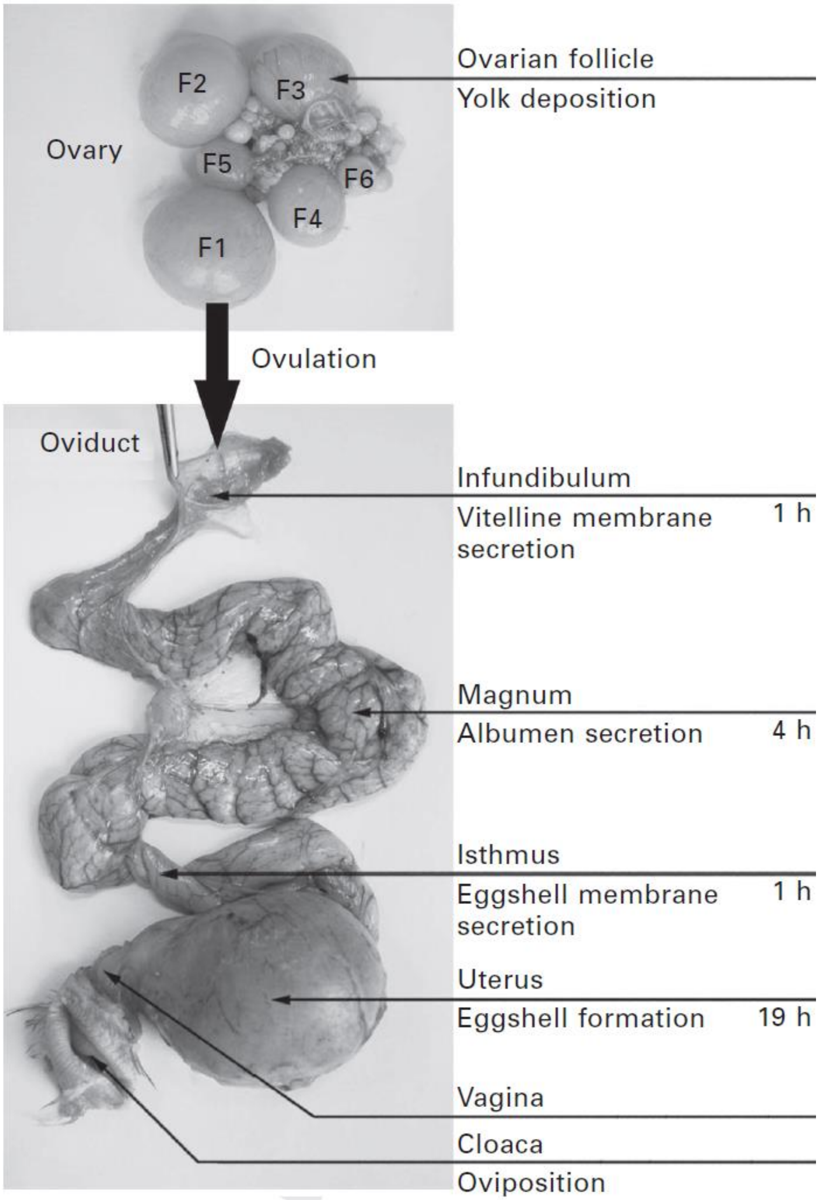
Ähnelt der Zona pellucida

Extrazelluläre Matrixproteine

- trennt Dotter und Eiklar
- spielt ein Rolle in der Fertilisation
- ist antimikrobiell

  (ß-Defensin, Lysozym, Proteasen)

Eiklar



Eiklar

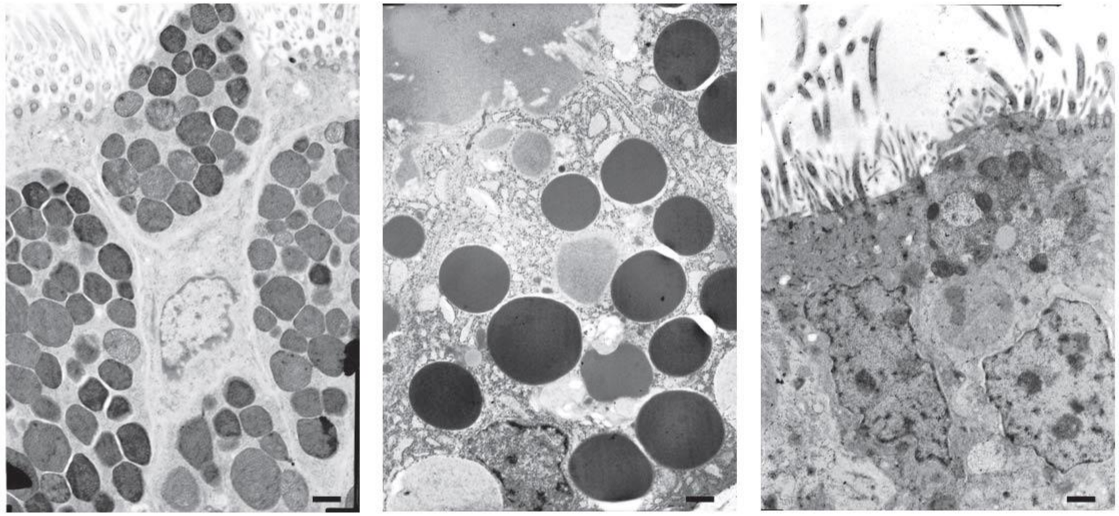
88% Wasser

90% der TS sind Proteine

6 % sind Mineralstoff

3,5% nicht gebundene Glucose

Eiklar



Alle Proteine werden im Magnum synthetisiert und sezerniert

Proteinsynthese ist unabhängig von der Anwesenheit eines Eies

Sie wird dadurch aber verstärkt

Die Sekretion wird durch die Eipassage induziert (nicht nerval, nicht hormonell induziert)

Tubuläre Drüsen: Ovalbumin, Ovotransferrin, Ovomucoid und Lysozym

Becherzellen: Ovomucin und Avidin

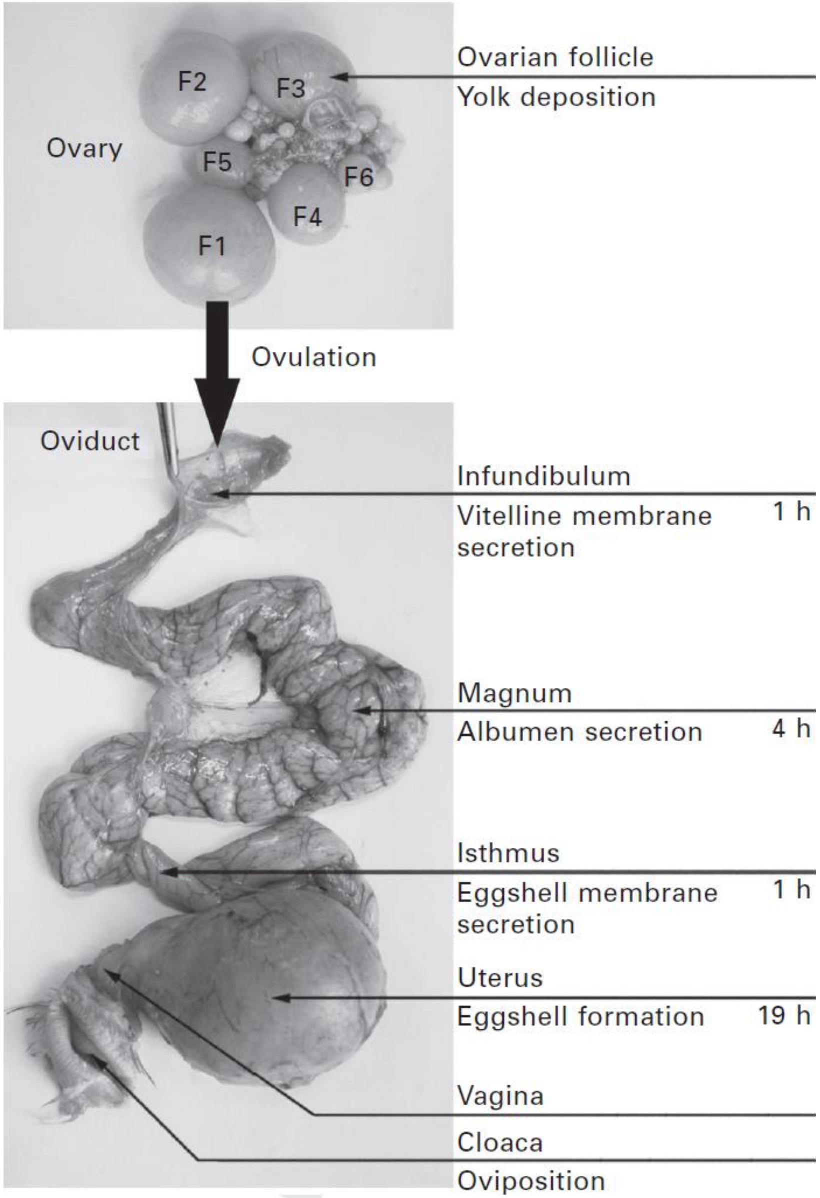
Regulation der Synthese

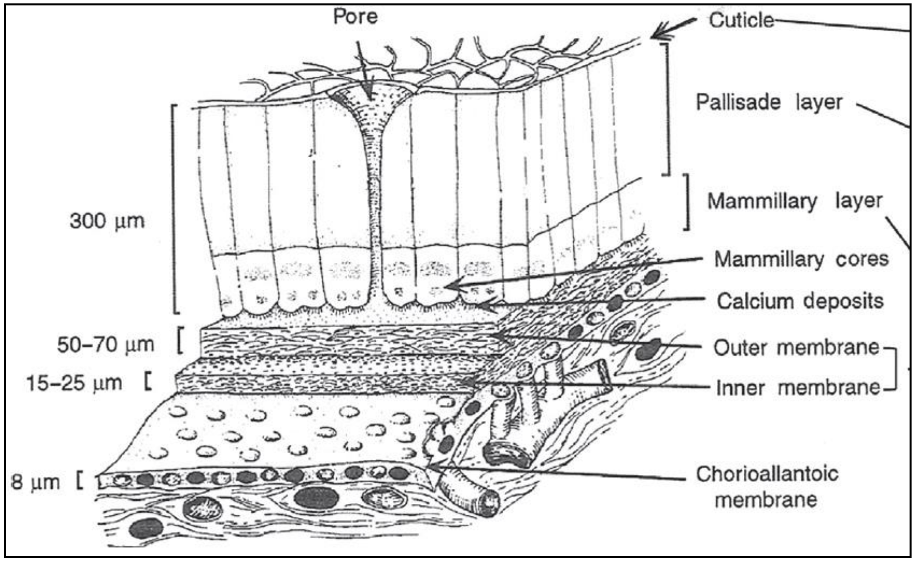
Östrogen
Ovalbumin
Ovotransferrin

Progesteron
Avidin

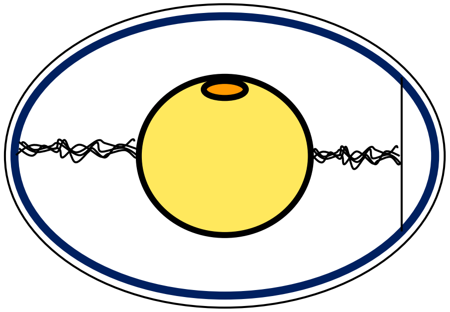
Testosteron
Glucocorticoide

Eischalenhaut

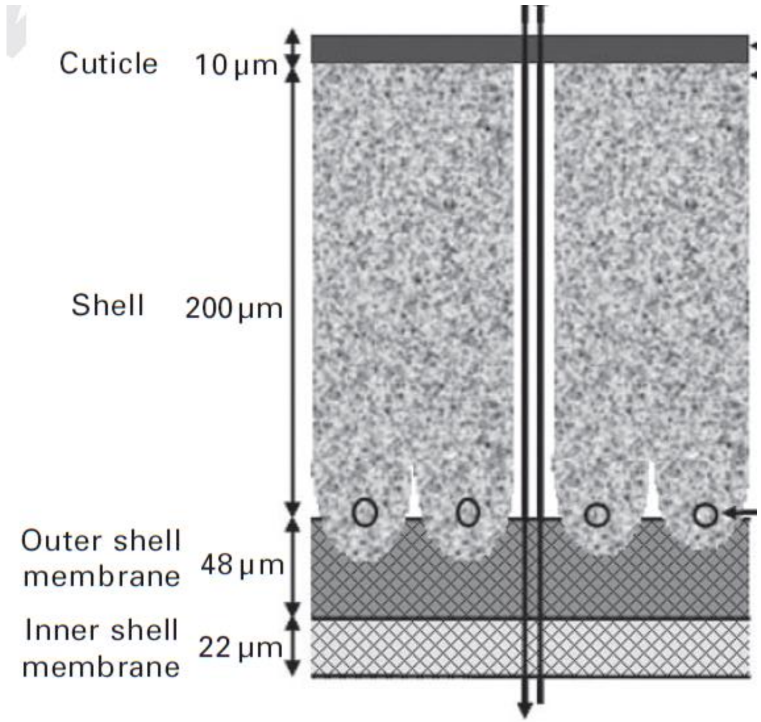


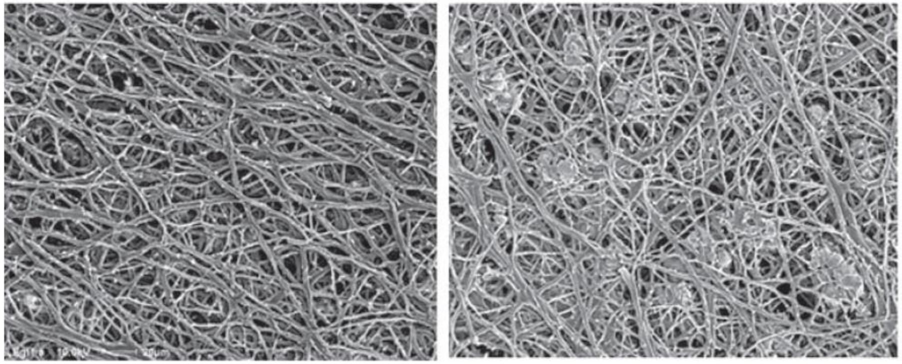


Eischalenhaut



Eischalenhaut





Semipermeable

- Wasser
- Gase (Sauerstoff)
- Mineralstoffe

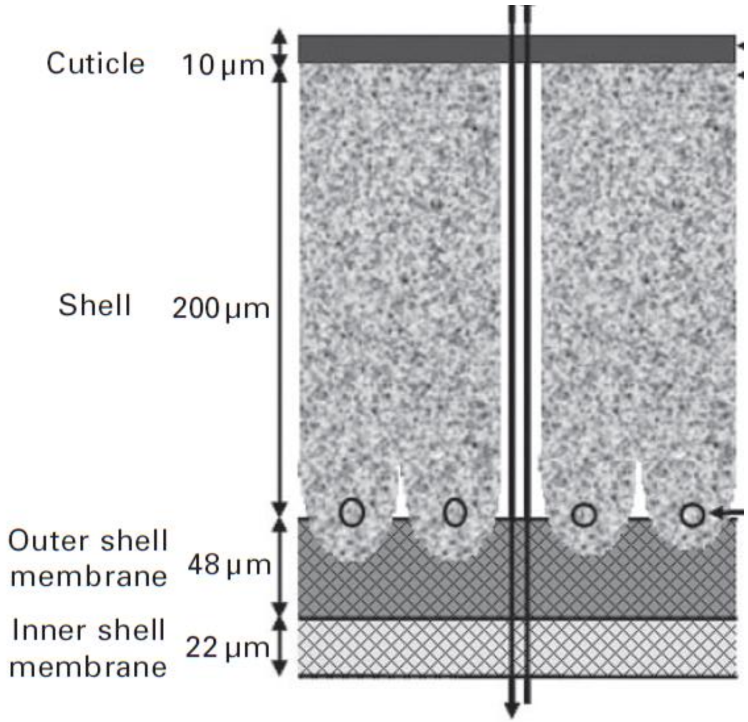
Nicht permeable für Eiklar

10% Collagen

75% Proteine und Glycoproteine

Nys et al., Egg Production, Woodhead Publishing 2011

Eischalenhaut



Semipermeable

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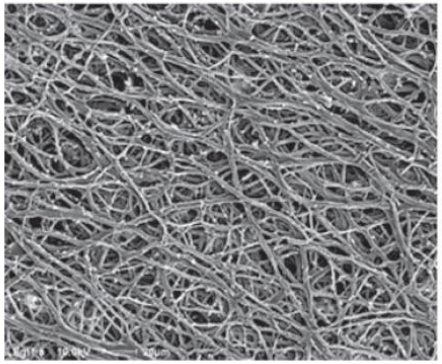
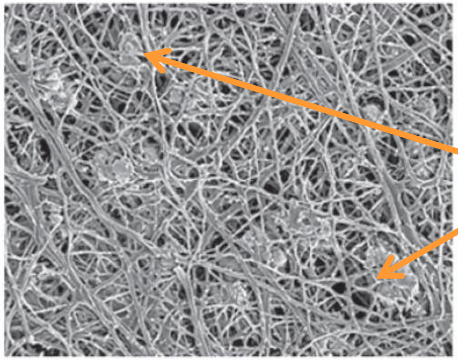
Nicht permeable für Eiklar



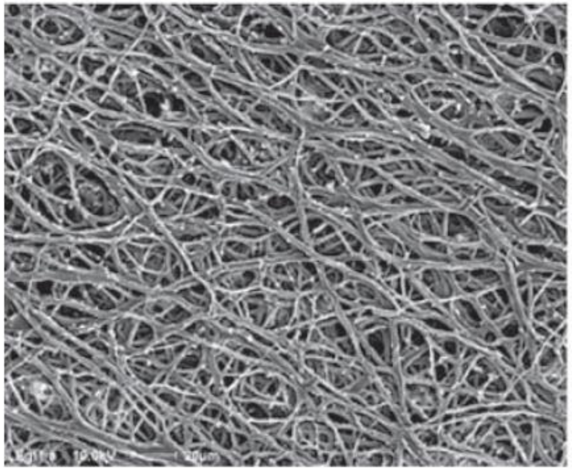


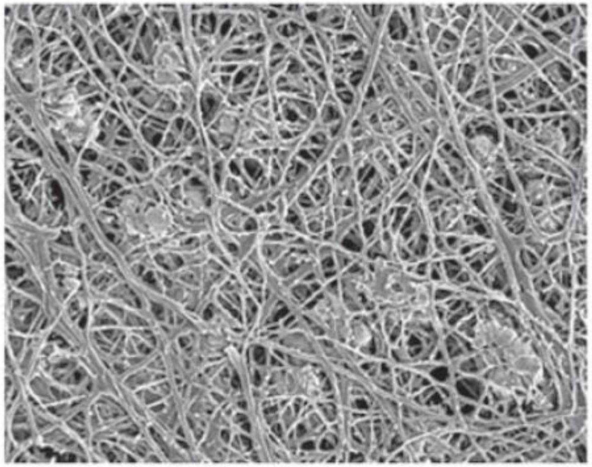
Projektionen (Mammillary Cores)

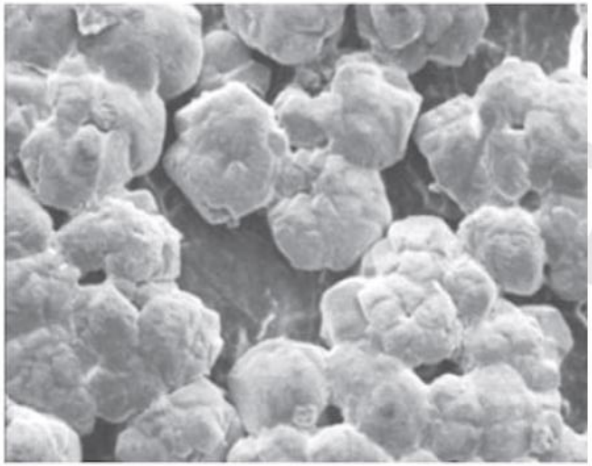
Proteine und Mucopolysaccharide

Beginn der Verkalkung

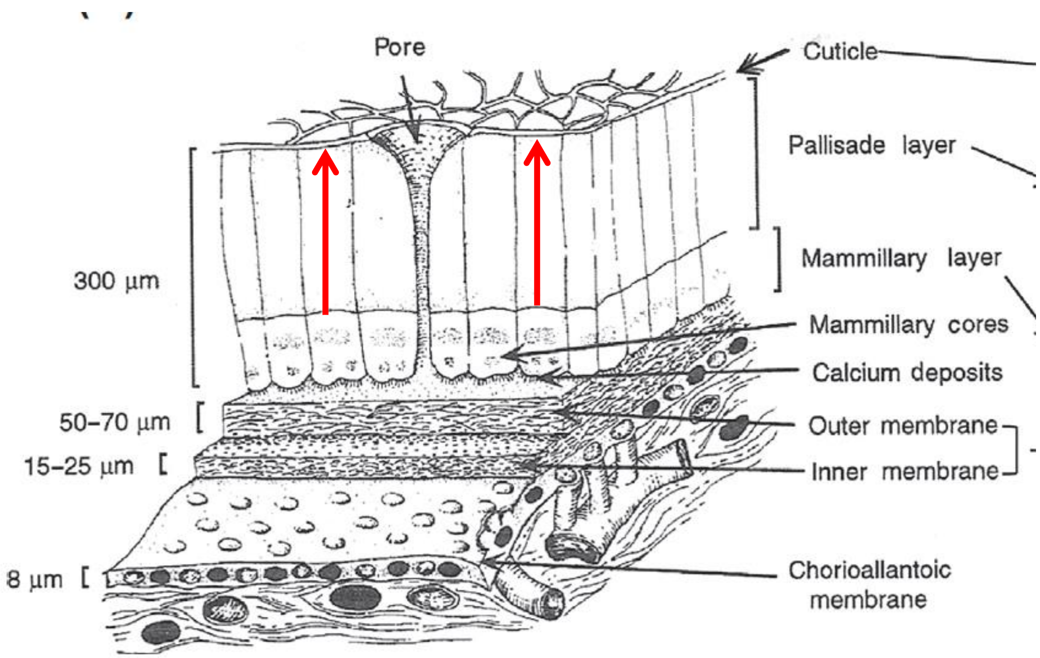
Bildung der Kalkschale



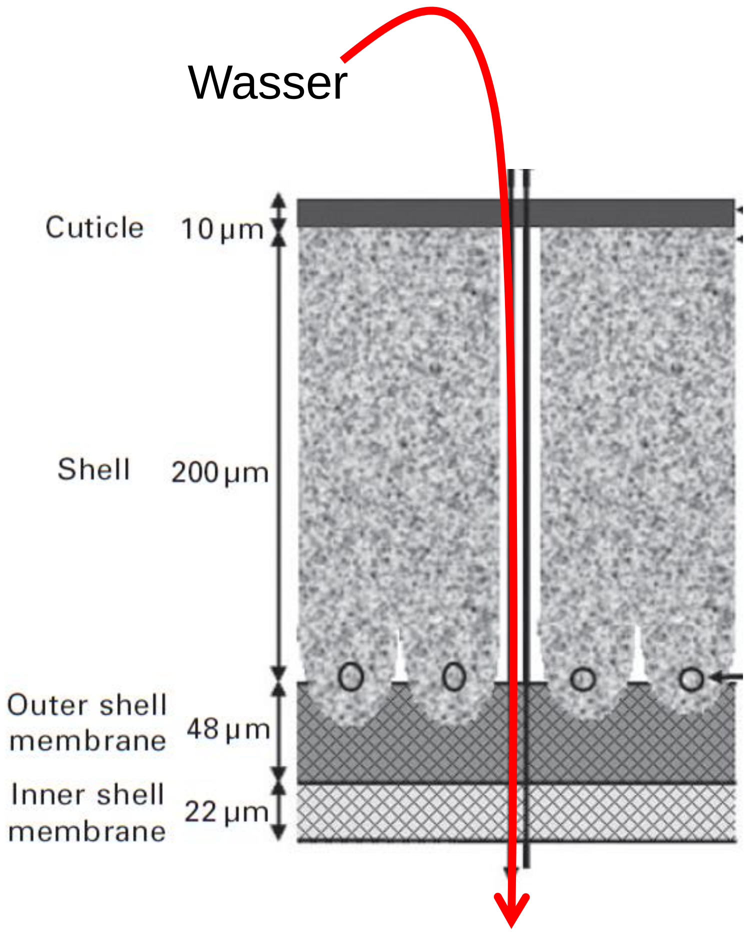




erste 5 Stunden



Bildung der Kalkschale



Cuticula

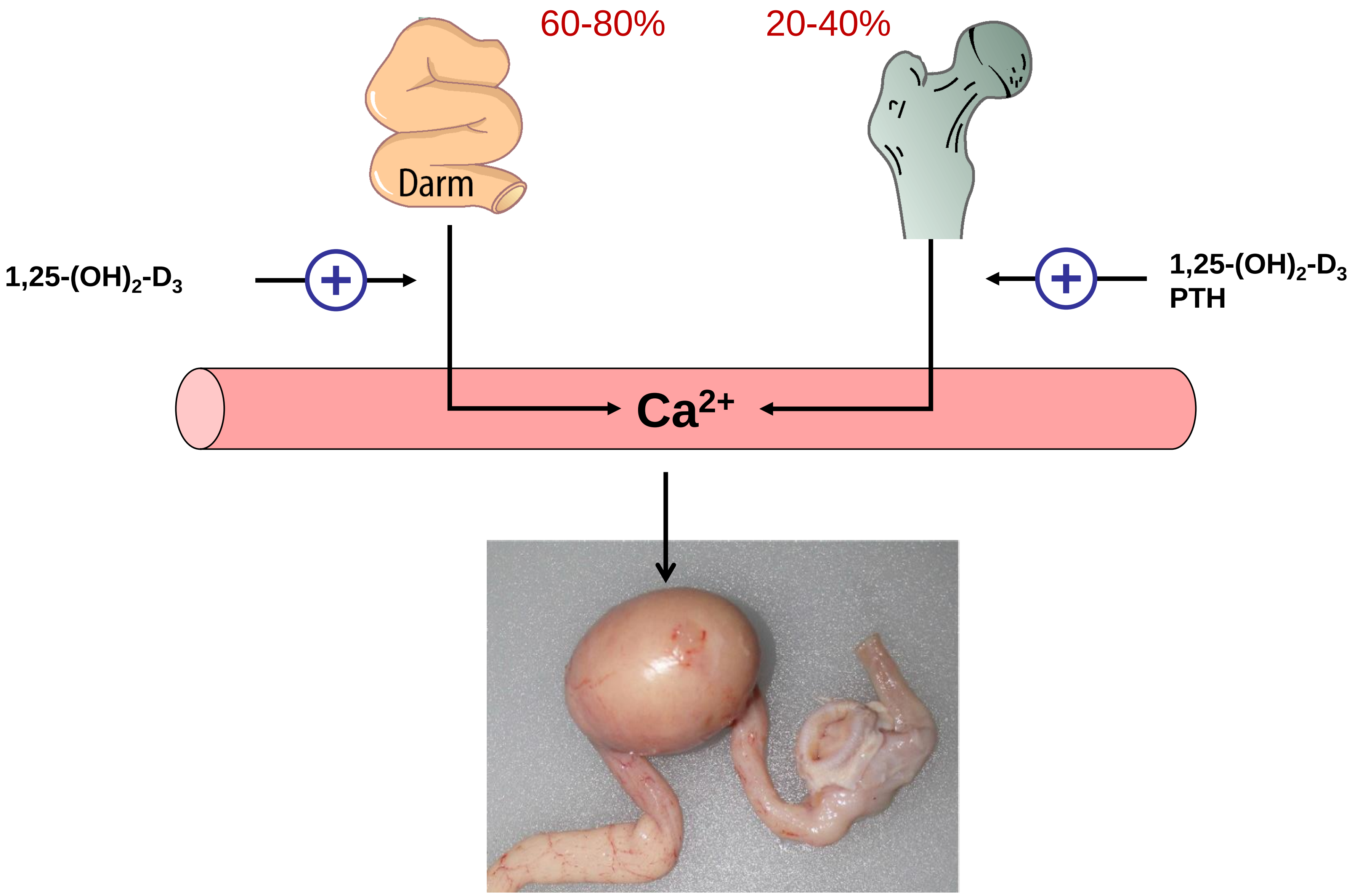
- Polysaccharide, Lipide, Proteine
- 47 Proteine identifiziert
- viele haben antimikrobielle Wirkung
- u.a: Lysozym, Ovotransferrin, Ovocalyxin-32

Bildung der Palisaden

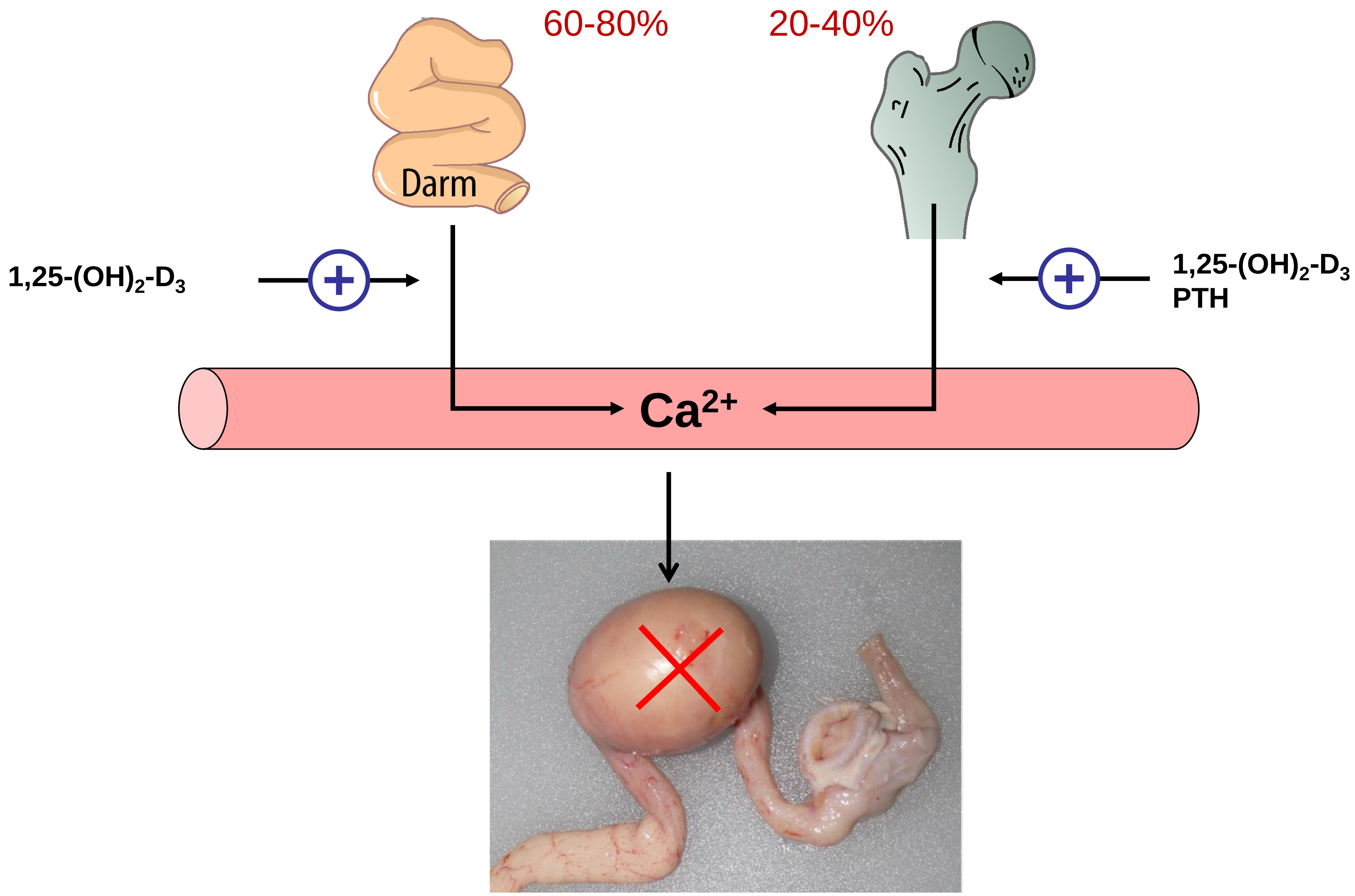
- Ablagerung von Calcit = $CaCO_3$
- Dieses Calcium stammt aus dem Blut
- 2g Calcium pro Ei
- Der Blut-Calcium Pool muss dazu alle 12 Minuten erneuert werden
- Bei 300 Eiern entspricht das 1,8 kg Calcium

- Anschwellen des Eies
- Dichtes Anlegen an die Uteruswand
- Enger Kontakt für die Verkalkung

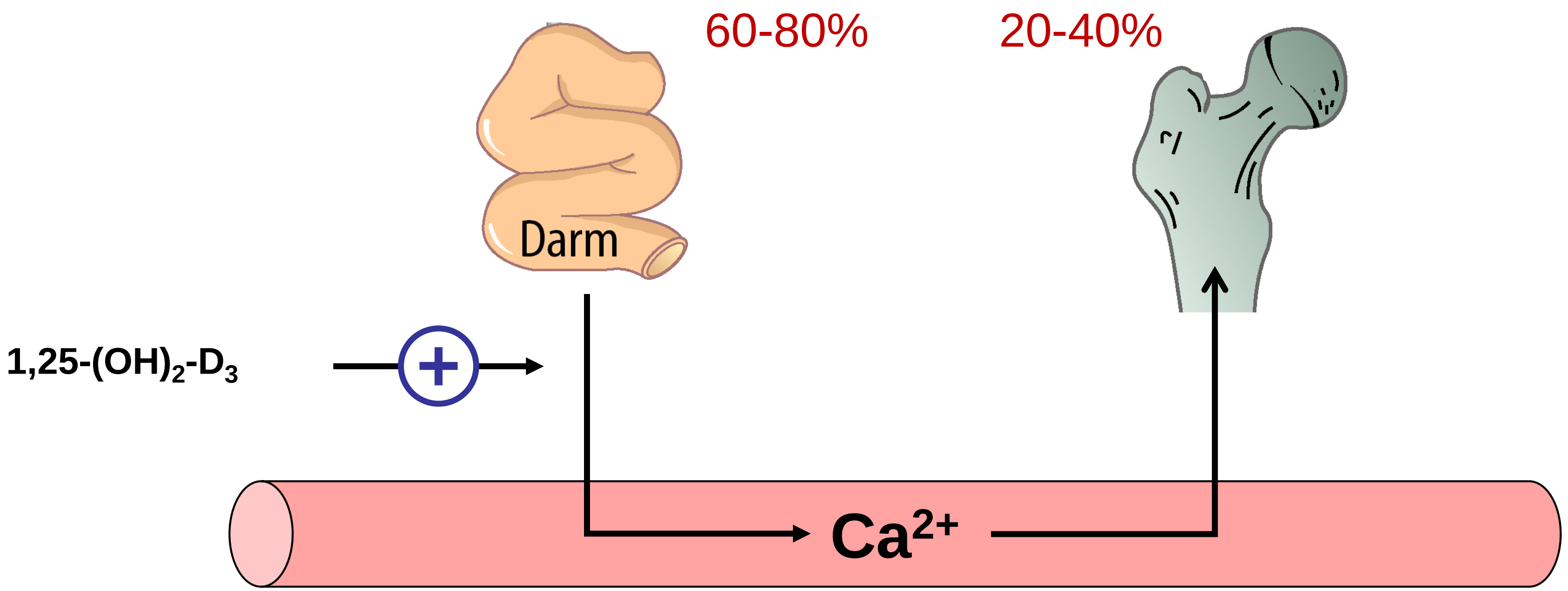
Calcium-Homöostase

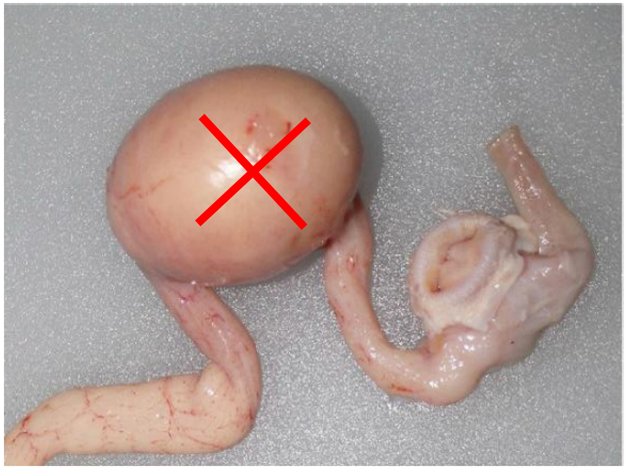


Calcium-Homöostase

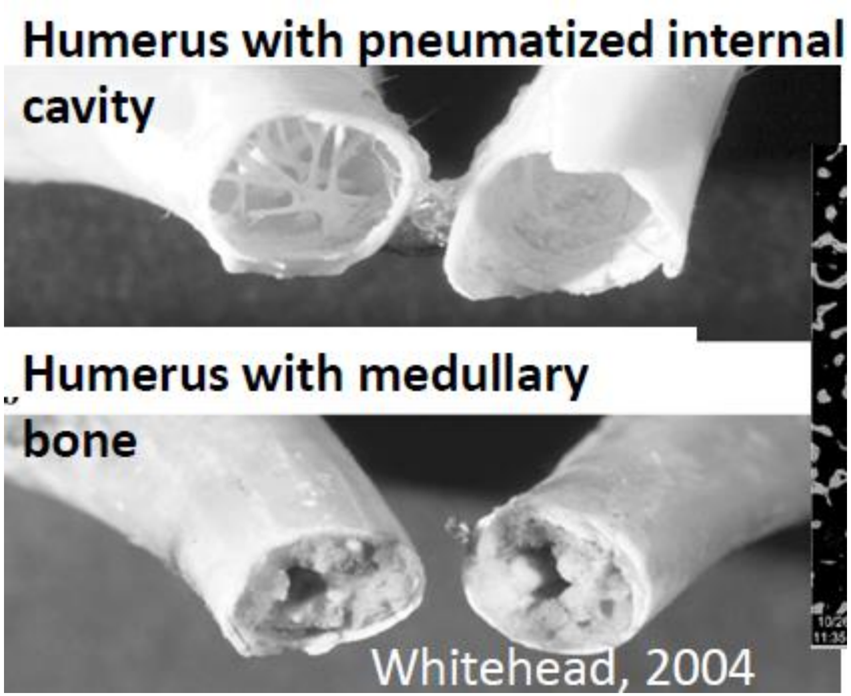


Calcium-Homöostase

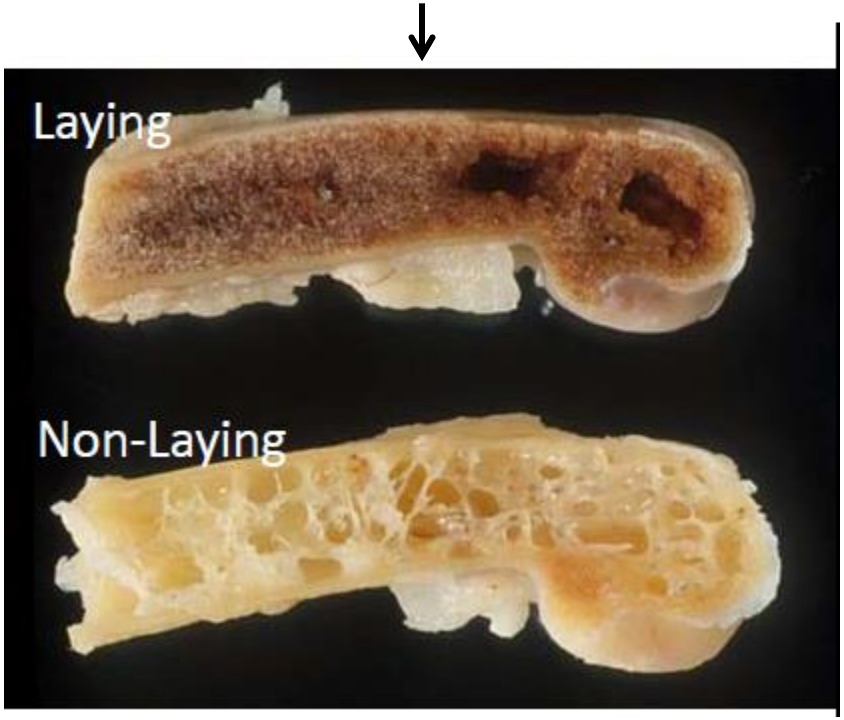




Medullärer Knochen



Östrogen & Testosteron



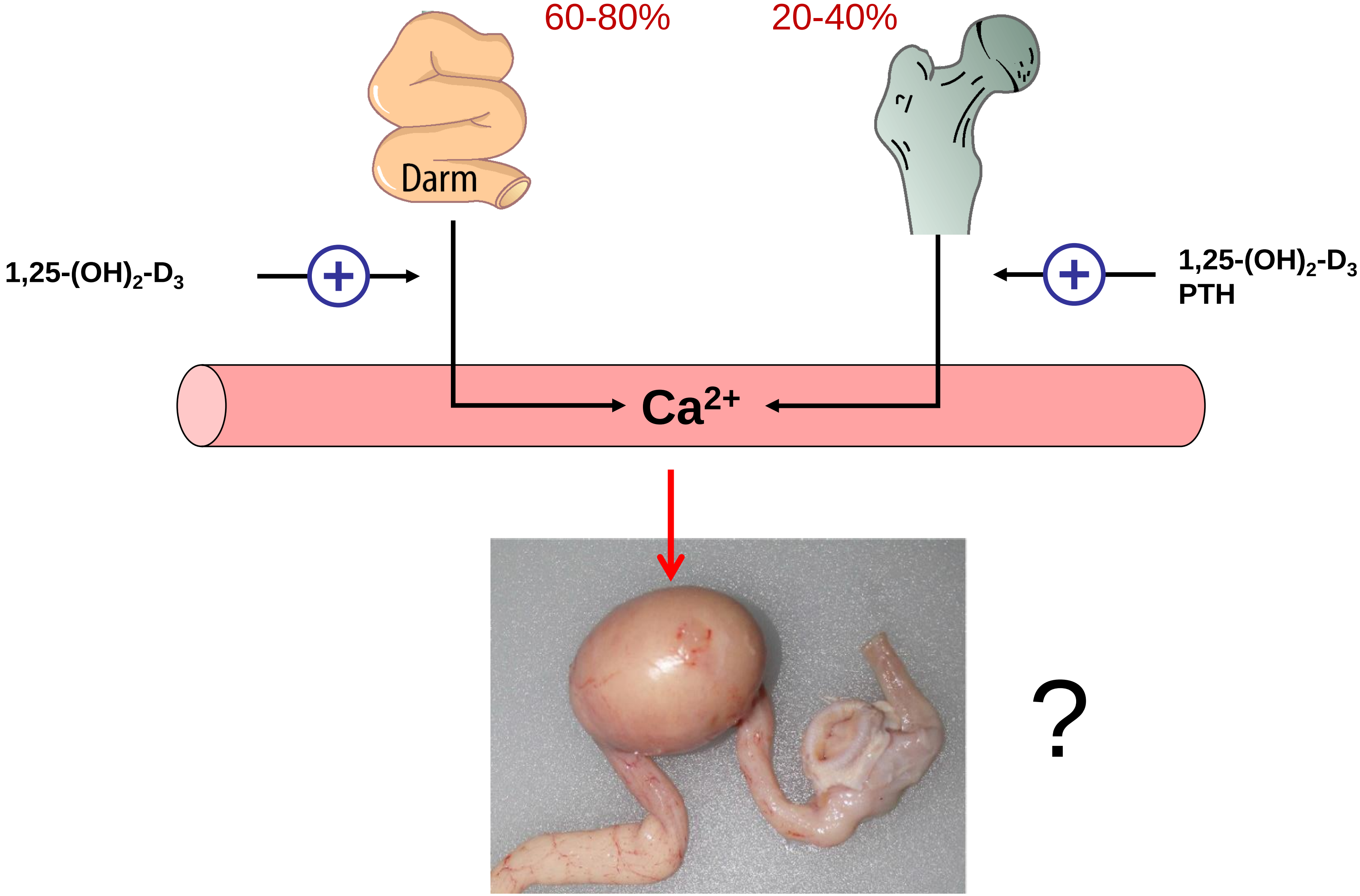
Entwickelt sich mit Beginn der sexuellen Reife

Macht ca. 12% der gesamten Knochenmasse aus

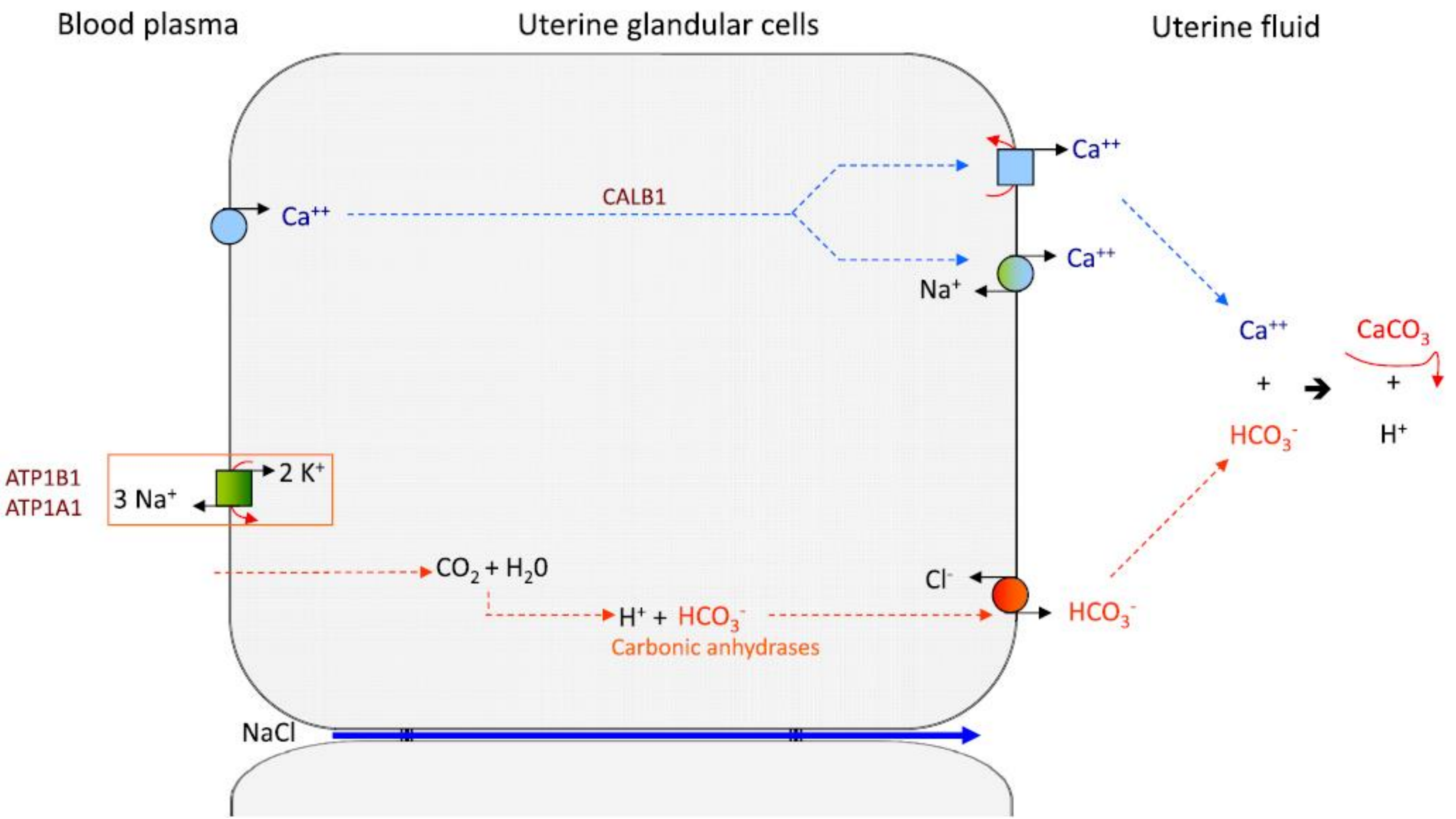
Kann 10-15 x schneller als corticaler Knochen mobilisiert werden

Trägt nicht zur Stabilität der Knochen bei

Bildung der Kalkschale



Klassisches Modell



Jonchère et al. BMC Physiology 2012, 12:10

Genexpressionsstudien

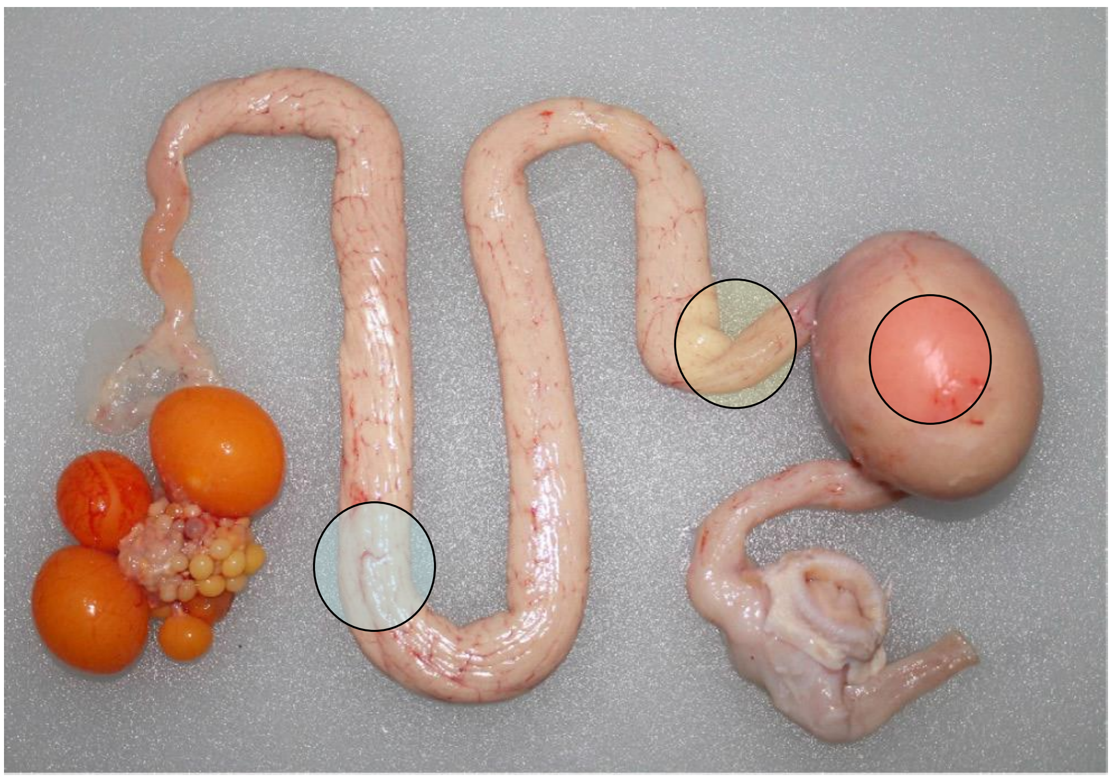
Jonchère *et al. BMC Physiology* 2012, **12**:10
http://www.biomedcentral.com/1472-6793/12/10

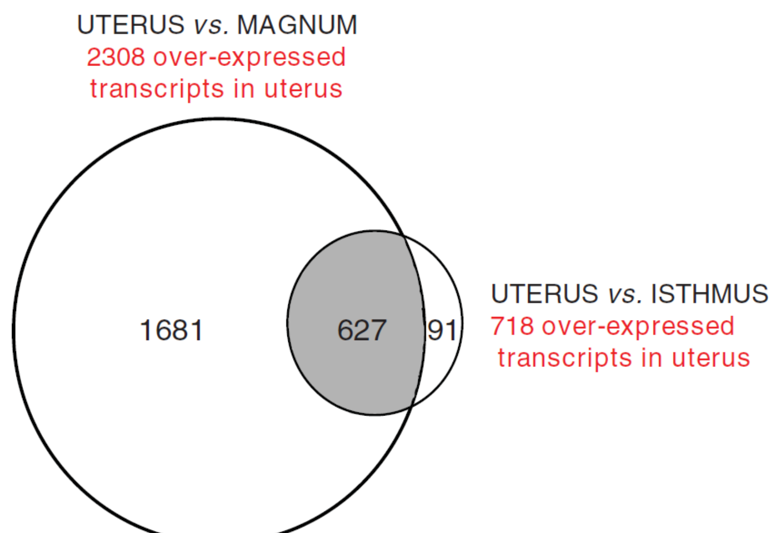
BMC Physiology

RESEARCH ARTICLE Open Access

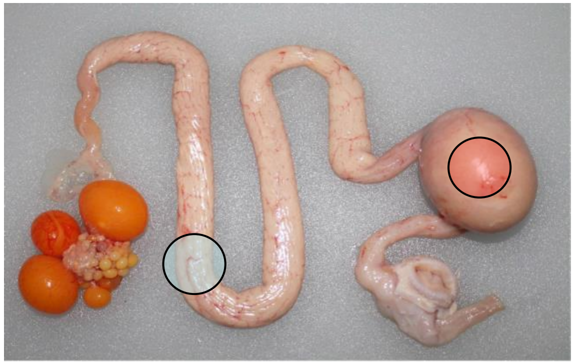
Identification of uterine ion transporters for mineralisation precursors of the avian eggshell

Vincent Jonchère, Aurélien Brionne, Joël Gautron and Yves Nys*





Genexpressionsstudien



Höher exprimiert im Uterus als im Magnum

↓

Vergleich mit einer Liste bekannter Transportproteine aus Darm und Niere

↓

34 Gene identifiziert, die Kandidaten für Ionentransport im Uterus sind

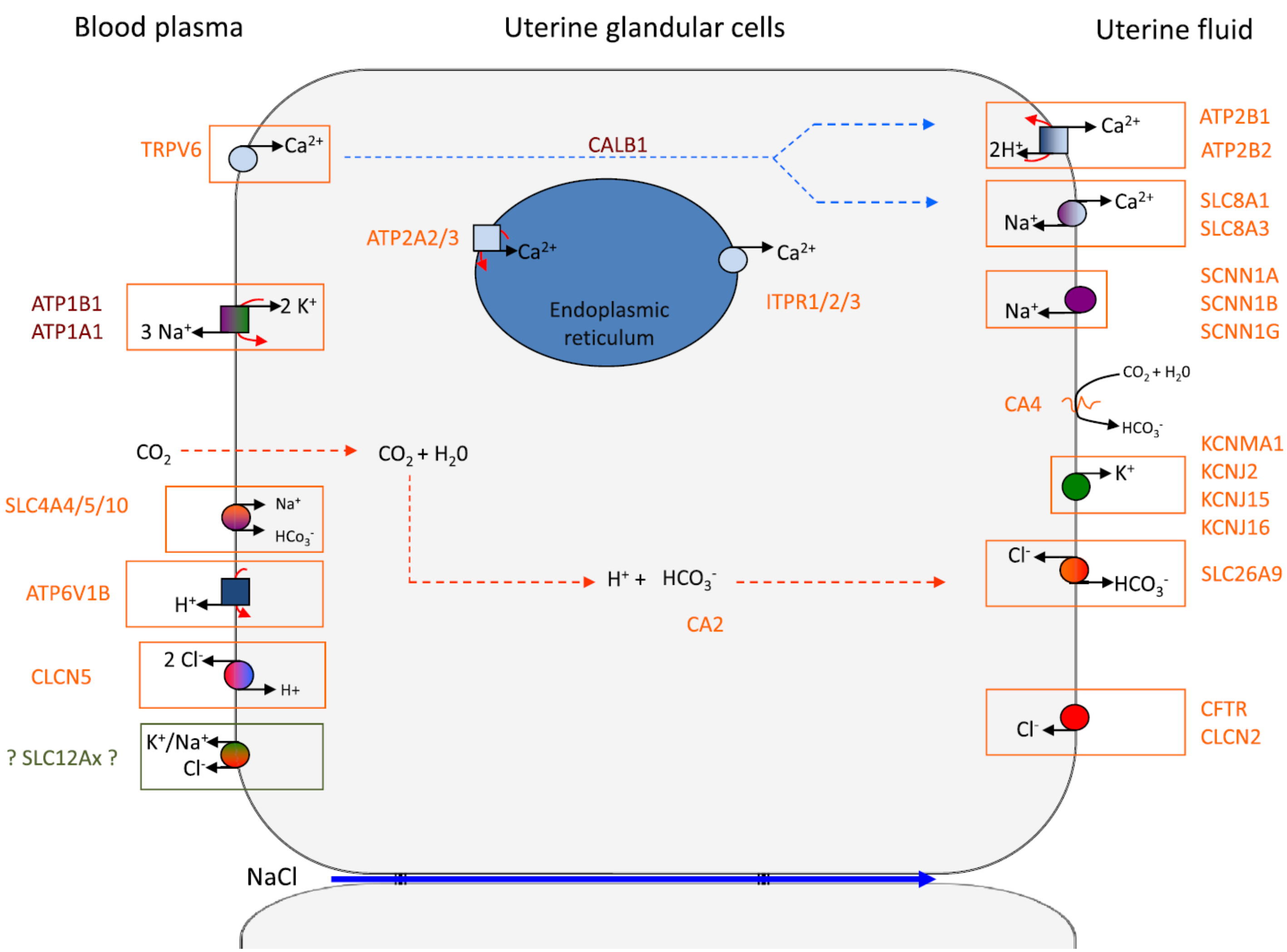
↓

Bestätigung der Expressionsmuster mittels qRT-PCR

↓

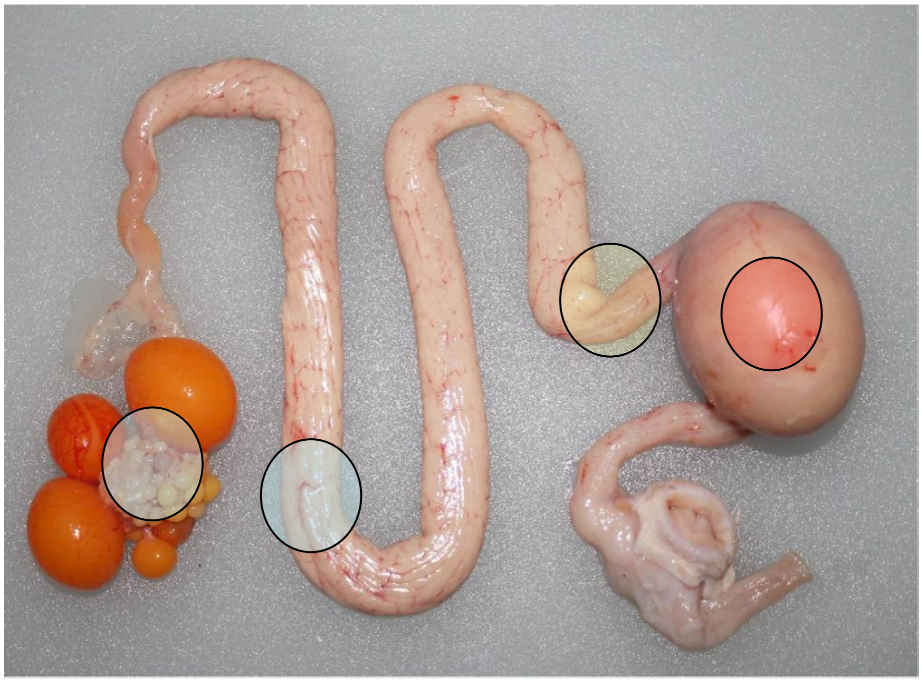
Entwicklung eines erweiterten Modells der Calcium- und Bicarbonat-Sekretion

Erweitertes Modell



Jonchère et al. BMC Physiology 2012, 12:10

Transcriptomic und Proteomic



Jonchère *et al. BMC Genomics* 2010, **11**:57
http://www.biomedcentral.com/1471-2164/11/57

BMC Genomics

RESEARCH ARTICLE Open Access

Gene expression profiling to identify eggshell proteins involved in physical defense of the chicken egg

Mann and Mann *Proteome Science* 2011, **9**:7
http://www.proteomesci.com/content/9/1/7

PS PROTEOME SCIENCE

RESEARCH Open Access

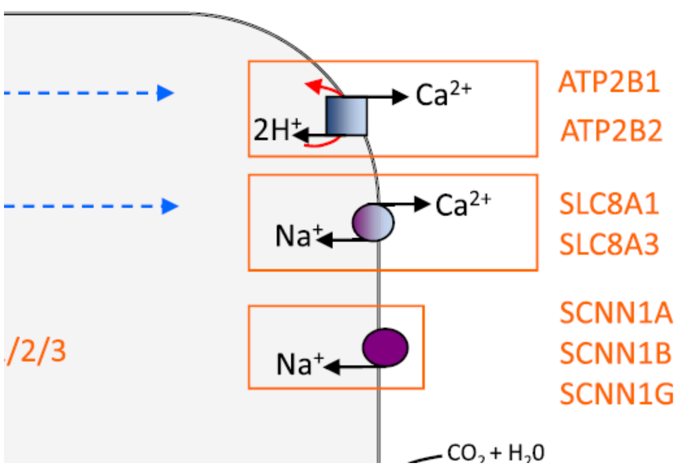
In-depth analysis of the chicken egg white proteome using an LTQ Orbitrap Velos

Anim Breed Genet. 2014 Jun;131(3):173-82.
Genome-wide association study for egg production and quality in layer chickens.
Wolc A et al.

Wie prüfe ich die funktionelle Bedeutung?

The model qualitatively describes putative mechanisms and cellular localisation of the candidates. These hypotheses relying on expression of the genes and on analogies with other tissues that transfer large amount of ions, need to be confirmed using immunochemistry for their cell localisation or by specific inhibition, to establish their relative contribution and understand their interaction and regulation. This avian model where huge

Gen knockout



PNAS

Immunoglobulin knockout chickens via efficient homologous recombination in primordial germ cells

Benjamin Schusser[a,b], Ellen J. Collarini[a], Henry Yi[a], Shelley Mettler Izquierdo[a], Jeffrey Fesler[a], Darlene Pedersen[a], Kirk C. Klasing[b], Bernd Kaspers[c], William D. Harriman[a], Marie-Cecile van de Lavoir[a], Robert J. Etches[a], and Philip A. Leighton[a,1]

[a]Research Division, Crystal Bioscience Inc., Emeryville, CA 94608; [b]Department of Animal Science, University of California, Davis, CA 95616; and [c]Department of Veterinary Science, Institute for Animal Physiology, Ludwig-Maximilians-Universitaet Muenchen, 80539 Munich, Germany

Edited by Max D. Cooper, Emory University, Atlanta, GA, and approved October 30, 2013 (received for review September 12, 2013)

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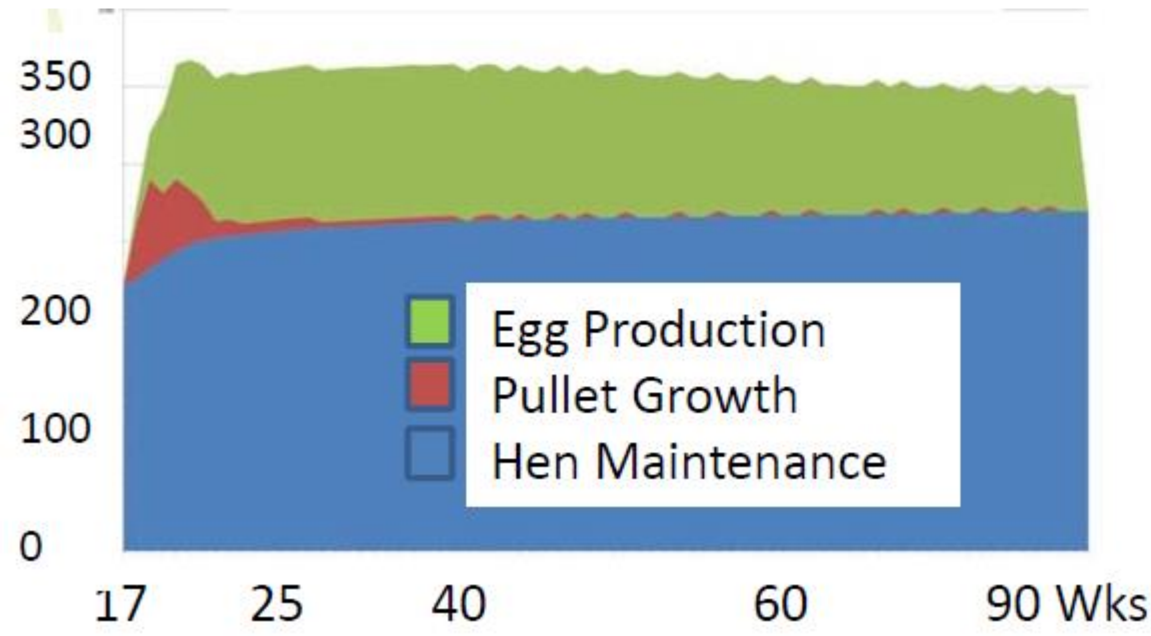
Sun Chong Hong, Singapore

Energiebedarf



Energiebedarf nimmt im Alter nur geringfügig ab

Hennen bis zur 30-igsten Woche haben einen höheren Energiebedarf für das Wachstum

Die Eibildung benötigt etwa 1,8 kcal/g

Der Bedarf hängt aber auch von der Temperatur und der Befiederung ab

Der Energiegehalt im Futter beeinflusst die Eizahl nur geringfügig

Hennen können die Futteraufnahme sehr gut dem Energiegehalt anpassen