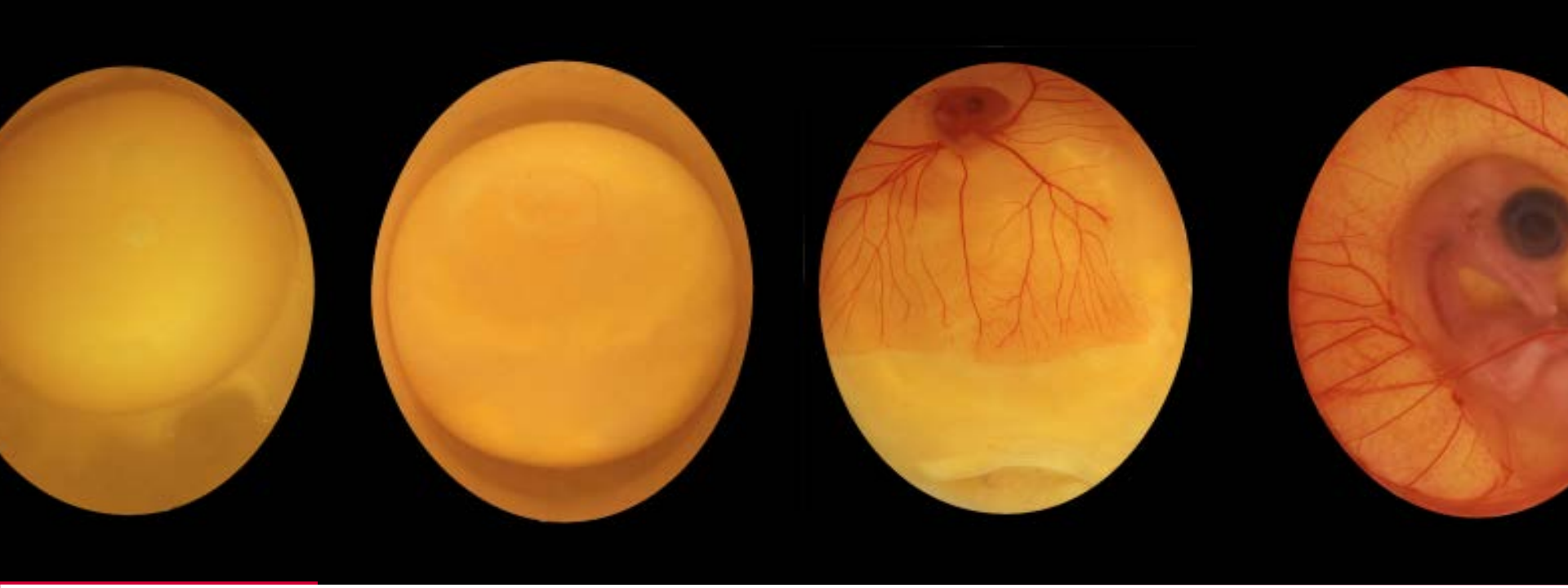
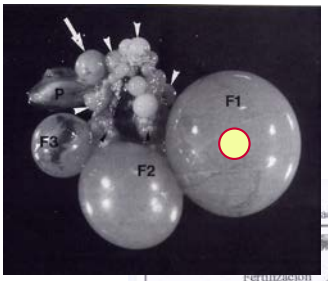
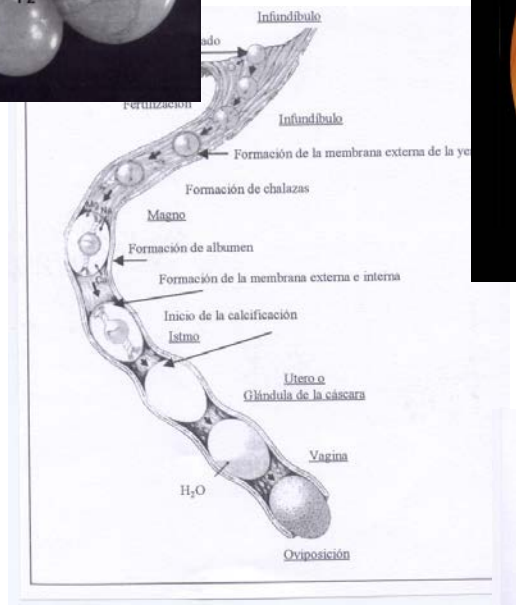


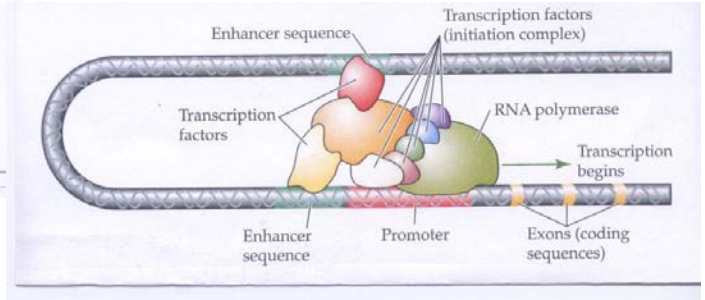
Embryonic development of the chick

Dr. Marleen Boerjan
Director R&D

Embryonic development of the chicken starts in the oviduct of the hen and continues in the incubator







Fertilization---differentiation---growth---maturation

Embryonic development of the chicken starts in the oviduct of the hen and continues in the incubator

Contents

- Early development in the hen

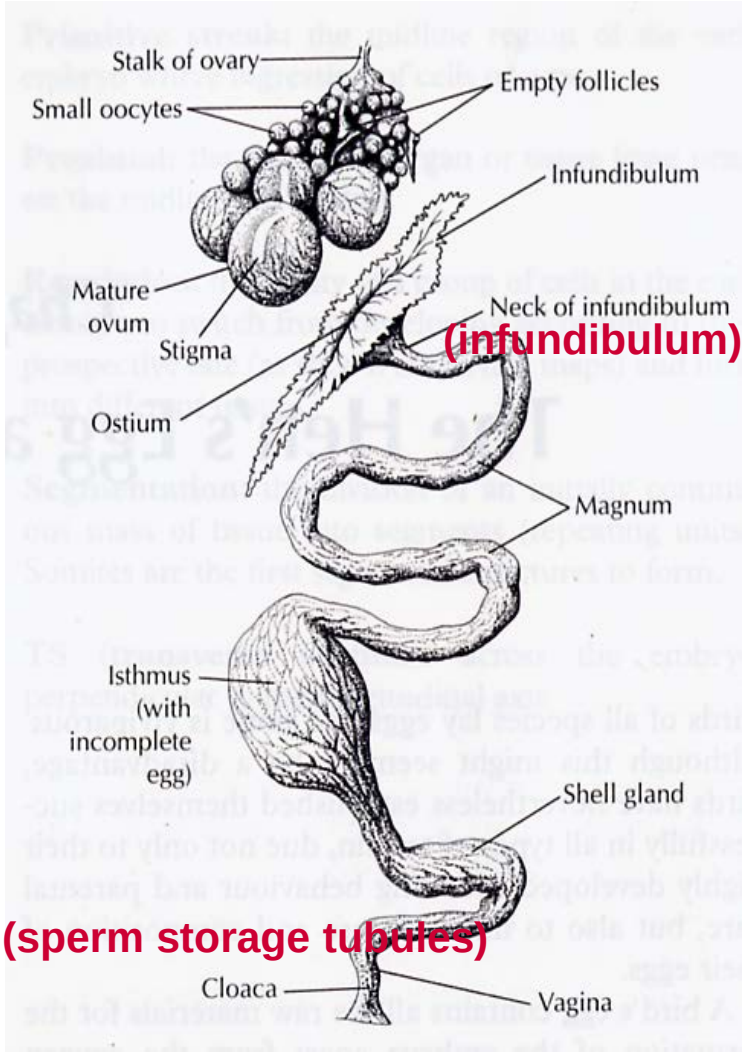
- Development during incubation
  - the early- and late-embryo
  - the extra-embryonic tissues

Embryonic development starts during egg formation: fertilization

Ovulation: release unfertilized oocyte in the infundibulum

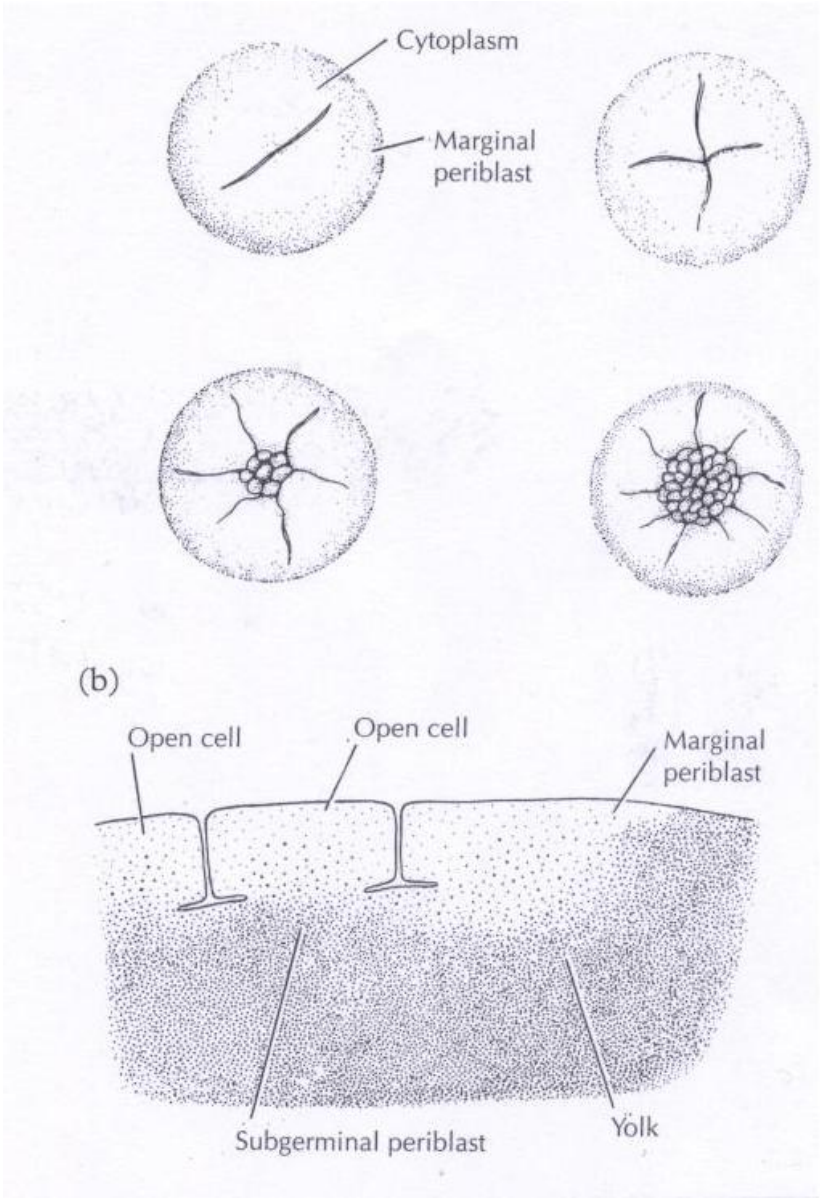
(within 15 min)

Fertilization : fusion of sperm and oocyte: one-cell embryo

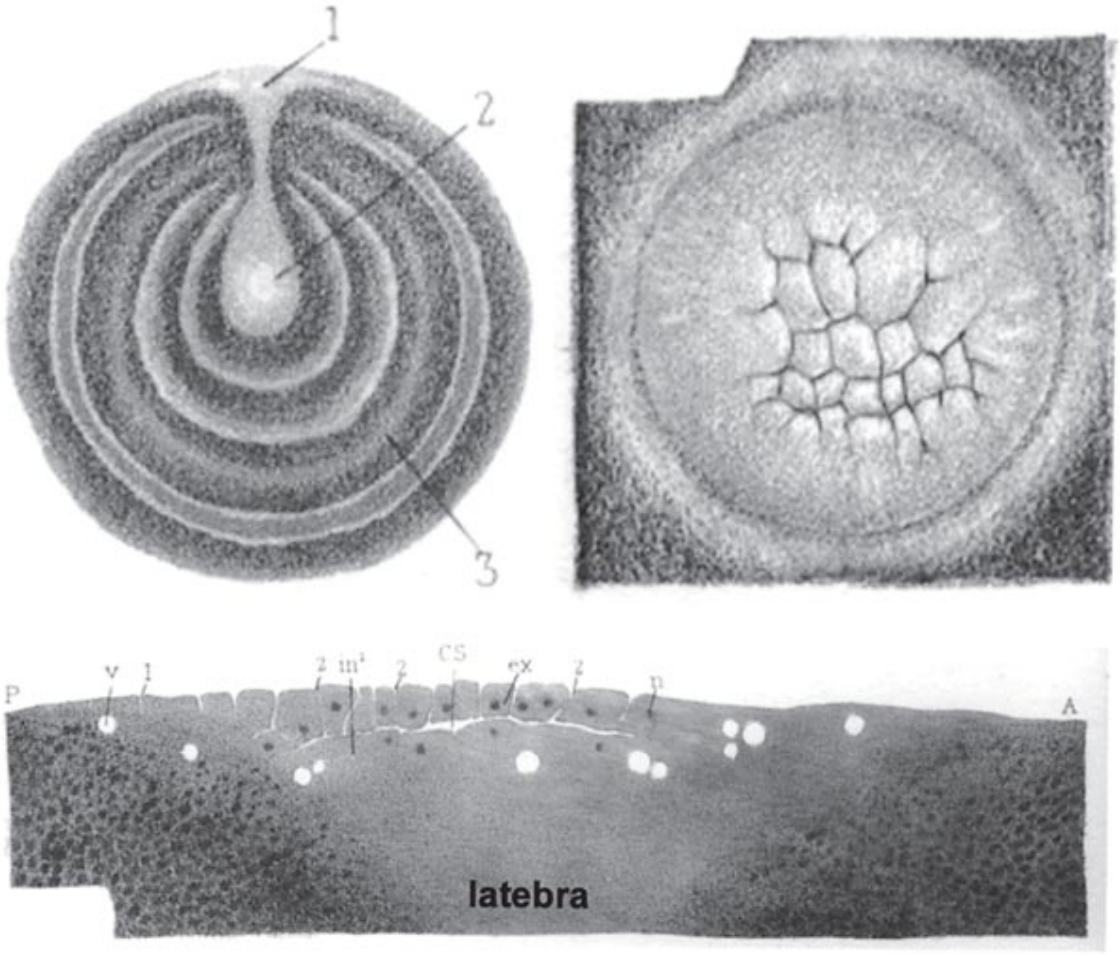


The avian embryo: development in the oviduct

First cleavage divisions after fertilization



The avian embryo: cleavage divisions in the oviduct

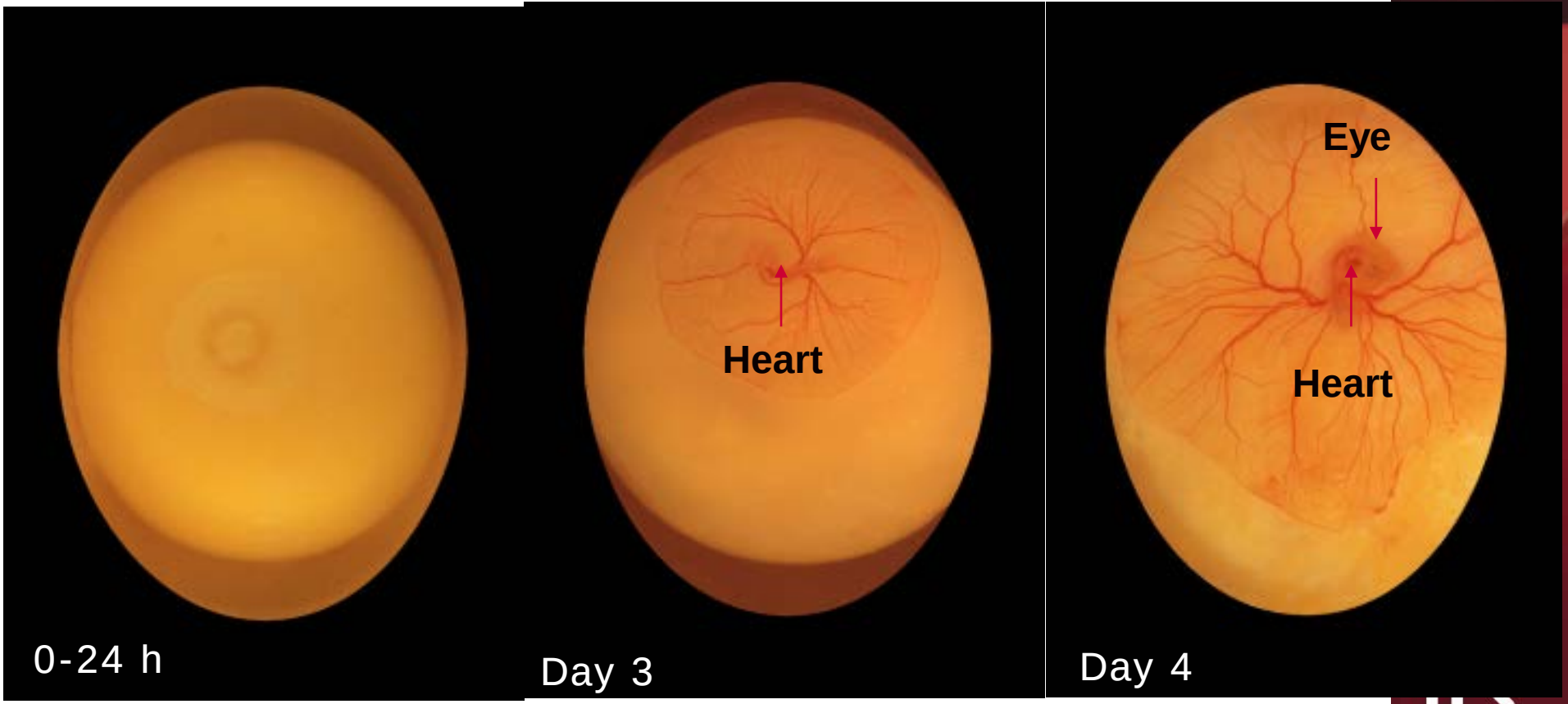


M. Duval (1889)
From *Gastrulation: From Cells to Embryo*

Chapter 15, Figure 2

Embryonic development of the chicken: differentiation

- Embryonic development is characterized by the generation of specialized cells form the undifferentiated cleavage cells



Embryonic development of the chicken: differentiation

Differential gene expression:

in each cell RNA is synthesized specific for that cell type. Only a small percentage of the total genome is expressed

Differential gene expression is induced by:

- Cell-environment interactions
- Cell-cell interactions

Embryonic development of the chicken: differentiation

Question:

- Which (inductive) factors are involved in differential gene expression during embryogenesis of the chicken?

Embryonic development of the chicken: differentiation

Factors involved in differential gene expression:

- Embryonic factors
  - cell-cell interactions
  - inducer molecules
- Extra-embryonic (environmental) signals

Embryonic development of the chicken: differentiation

- cell-cell interactions

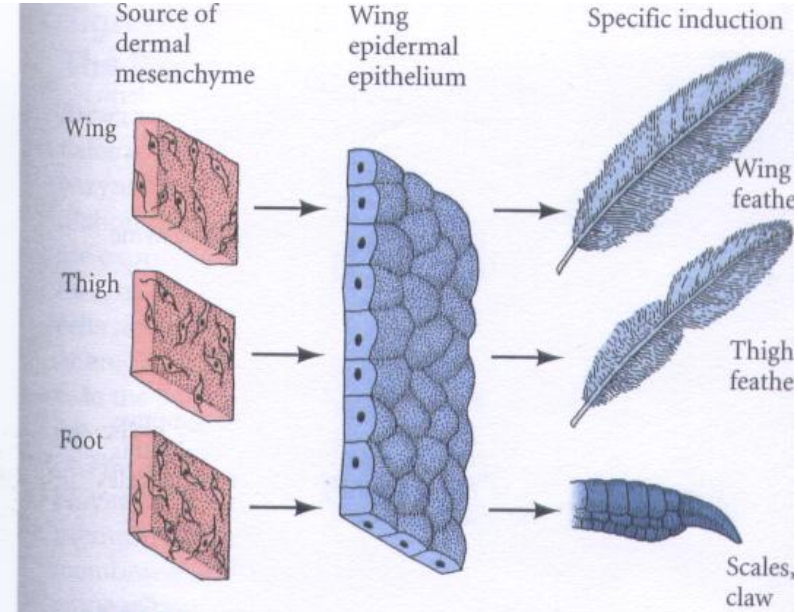
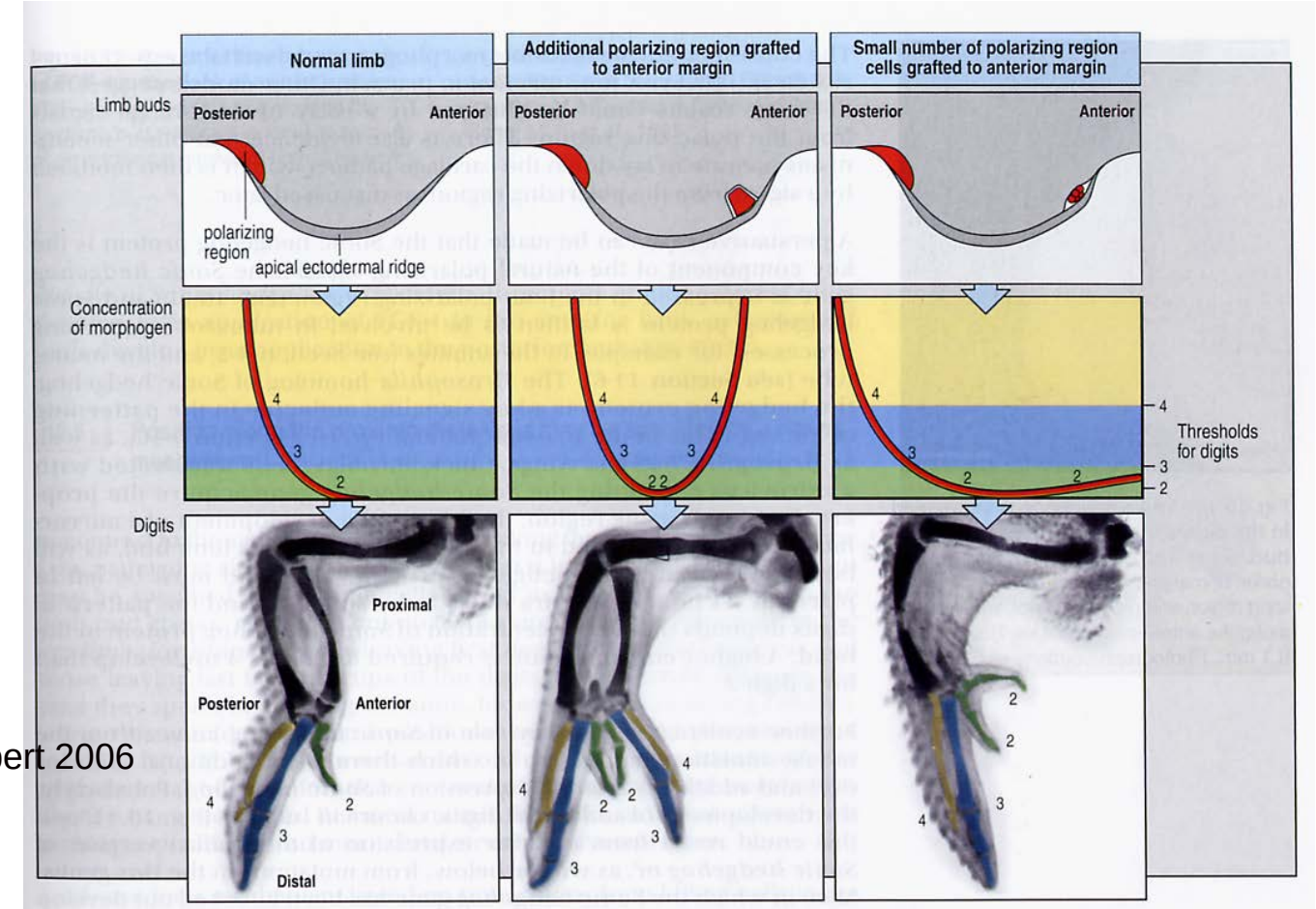


FIGURE 6.7 Regional specificity of induction in the chick. When cells from different regions of the dermis (mesenchyme) are recombined with the epidermis (epithelium), the type of cutaneous structure made by the epidermal epithelium is determined by the original source of the mesenchyme. (After Saunders 1980.)

Source: Gilbert 2006

Embryonic development of the chicken: differentiation

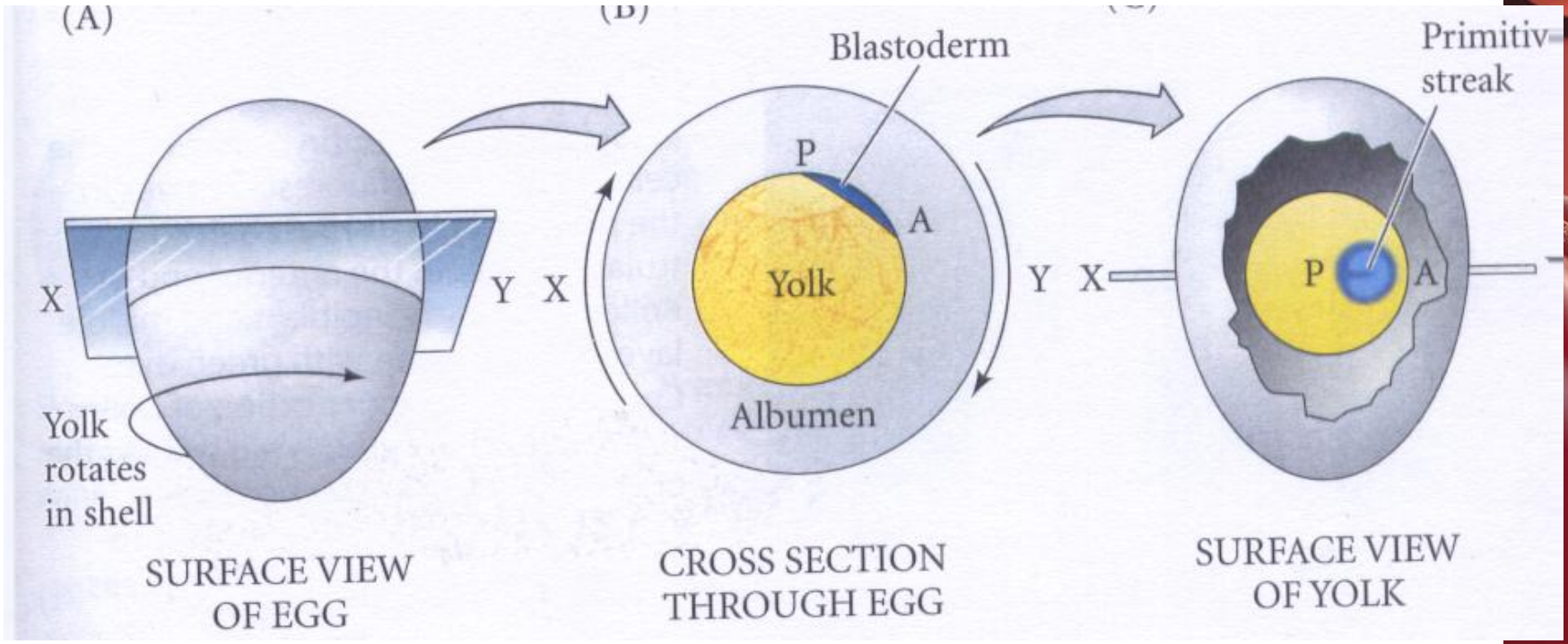
- Inducer molecules (morphogens)



Source: Gilbert 2006

Embryonic development of the chicken: differentiation

- Environmental inducing factors: *gravity* during shell formation

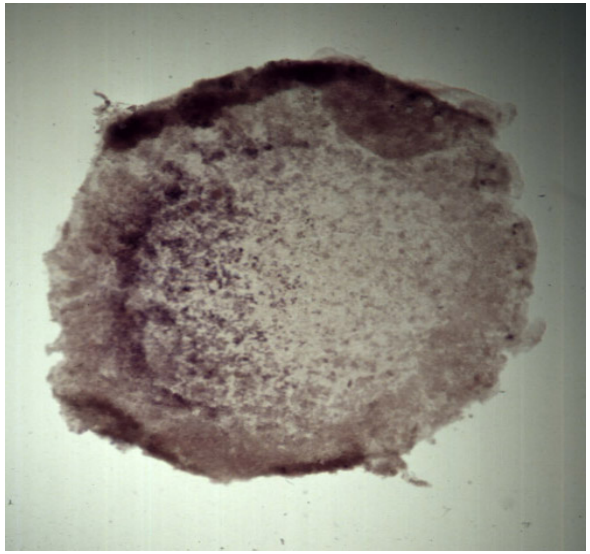


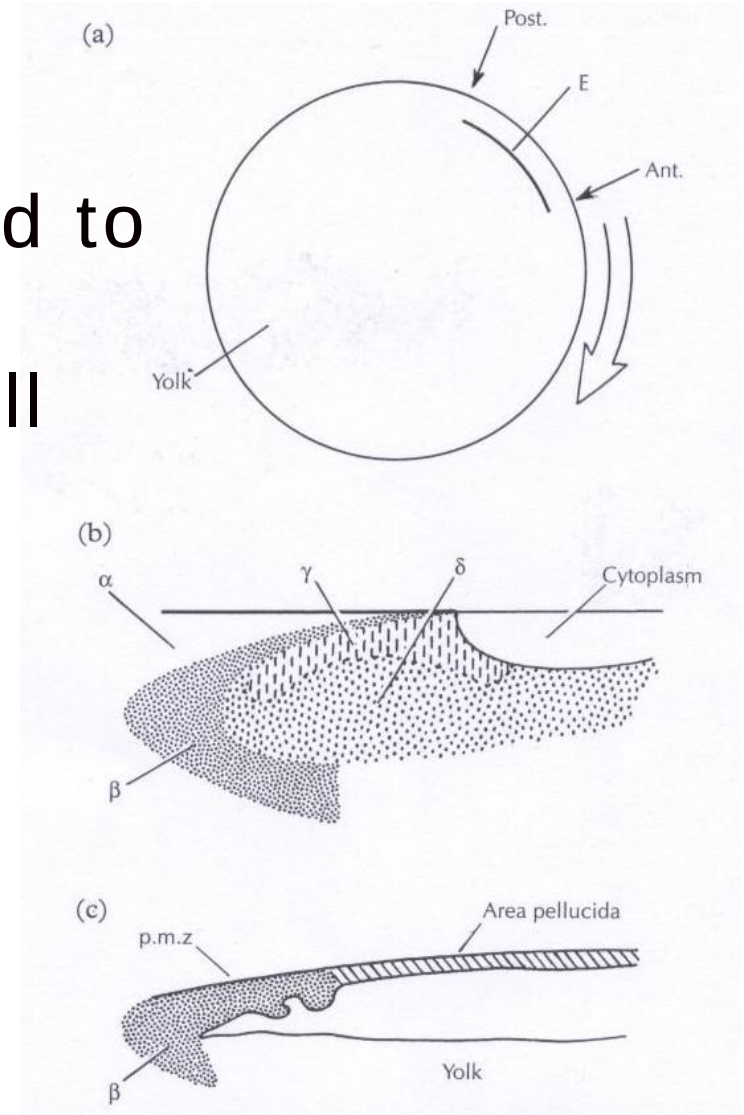
Source: Gilbert 2006

Embryonic development of the chicken: differentiation

- Environmental inducing factors:

  Induction of the head to tail axis during formation of the shell

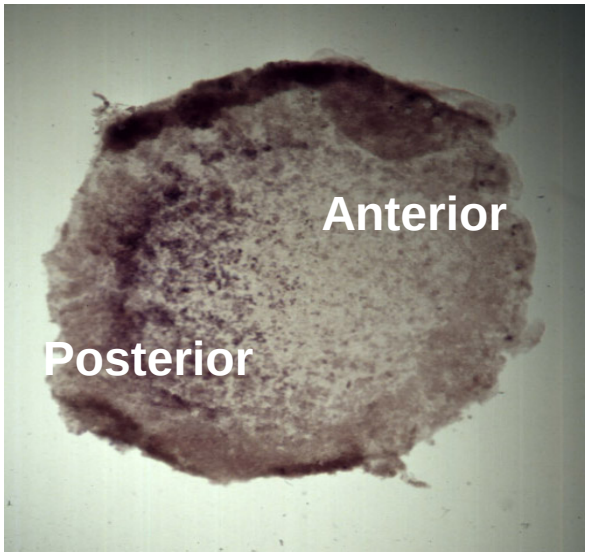




Embryonic development of the chicken: differentiation

Differential gene expression in the blastoderm before incubation:

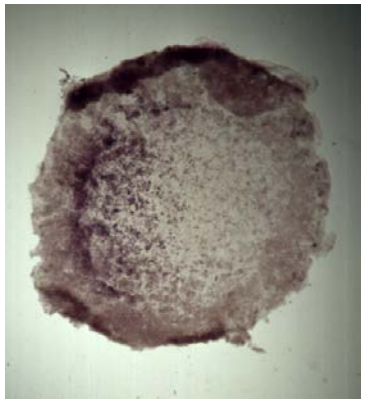
Goosecoid gene expression in the unincubated egg

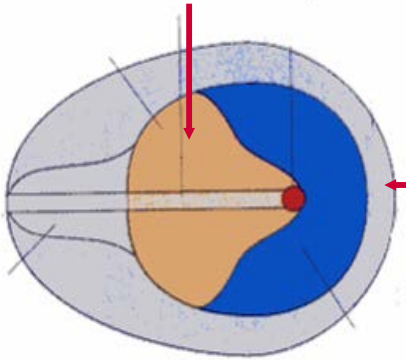


Embryonic development of the chicken: differentiation

Conclusion:

- future function of embryonic cells is induced and determined during shell formation in the oviduct





Future tail → Future head

Embryonic development of the chicken: differentiation

Consequences for hatching egg quality:

- normal induction of embryonic cells
- nutrients in yolk and albumen optimum

The avian embryo: consequences for hatching egg quality

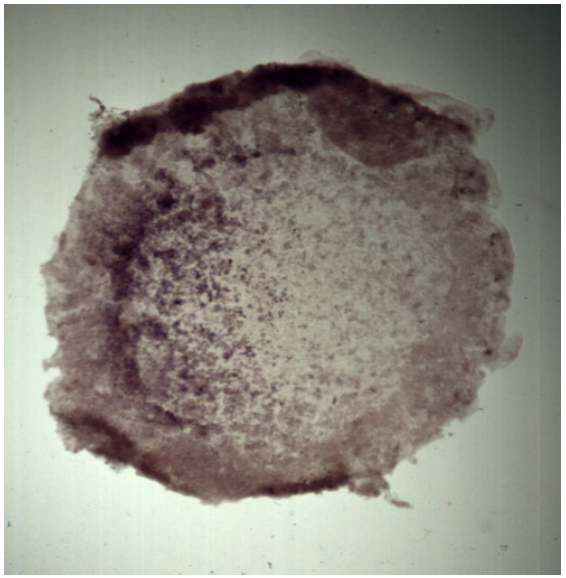
Embryonic stage at oviposition?

- New approach in practice: pre-storage incubation

Embryonic development of the chicken: differentiation

Consequences for hatching egg quality:

- nutrients in yolk and albumen optimum
- embryonic stage resistant to egg-handling



Stage XII

(Eyal-Giladi and Kochav, 1975)

The avian embryo: consequences for hatching egg quality

Questions from the practice:

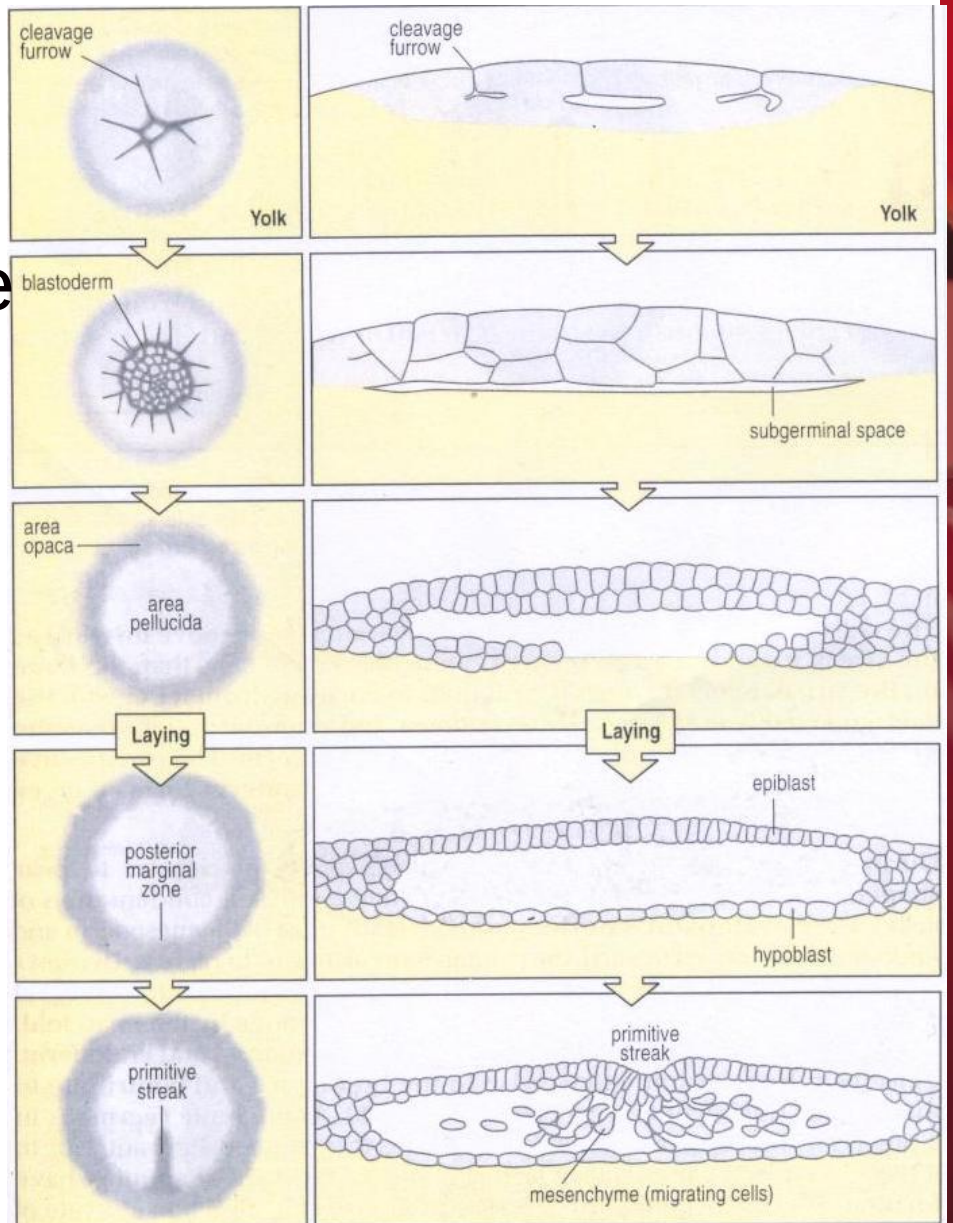
- Embryonic stage at oviposition?

- New approach in practice: pre-storage incubation

Embryonic development of the chicken: differentiation

Questions from the practice:

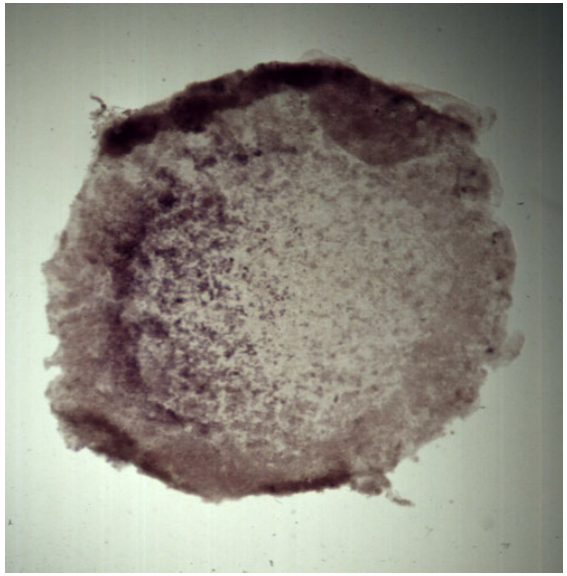
- Embryonic stage at oviposition?



The avian embryo: consequences for hatching egg quality

Hypothesis 1: pre-storage incubation stimulates development of the embryo to the more resistant embryonic stage XII.

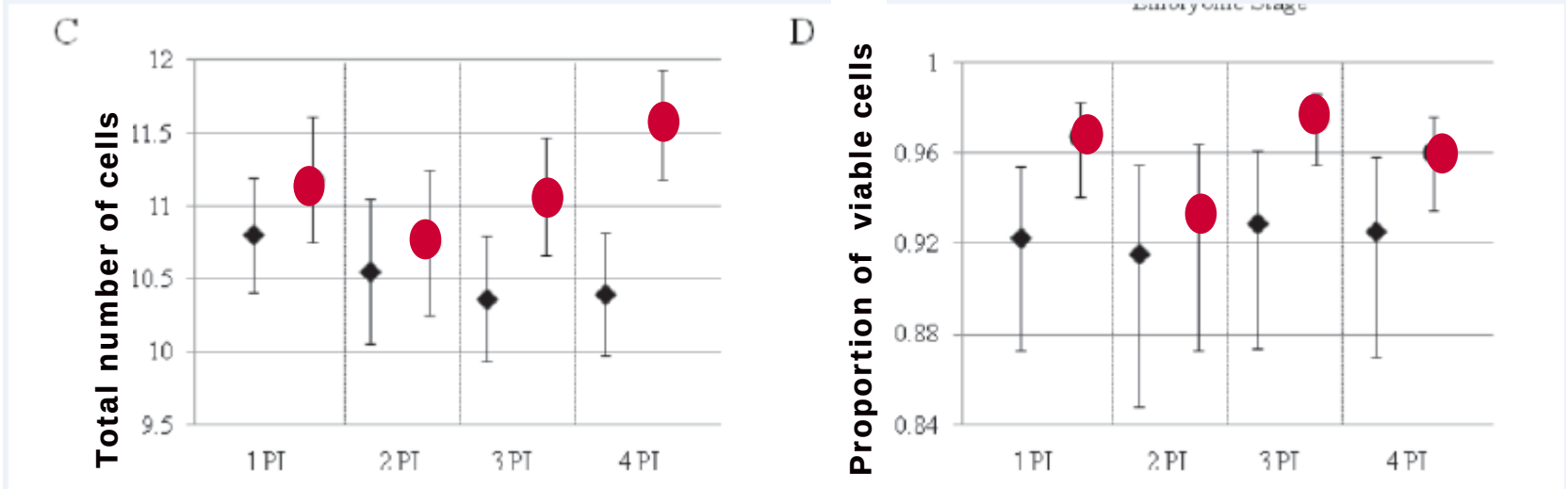
Today I often find: Stage IX-Xv (broilers)



Stage XII

The avian embryo: consequences for hatching egg quality

Hypothesis 2: Short Periods of Incubation During Egg Storage (SPIDES) increase liveability of embryonic cells during long term storage.

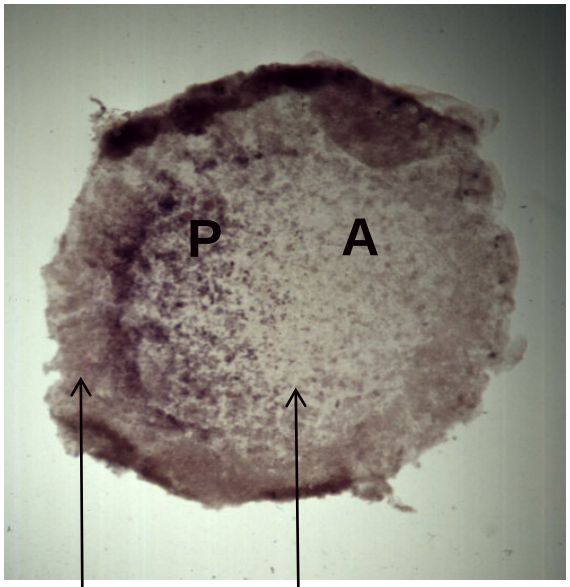


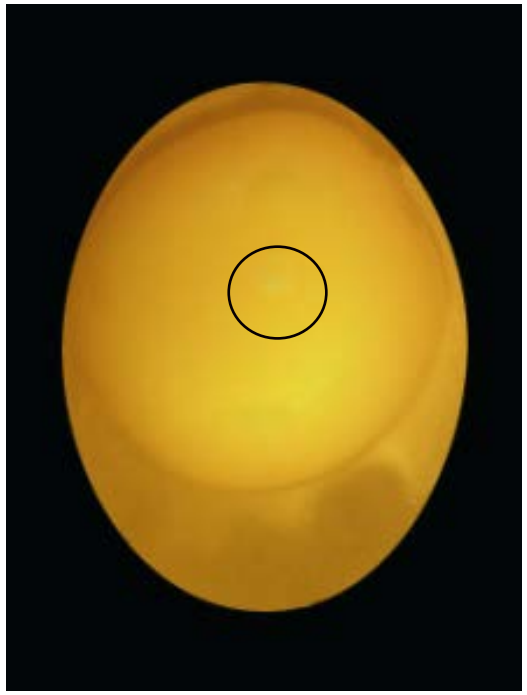
Ref. Dymond et al. 2013

Conclusion

The unincubated embryo (30-60 10^3 cells):

- Fate of embryonic cells has been determined
- Blastoderm measures 3-5mm

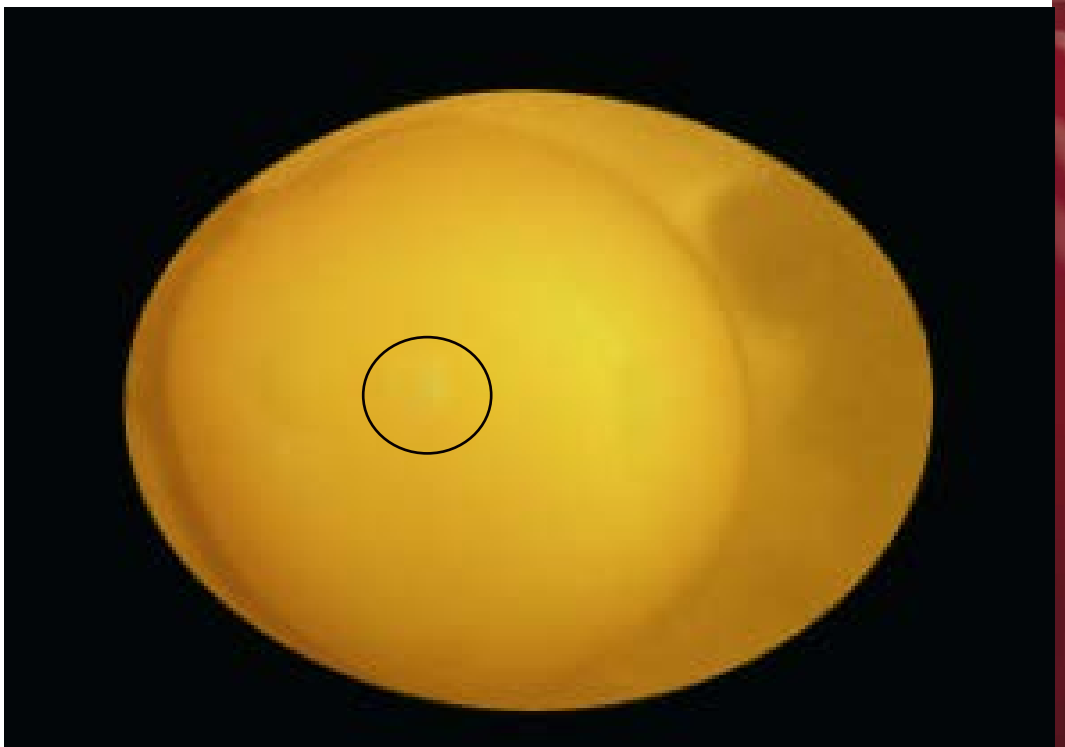




Contents

- Early development in the hen

- Development during incubation
  - the embryo
  - the extra-embryonic tissues

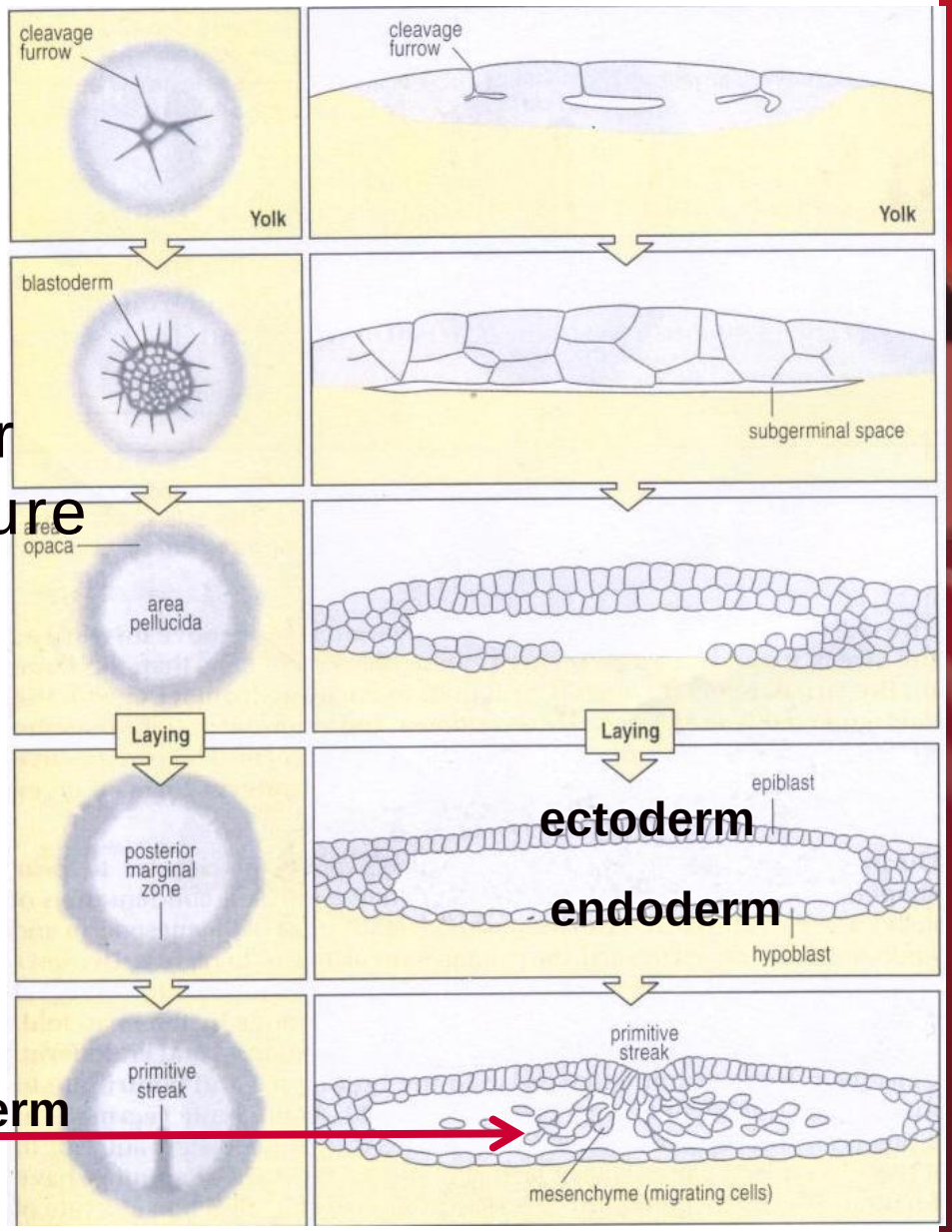


Embryonic development of the chick: differentiation phase

- If we start incubation (embryo) temperature increases and development of the blastoderm continues!!

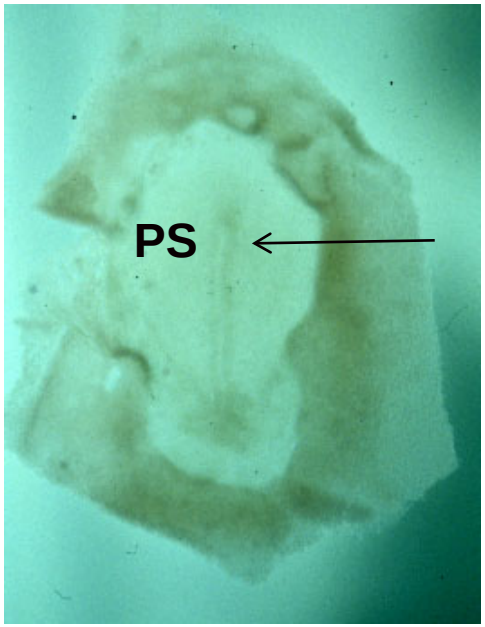
Embryonic development of the chick: differentiation phase

- Embryonic cells migrate (arrow) after embryonic temperature reached incubation temperature!!

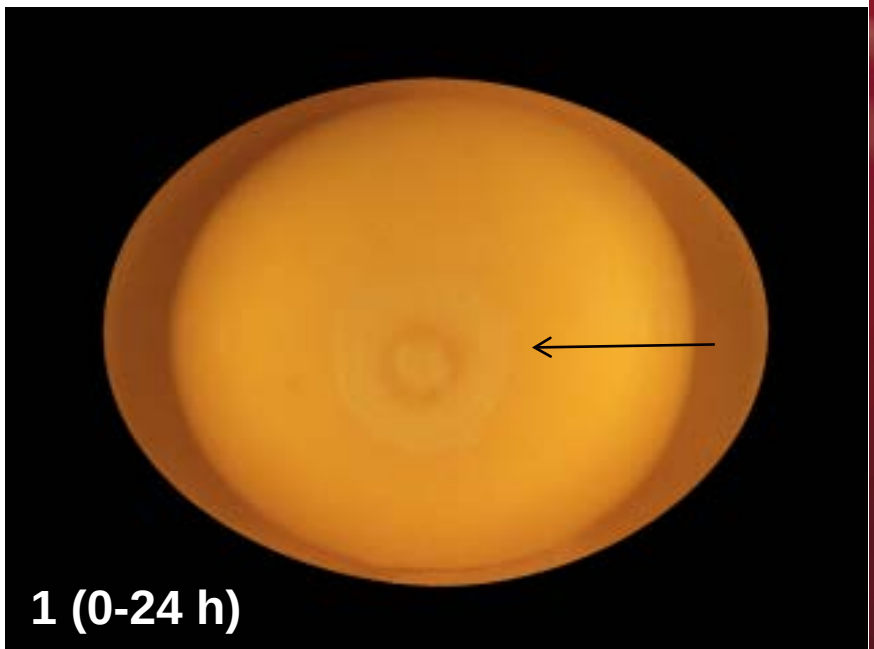


Embryonic development of the chick: 1st day of incubation

- A primitive streak (PS) and head-fold are visible in the embryo



- Sub-embryonic fluid forms a concentric ring around the embryo



Embryonic development of the chick: 2nd of incubation

- Head and heart structures are formed
- First signs of blood ring
- Sub-embryonic fluid formation is visible in the yolk

Embryonic development of the chick: 2nd of incubation

- Head and heart structures are formed
- Left-right differentiation

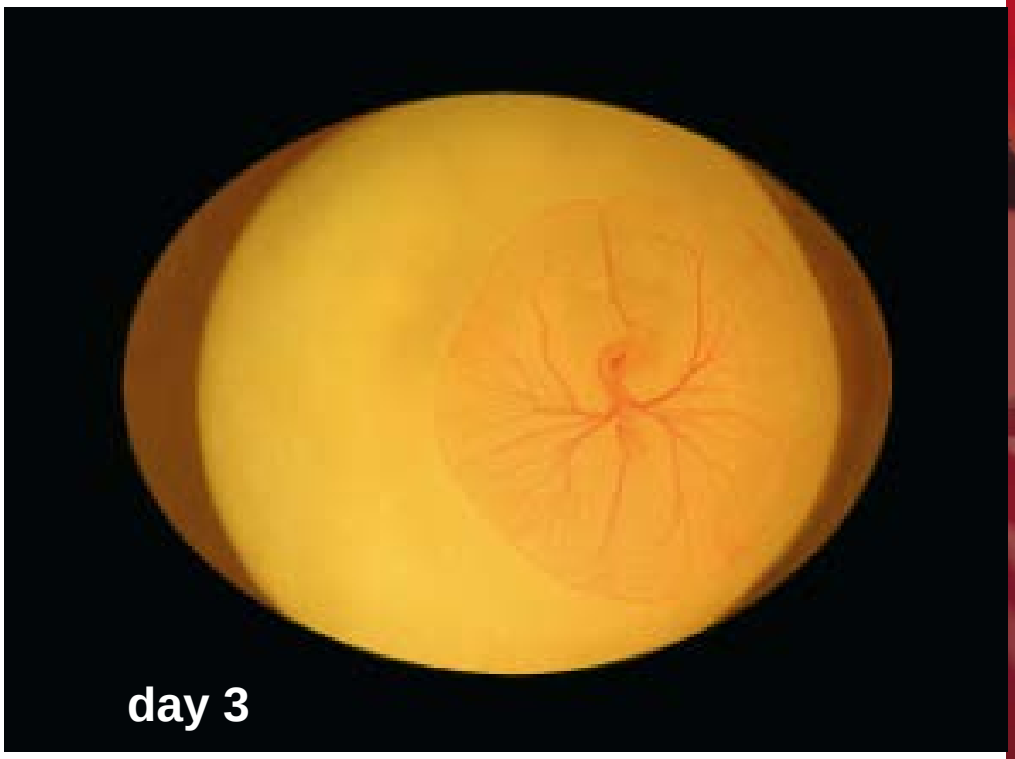
breed: layer

breed: broiler

2 (25 - 48 h)

Embryonic development of the chick: day 3 of incubation

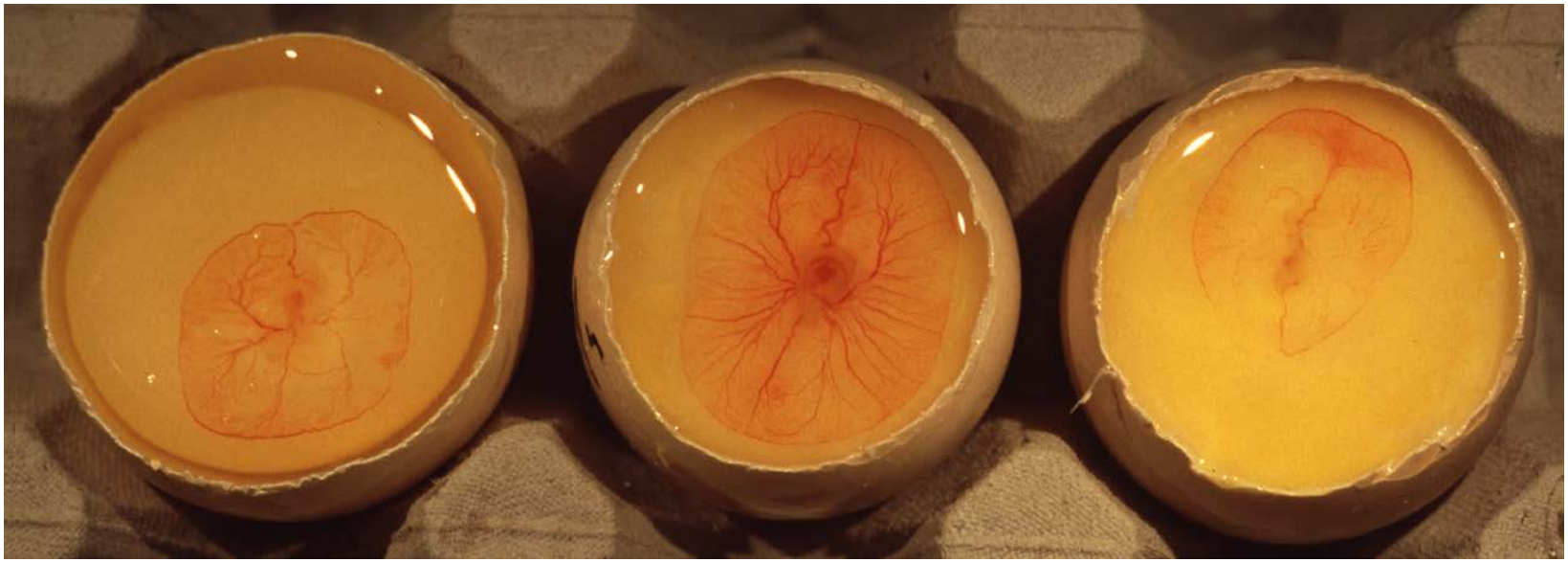
- Blood ring (area vasculosa)
- Heart beats
- Head is turned the to right



Embryonic development of the chick: day 3 of incubation

- Blood ring (area vasculosa) after storage of eggs

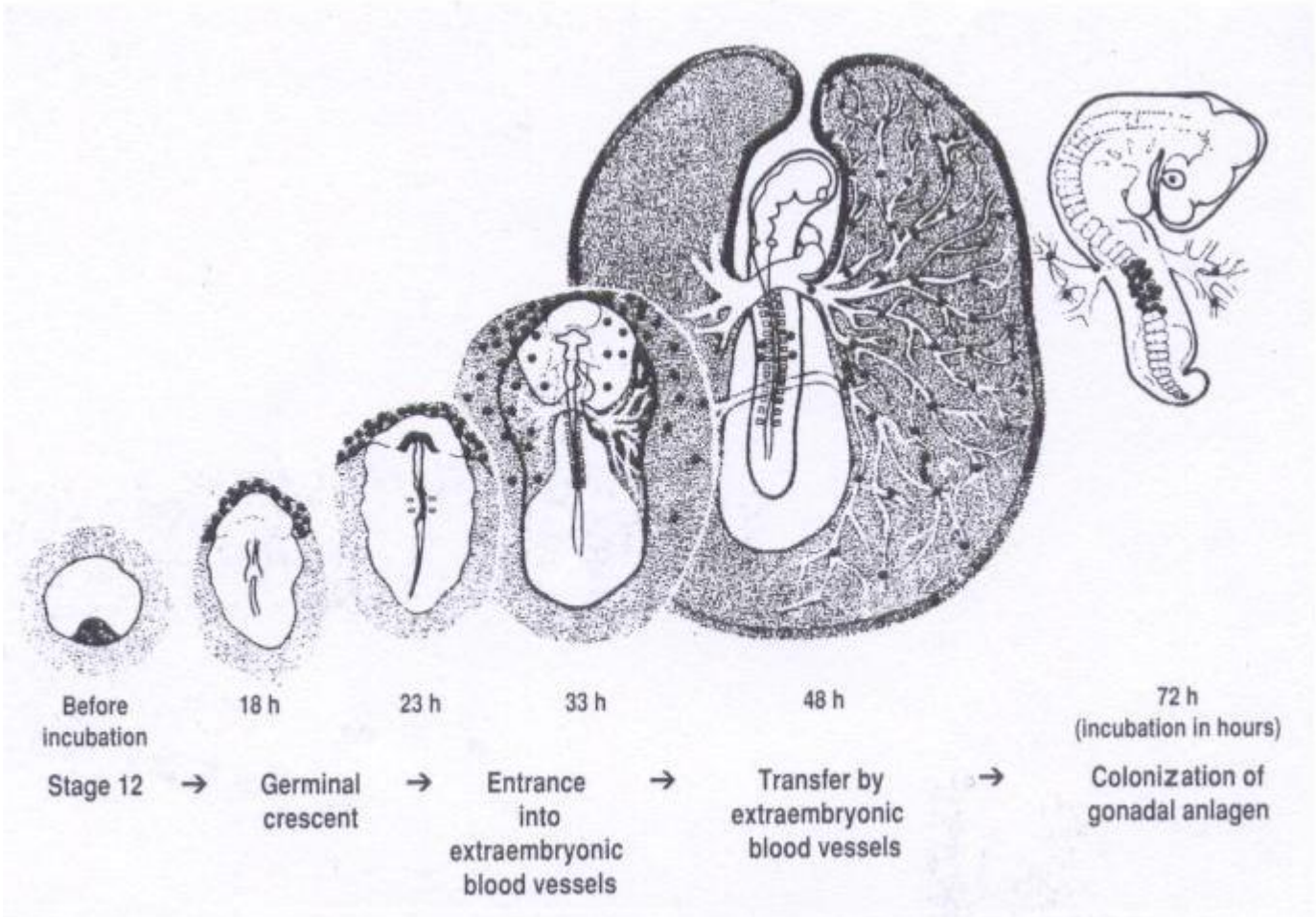
Embryos 60 hr of age



Stored 14 days Not stored 14 days Stored 14 days

Embryonic development of the chick day 3 of incubation

- The embryonic ovary (gonad) develops during embryonic development from day 3 of incubation onwards

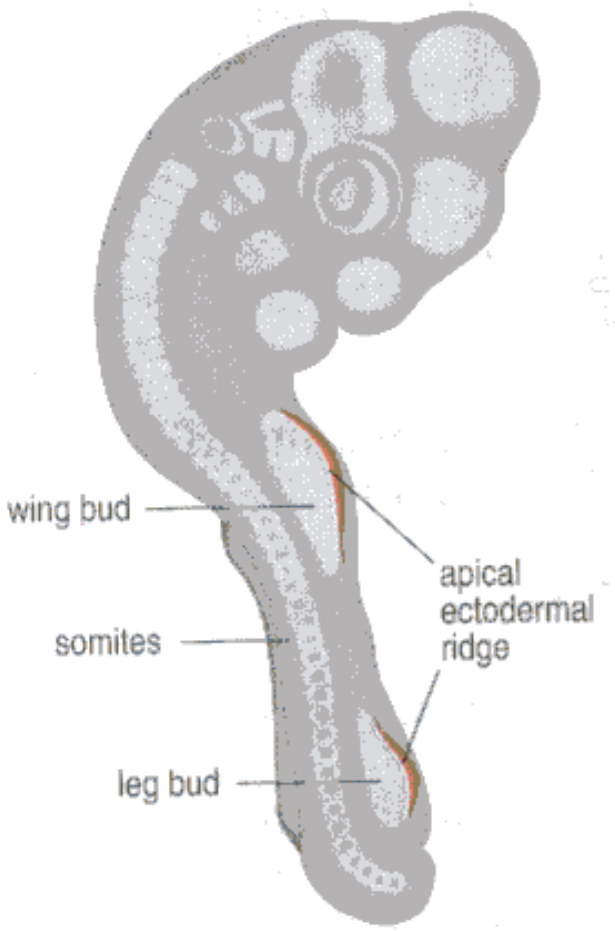


Embryonic development of the chick: day 4 of incubation

- Embryo turned to its left side
- Wing and leg buds develop
- Eye pigmentation: distinct

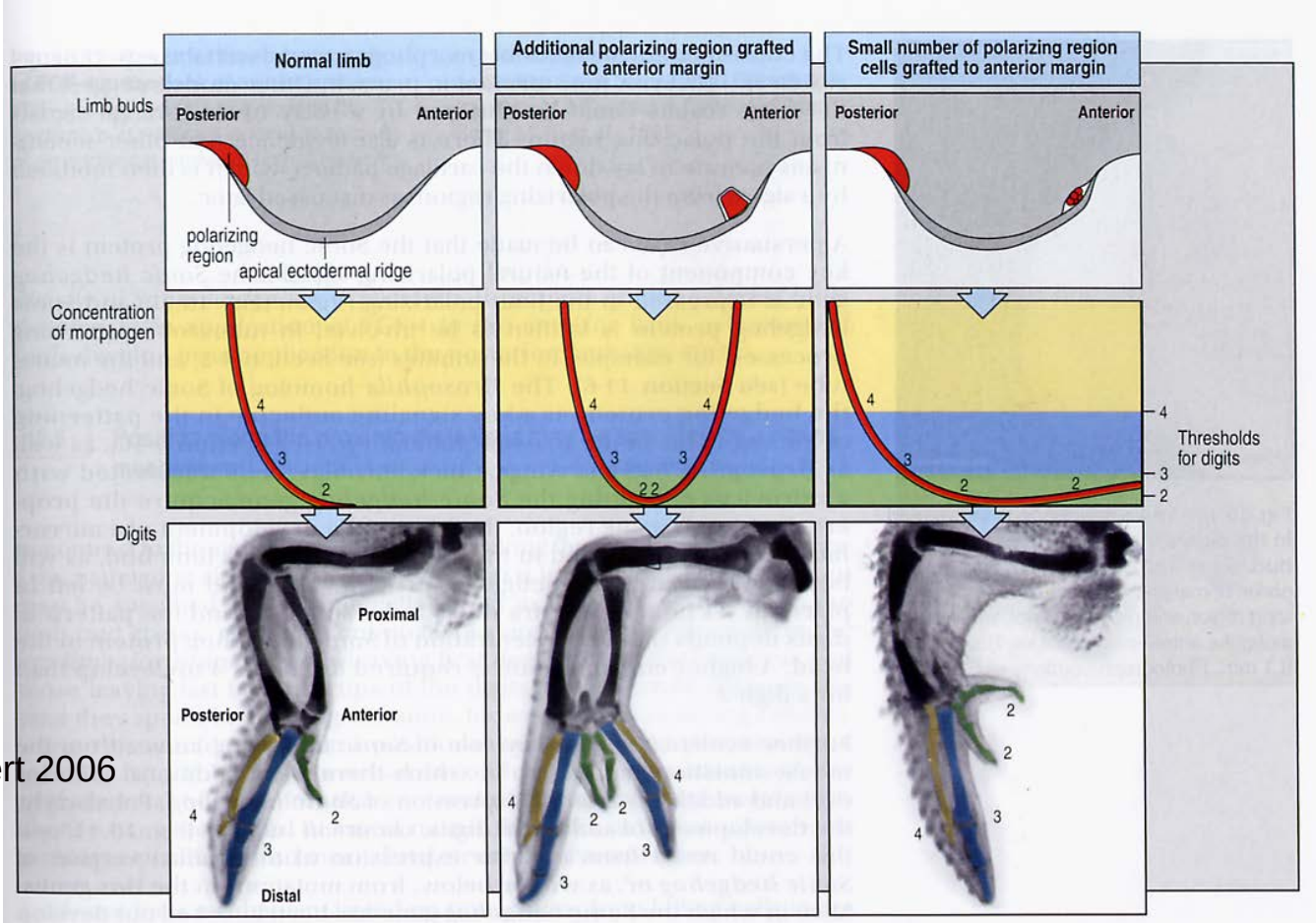
Embryonic development of the chick: day 4 of incubation

- Embryo turned to its left side
- Wing and leg buds develop



Embryonic development of the chicken: differentiation

- Embryonic factors involved in differential gene expression:
- Inducer molecules (morphogens)



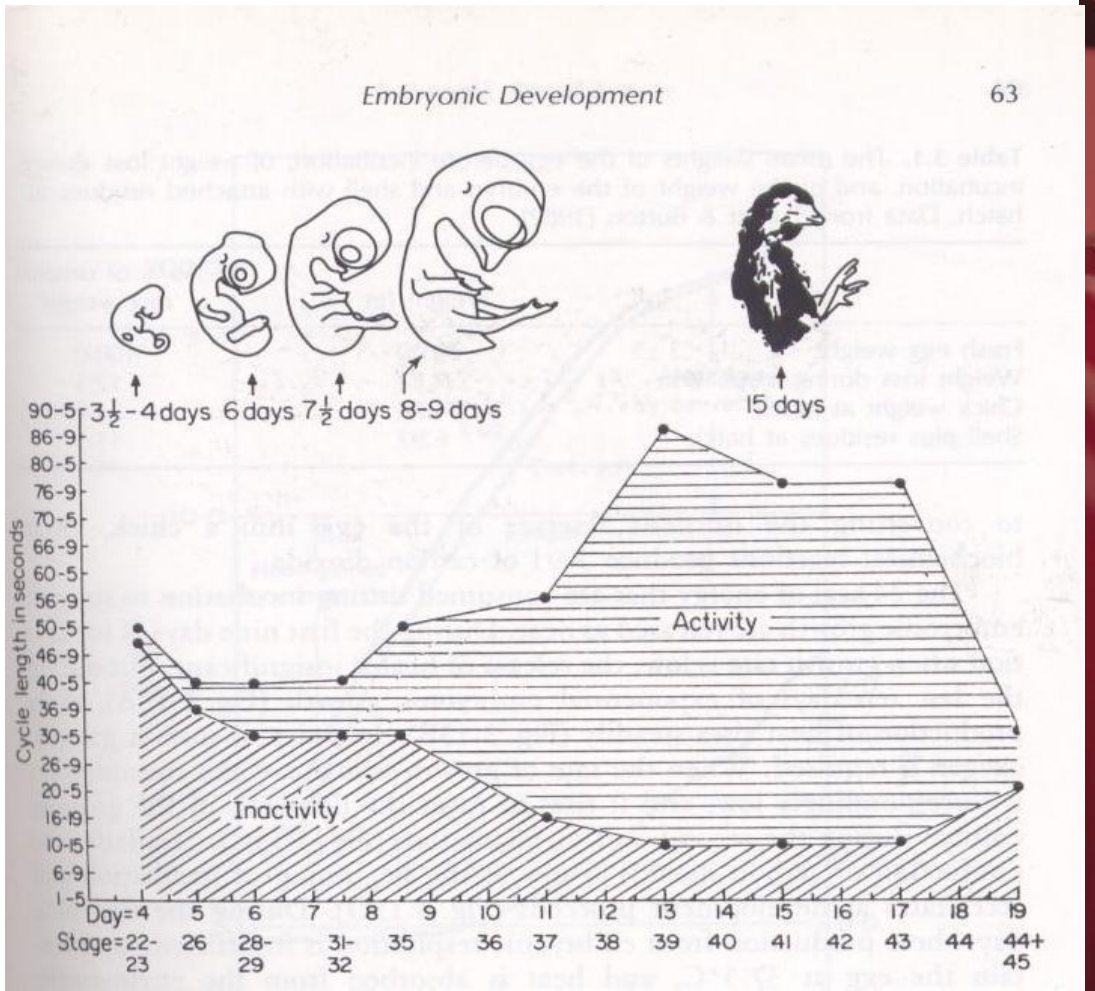
Source: Gilbert 2006

Embryonic development of the chick: day 5 of incubation

- First three toes are visible
- Elbows and knees develop
- First active movements of trunk

Embryonic development of the chick: day 5 of incubation

- First active movements of trunk

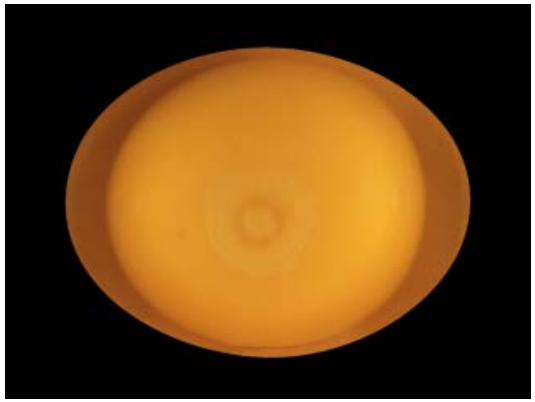


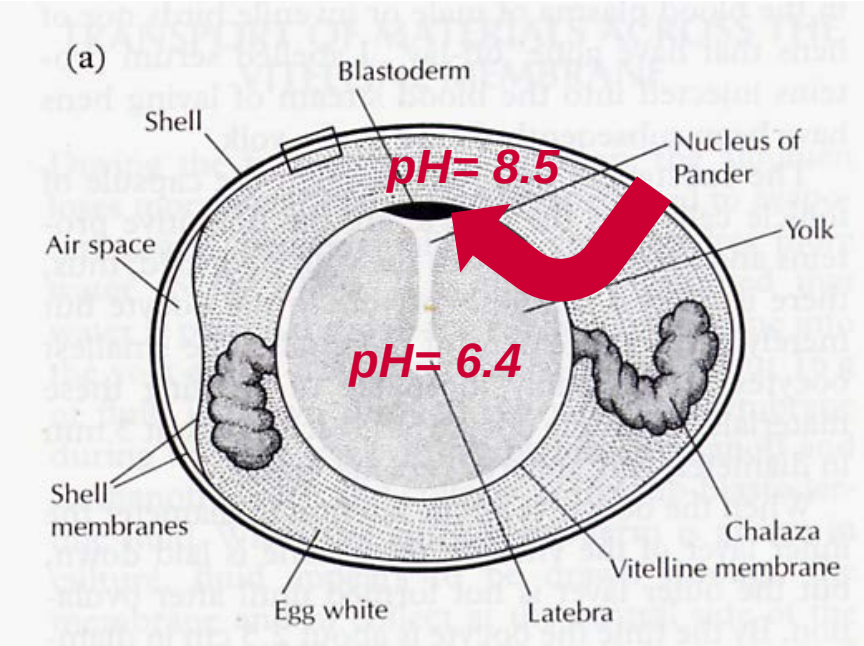
Embryonic development of the chick: day 6 of incubation

- Area vasculosa covers 75% of yolk sac
- Albumen proteins are concentrated in the sharp end of the egg
- Volume SEF maximum

Embryonic development of the chick: day 6 of incubation

- Formation of subembryonic fluid: redistribution of water from albumen to the area below the blastoderm/embryo





Embryonic development of the chick: extra-embryonic fluid compartments

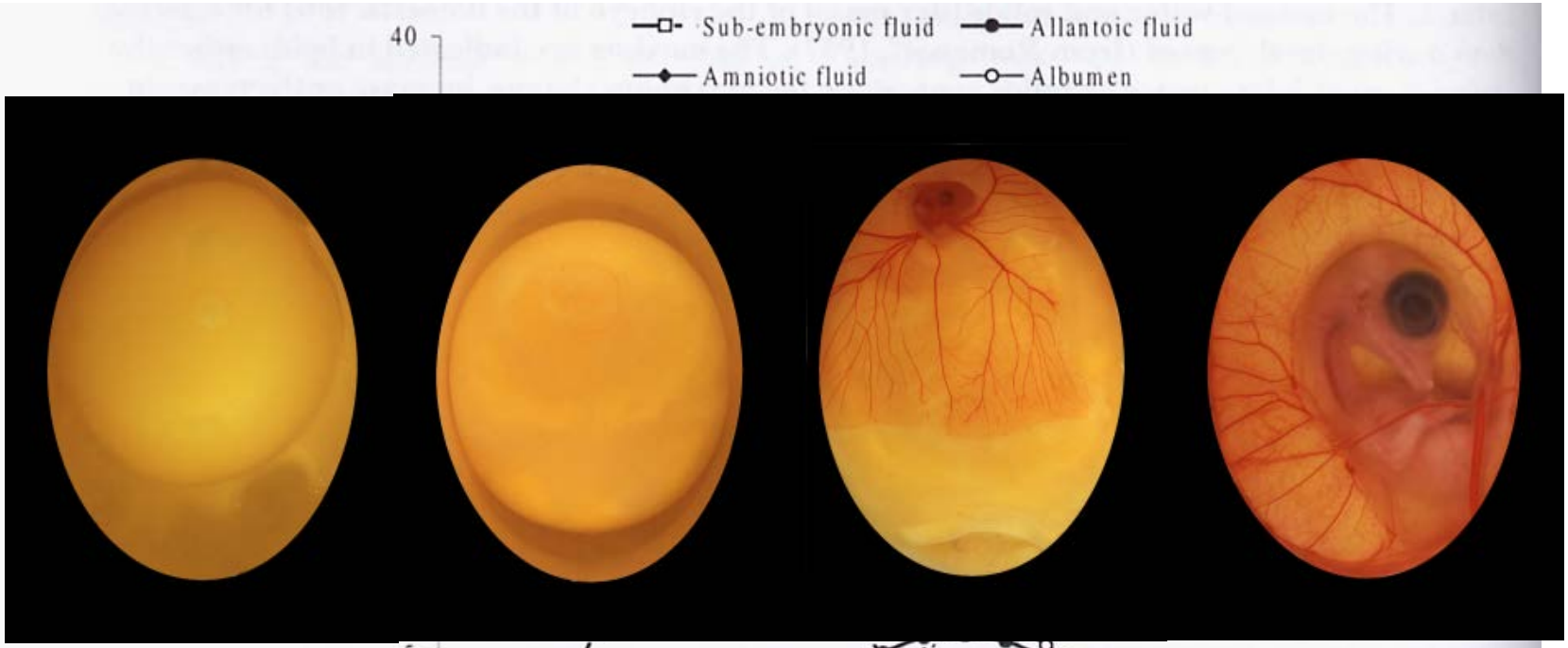


Figure 3. The pattern of changes in the mass of the embryo, yolk and albumen, and in the volume of the fluid compartments, of the developing fowl egg. Data from Romanoff (1967).

Embryonic development of the chick: extra-embryonic fluid compartments

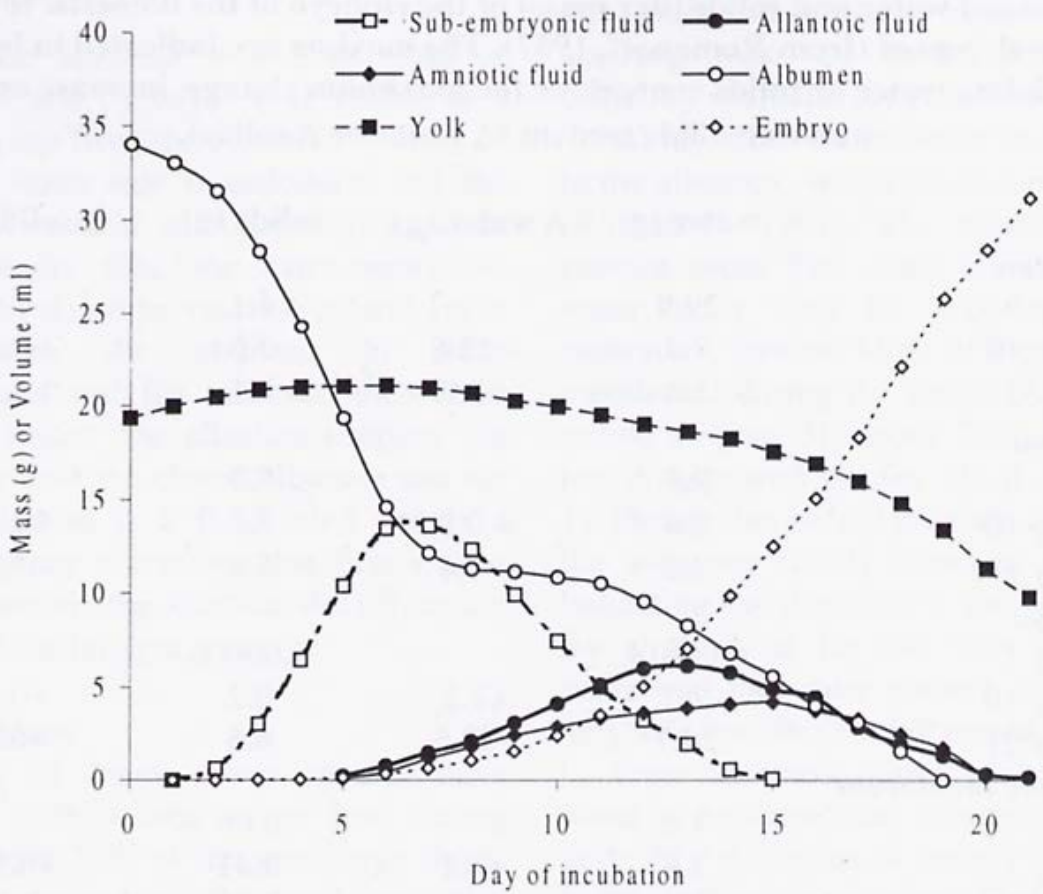
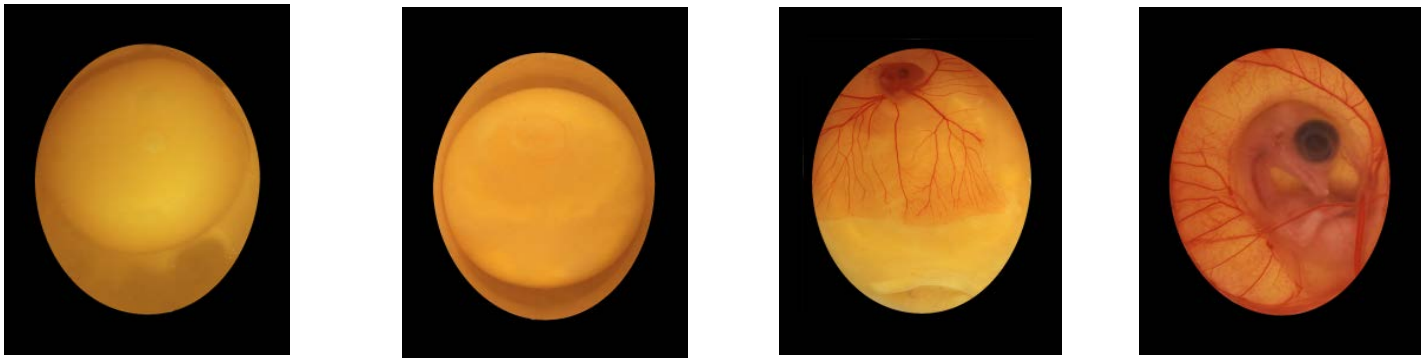


Figure 3. The pattern of changes in the mass of the embryo, yolk and albumen, and in the volume of the fluid compartments, of the developing fowl egg. Data from Romanoff (1967).

Embryonic development of the chick: extra-embryonic fluid compartments

- Incubation management (turning, temperature, relative humidity) supports normal development of embryonic and extra-embryonic structures



Embryonic development of the chick: day 7 of incubation

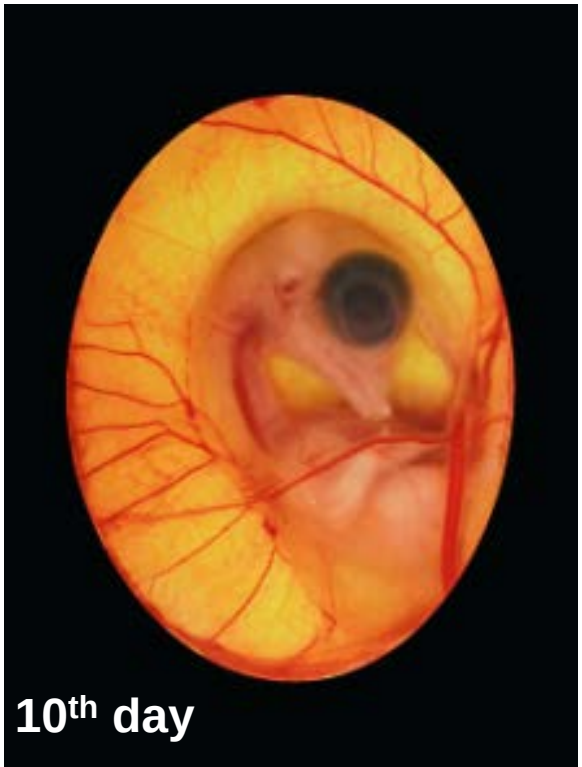
- Egg tooth and comb appear
- Digits and toes are visible
- Legs move
- First eyelid and independent limb movements

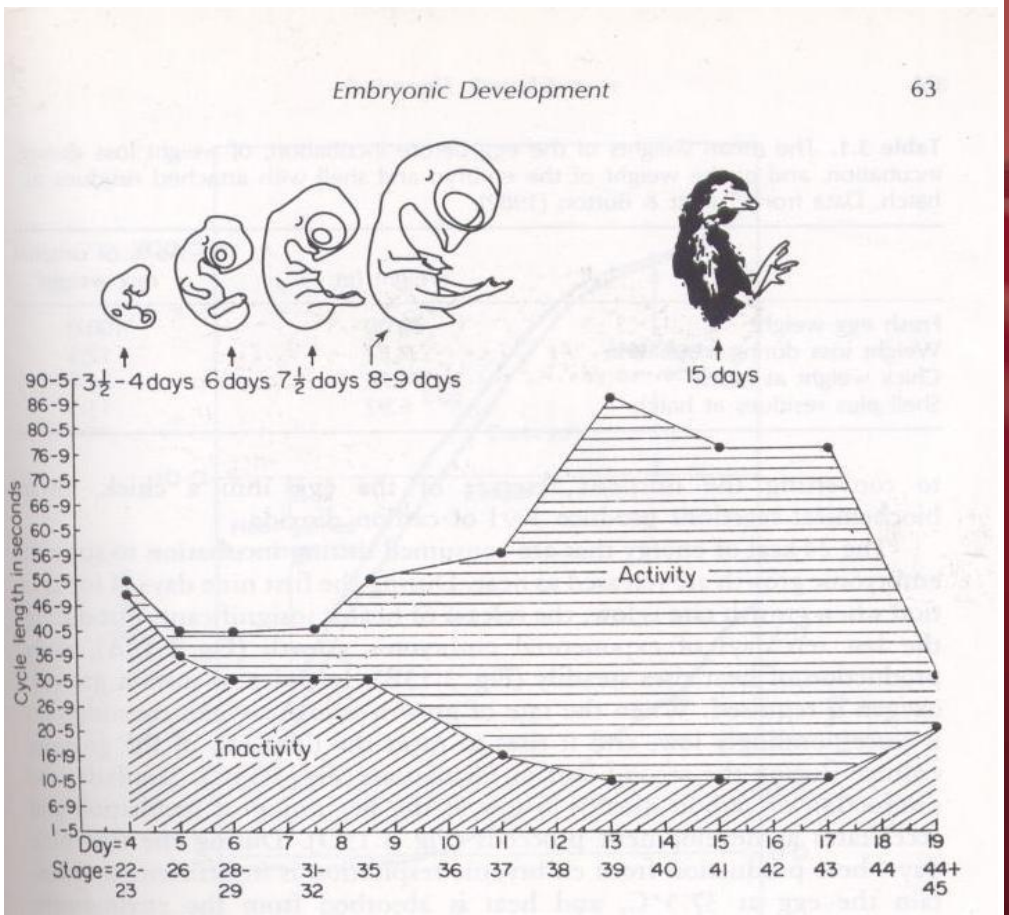
Embryonic development of the chick: day 10 of incubation

- The rhythmic contractions of amniotic muscles rock the embryo in the amniotic fluid
- Feather follicles are visible
- Toes are now completely separated

Embryonic development of the chick: day 10 of incubation

- The rhythmic contractions of amniotic muscles rock the embryo in the amniotic fluid





Embryonic development of the chick: day 11 of incubation

- Scales can be recognized on legs
- First feathers
- Volume of amniotic cavity maximum

Embryonic development of the chick: extra-embryonic fluid compartments

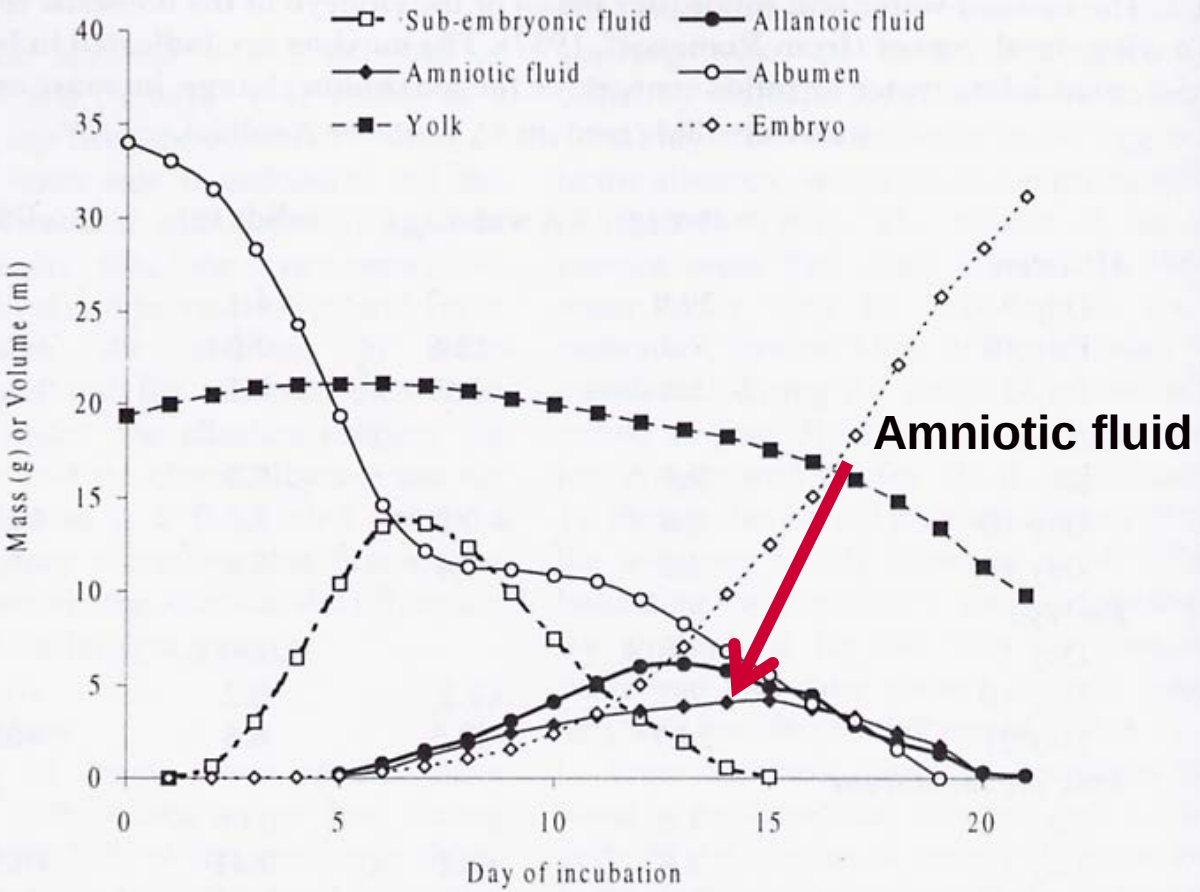


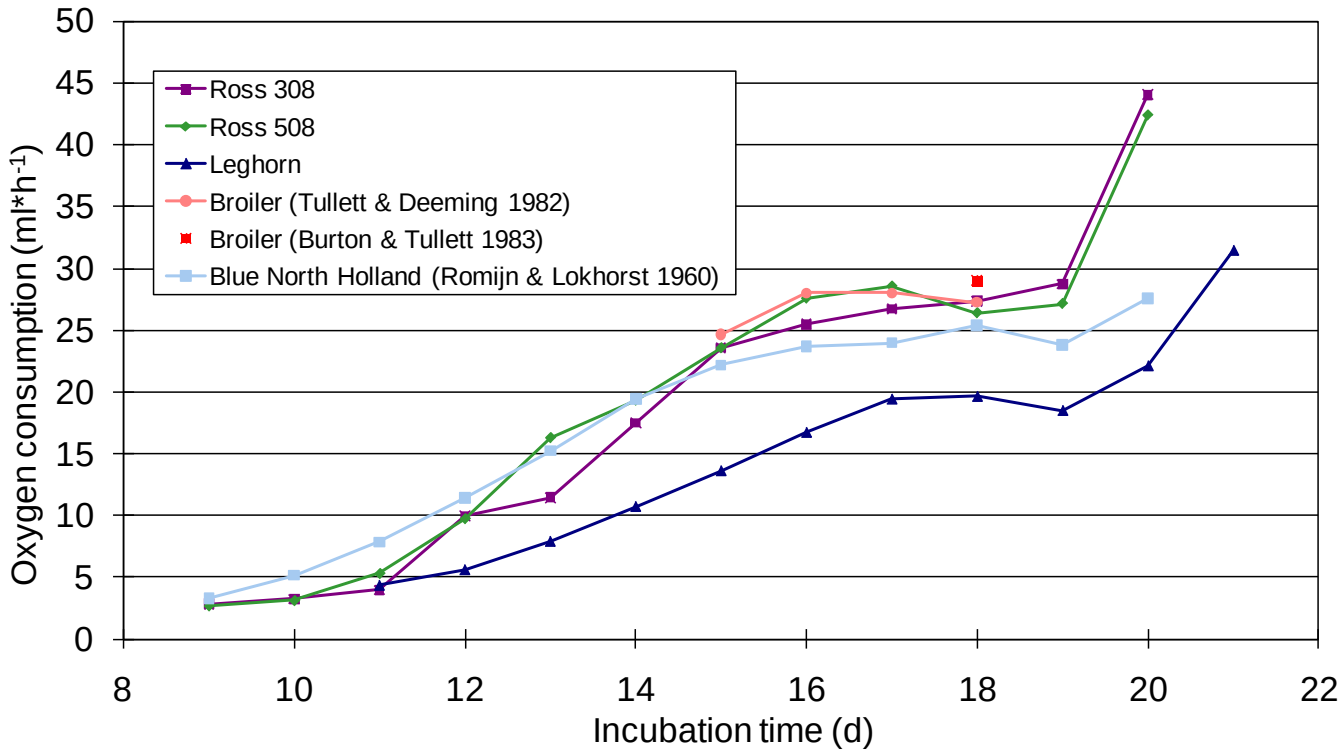
Figure 3. The pattern of changes in the mass of the embryo, yolk and albumen, and in the volume of the fluid compartments, of the developing fowl egg. Data from Romanoff (1967).

Embryonic development of the chick: day 13 of incubation

- Head in yolk sac
- Metabolic heat production exponentially
- Lipid transport by yolk sac accelerates

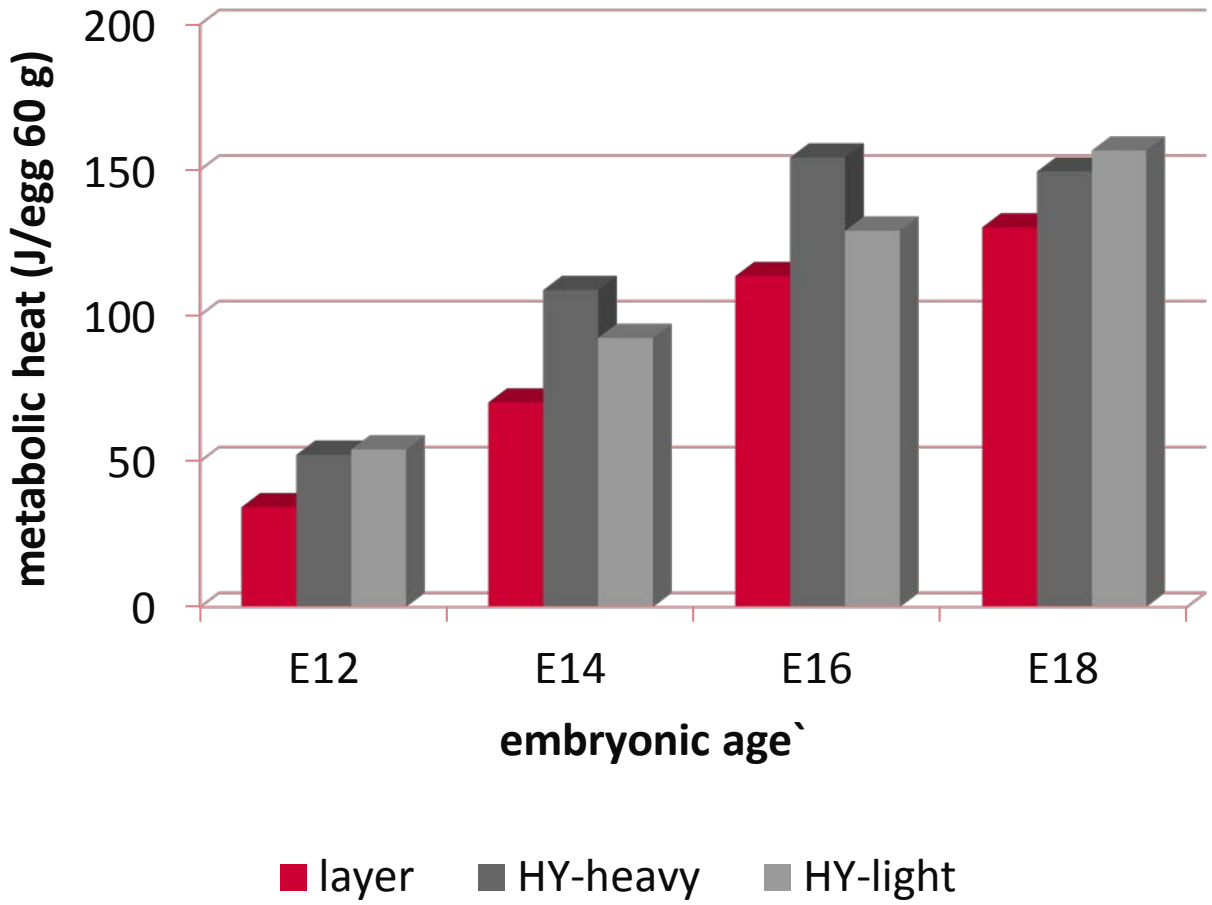
Embryonic development of the chick: day 13 of incubation
Layer embryo differs from broiler embryo

- Metabolic heat production exponentially
- Lipid transport by yolk sac accelerates



Embryonic development of the chick: day 13 of incubation
Layer embryo differs from broiler embryo

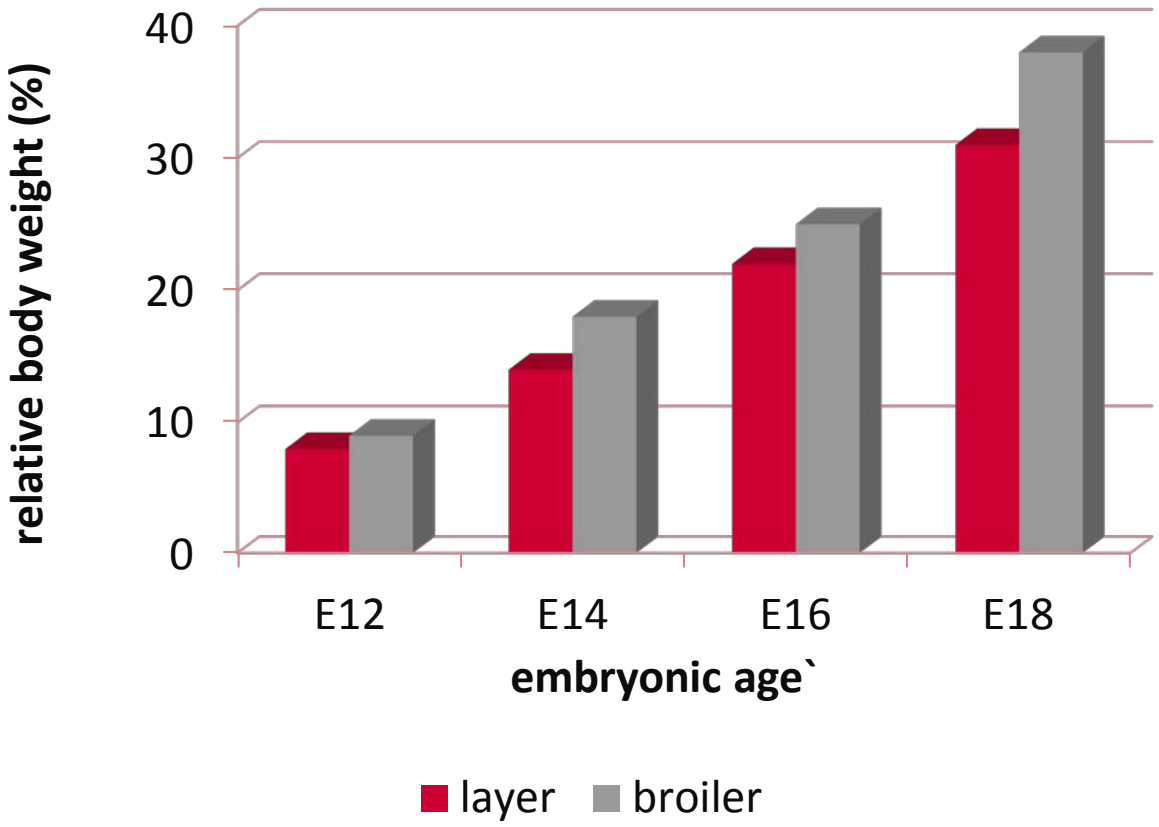
- Metabolic heat production



After Janke et al, 2004

Embryonic development of the chick: day 13 of incubation
Layer embryo differs from broiler embryo

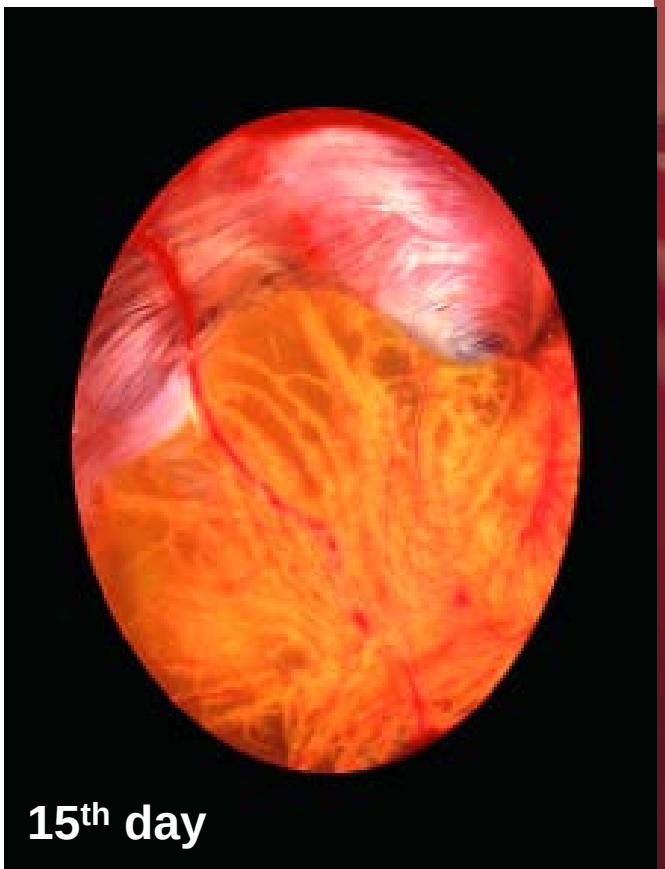
- Embryonic growth exponential



After Sato et al, 2006

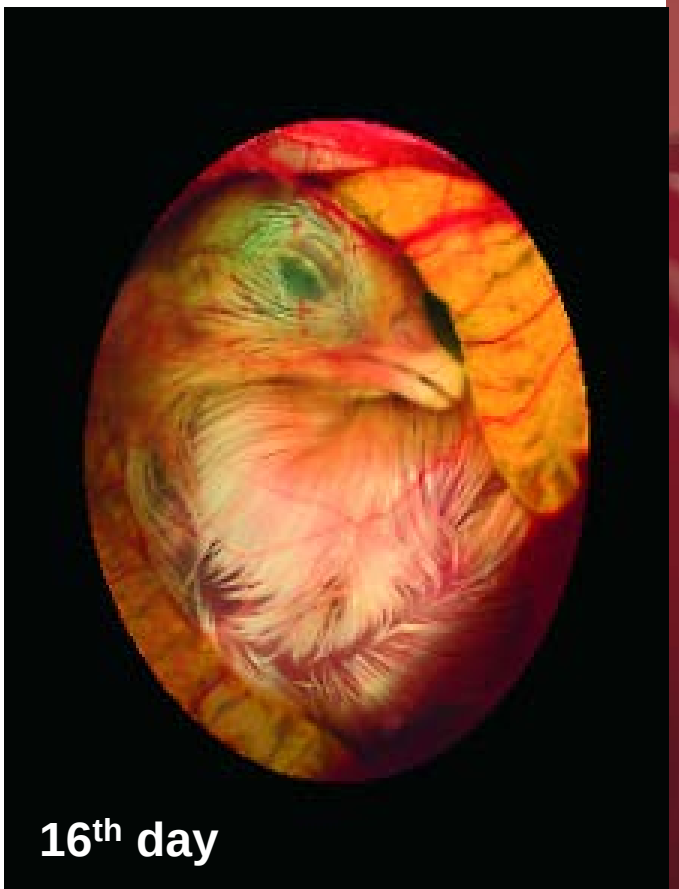
Embryonic development of the chick: day 15 of incubation

- The embryo continues to grow
- Activity is reduced
- Body covered with feathers
- Maturation of functional physiological control circuits



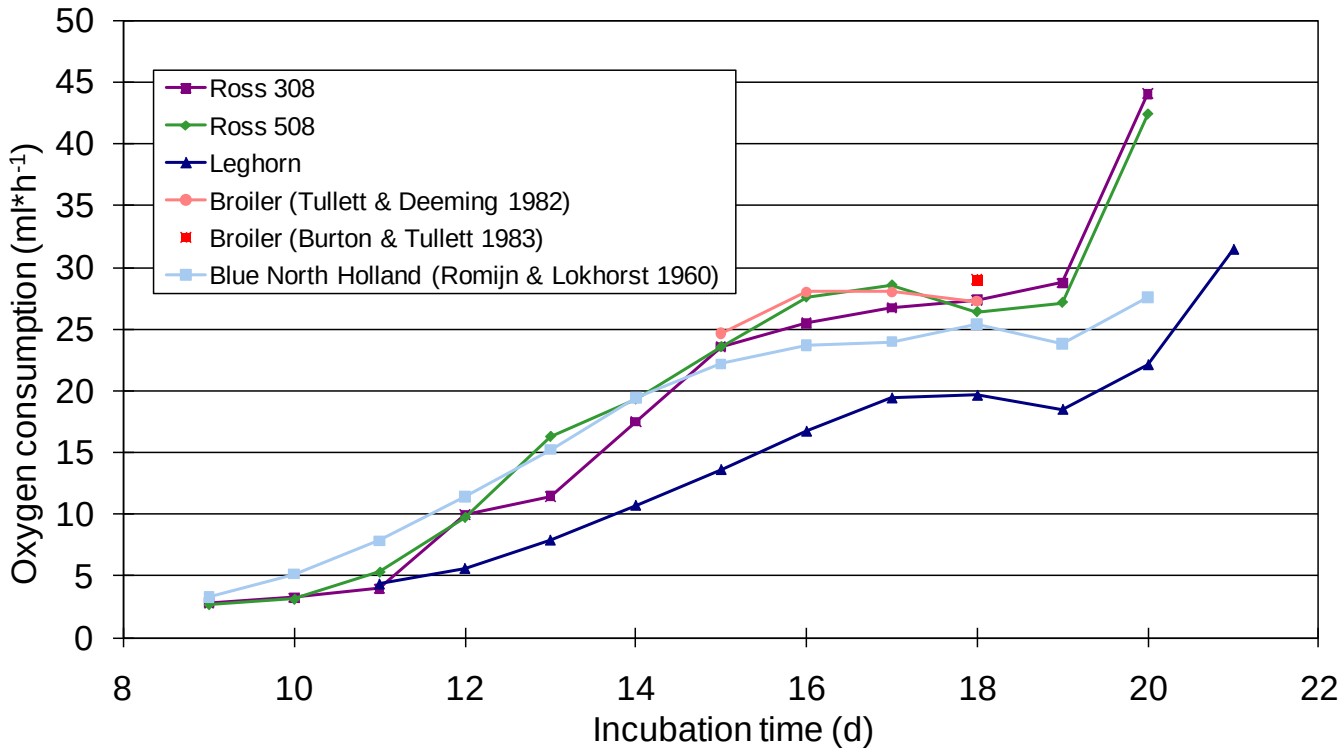
Embryonic development of the chick: day 16 of incubation

- Metabolic heat production maximum



Embryonic development of the chick: day 16-18 of incubation

- Metabolic heat production reaches the plateau phase



Embryonic development of the chick: day 18 of incubation

- Head under right wing
- Beak towards air cell
- Oxygen consumption in plateau phase

Embryonic development of the chick: the hatching proces day19-20 of incubation

- Chorio-allantoic membrane looses functionality
- Lungs are activated
- Yolk sac fully absorbed in body cavity

19-20th day

Embryonic development of the chick: day19-20 of incubation

Maturation of physiological systems:

- Hatching muscle
- Mobilization of glycogen
- The thermo-regulatory system
- Digestive tract

20th day

Embryonic development of the chick: day19-20 of incubation

- This embryonic stage is the sensitive phase for epigenetic adaptation:

  Maturing physiological systems can be trained by external triggers

19-20th day

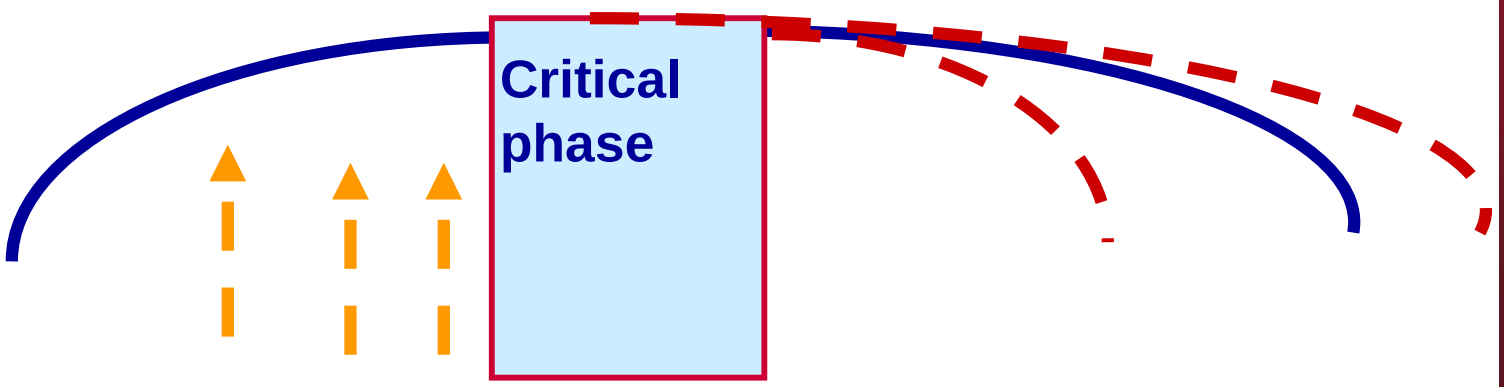
Epigenetic adaption: after Tzschentke, 2009:

Developing embryo pre-programmed by genetic instructions

Long-lasting modification of the pre-determined adult phenotype via changes in gene expression

environmental influences changes

hormone concentration
transmitters/neuropeptides
cytokines



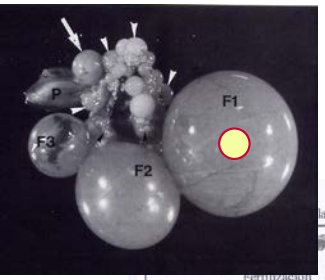
Embryonic development of the chick: day19-20 of incubation

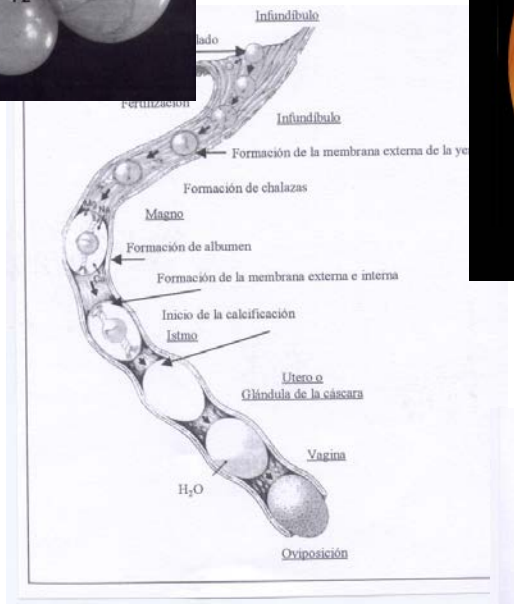
Maturing physiological systems can be trained by external triggers for long term adaptations

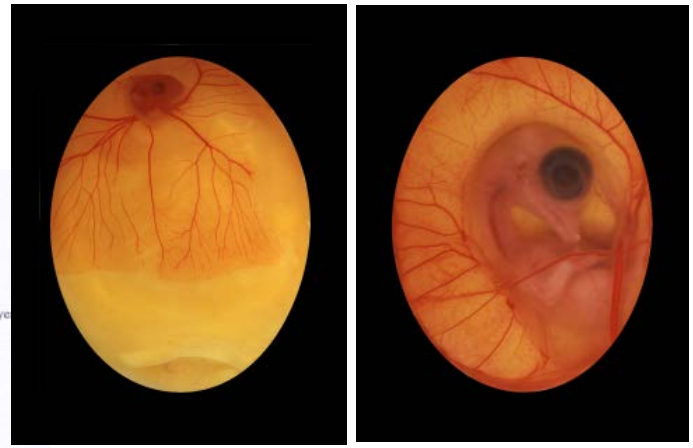
Example of temperature training

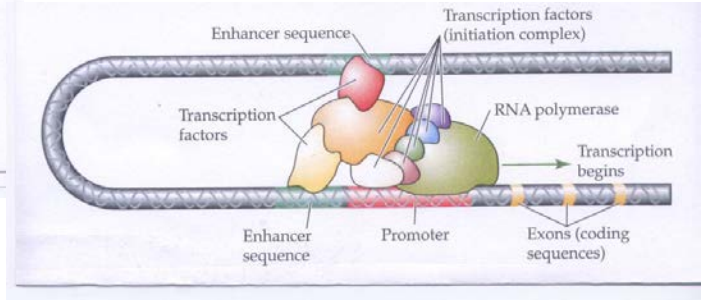
- lowers metabolism with long term effects on feed conversion rates

Conclusion: embryonic development of the chick is a complex process









Fertilization---differentiation---growth---maturation

Thank you

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