

# Dietary modulation of some digestive enzymes and metabolic processes in developing marine fish: applications to diet formulation

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# During the larval period...

- Maturation of the digestive system
  - Increase in pancreatic secretion
  - Settlement of an efficient brush border membrane in enterocytes
    - ➔ adult mode of digestion
- Functioning of metabolic processes controlling
  - Differentiation of tissues
  - Morphogenesis

# Maturation processes could be influenced by dietary nutrients...

- Necessity to understand these influences using adequate physiological indicators
- These indicators are related to some specific nutrients
- Useful information to find the optimal form of supply of these nutrients



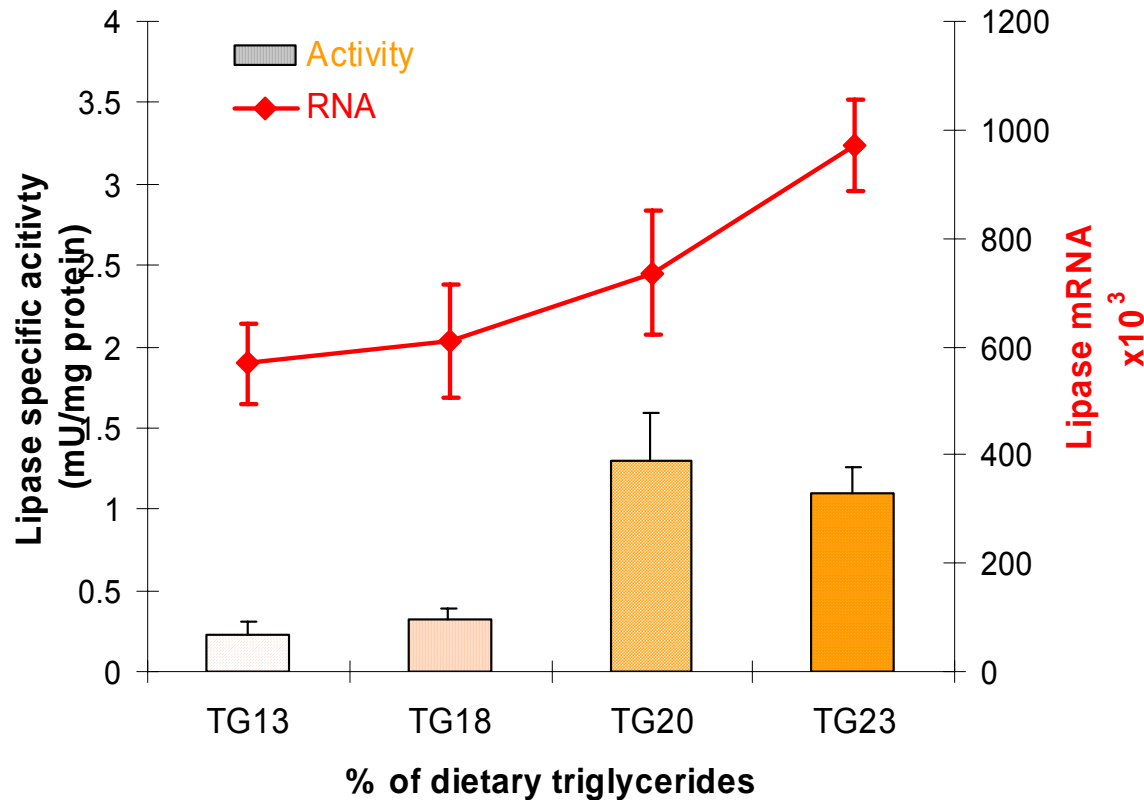
# Influence of the nature of the dietary lipids

## Modulation of lipases

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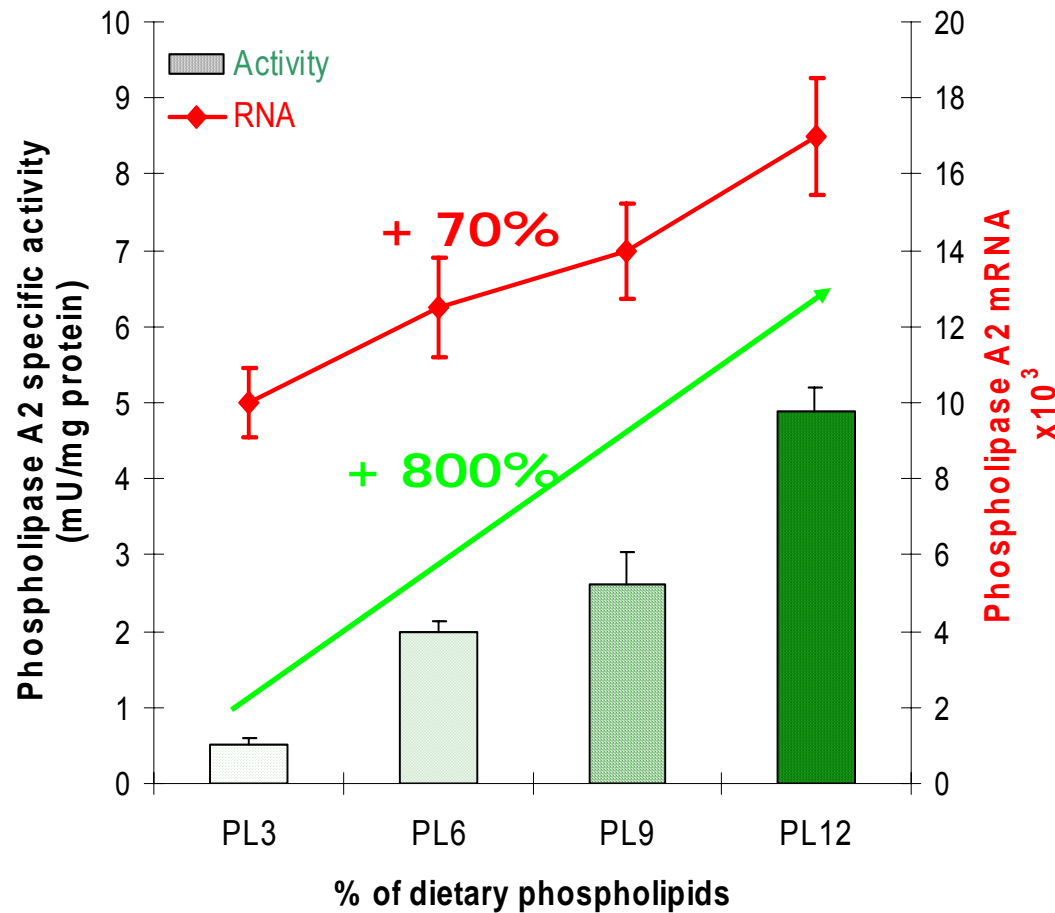
# Effect of dietary triglyceride levels



- Dietary modulation of lipase activity is not linear
- 20% TG = a threshold with maximum activity and messenger?

Diets containing ~25% total lipids

# Effect of dietary phospholipid levels

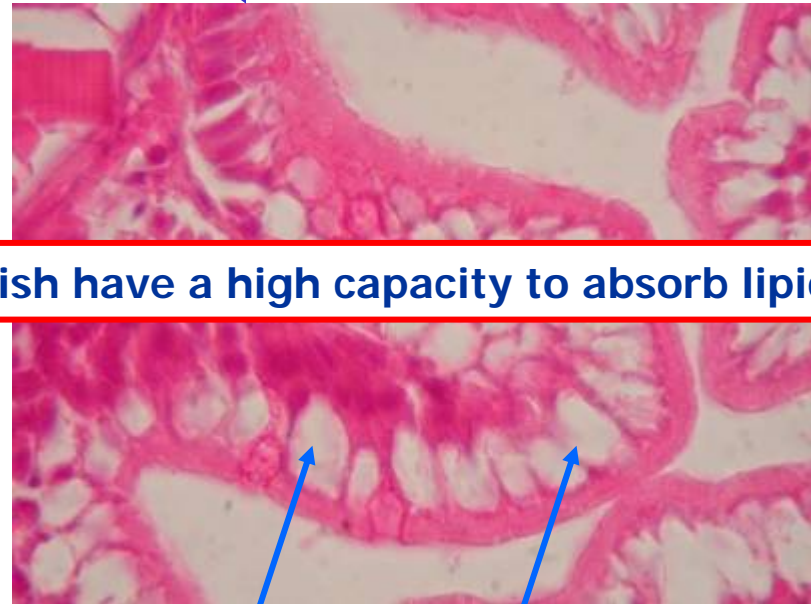
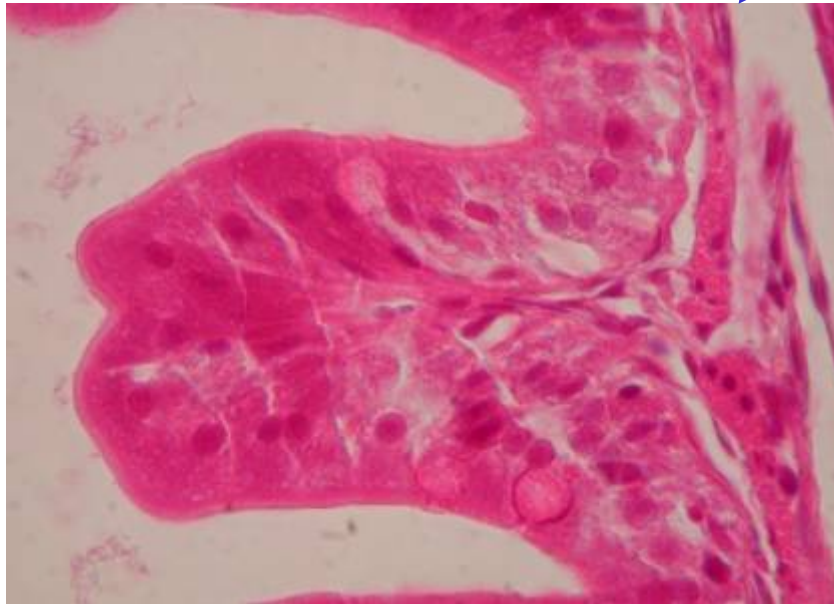


Diets containing ~25% total lipids

- The expression of the enzyme is highly modulated (mainly at transcriptional level)
- Growth: x 18, Survival: x 3
- PL better used by larvae than NL



# Prevalvular intestinal mucosa in 40-d old European sea bass larvae fed diets with low or high triglyceride content



**Fish have a high capacity to absorb lipids**

apical lipid droplets

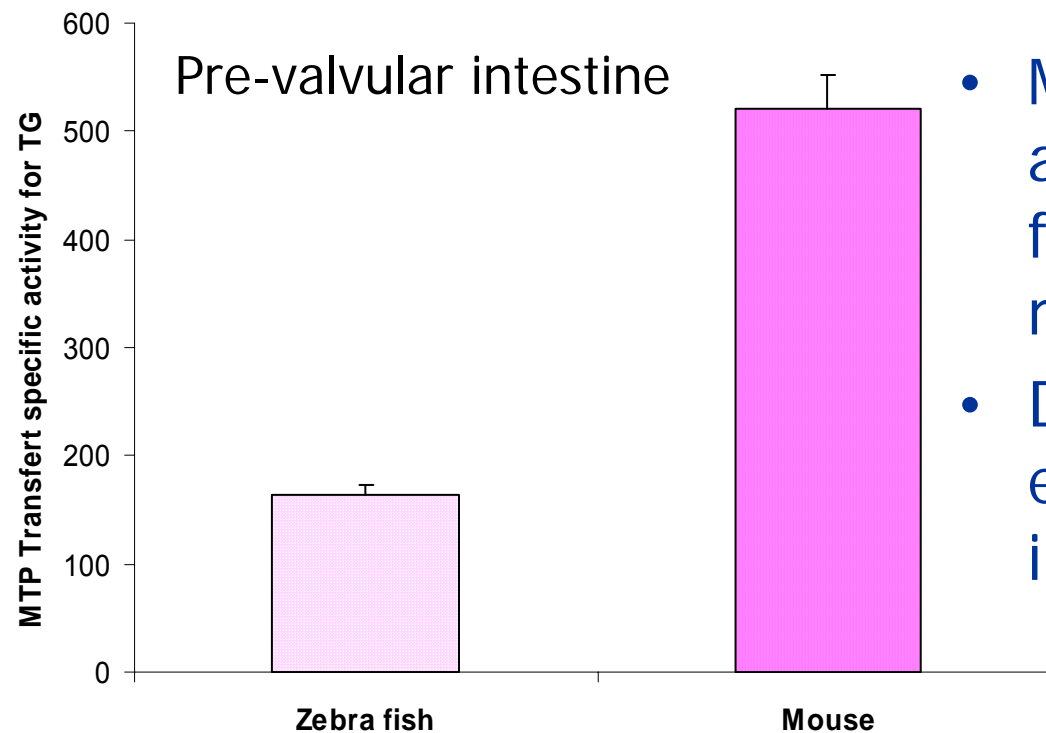
**Accumulation of lipids in the enterocytes of anterior intestine in fish fed diets with high levels of triglycerides**

**TG are not easily metabolized in fish larvae enterocyte**



# Comparison of the transfer specific activity for triglycerides in fish larvae and mouse

MTP = Microsomal Triglyceride transfer Protein, intracellular protein required for the assembly and secretion of triglyceride-rich lipoproteins



- MTP exhibited a transfer activity 4 times lower in fish compared to mammals
- Does absorption capacity exceed secretion capacity in fish enterocyte?



# Recommendations for diet formulations

- The lipid fraction of diets intended for marine fish larvae should incorporate a significant fraction of phospholipids instead of triglycerides
- Incorporation of 12% phospholipids in diets → 18 times and 3 times increase in growth and survival, compared to an isolipidic diet but containing only 3% phospholipids



# Influence of some nutrients

Modulation of some metabolic pathways controlling development

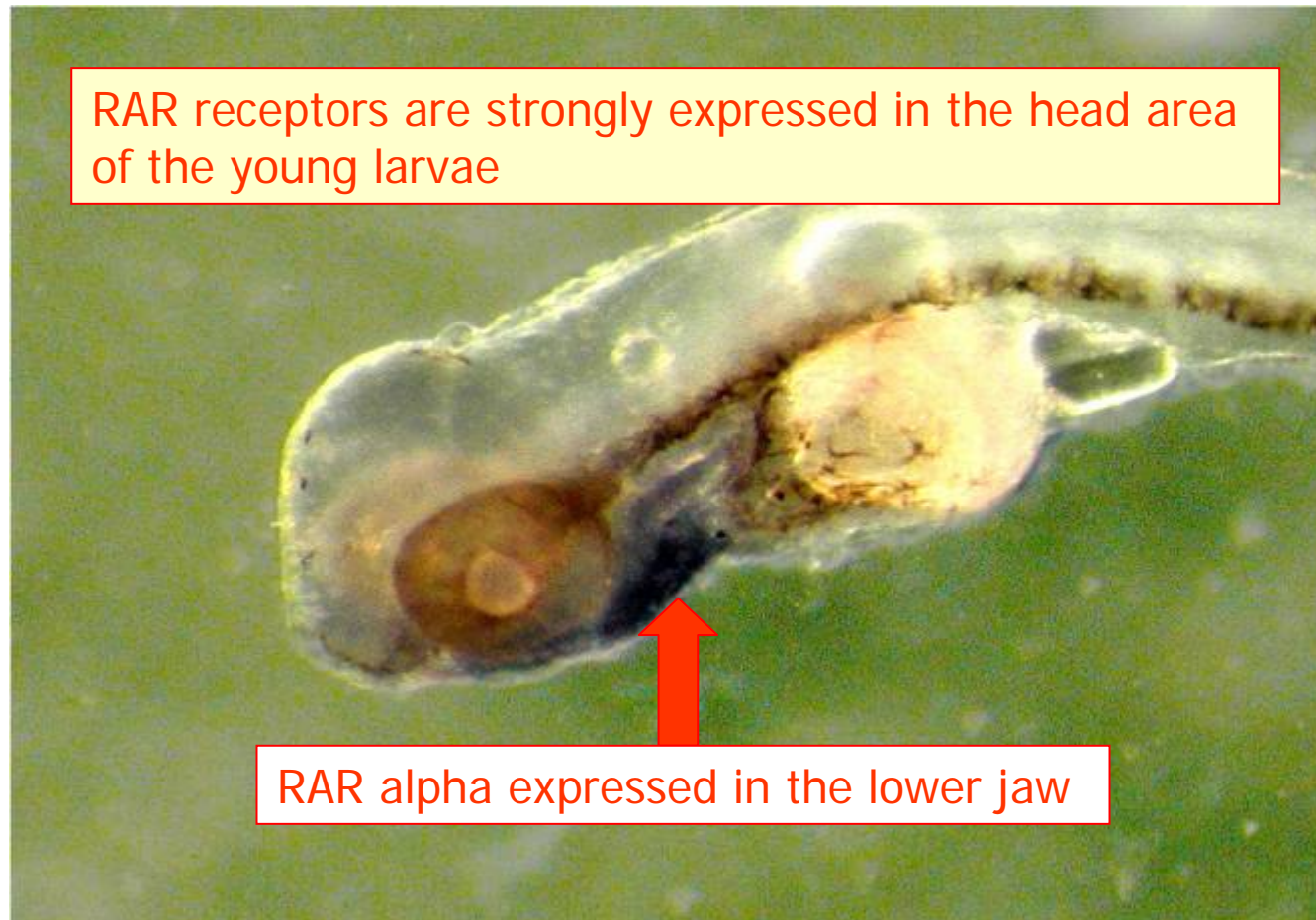


# Nutrition and development

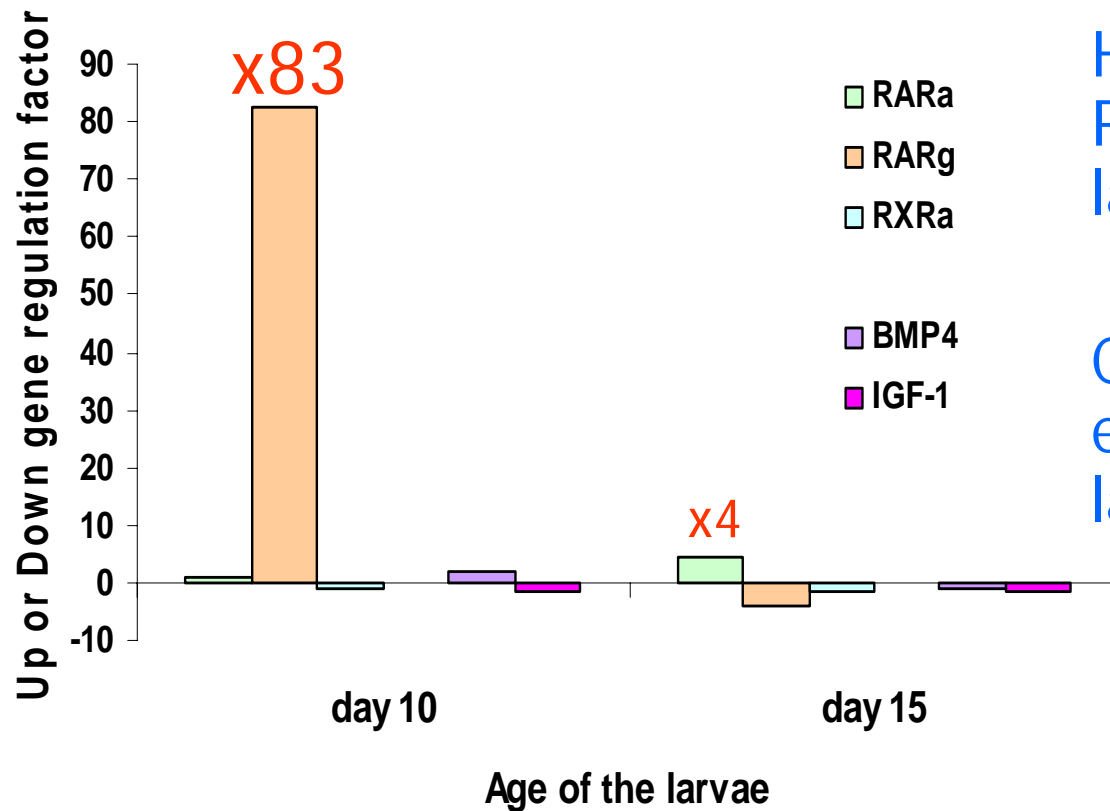
- close relationship between larval nutrition at first feeding and development, this relationship is easily observed in the case of skeletal abnormalities
- Action of some nutrients on particular nuclear receptors
- Pivotal role of retinoid pathway (RAR, RXR), that can be influenced by vitamin A, D and PUFA...
  - Example of action on RAR receptor and its consequences...



# Area of expression of RAR receptors in 5 day old sea bass larvae



# Effect of a diet containing a high level of Vitamin A

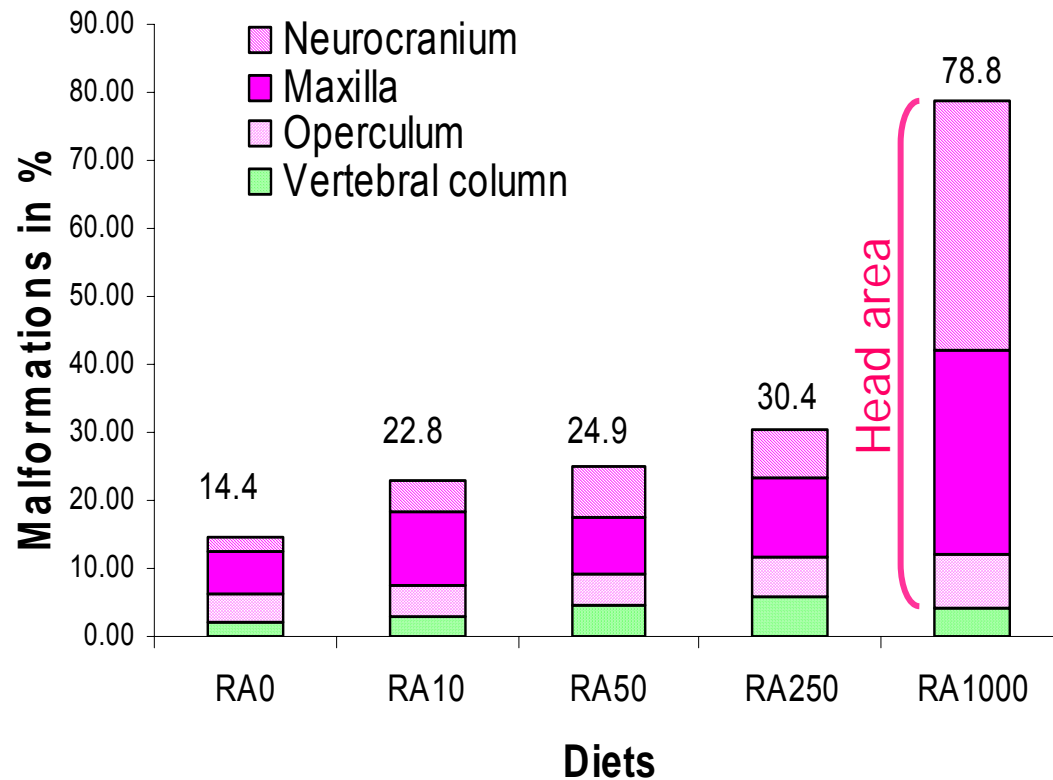


HUGE up-regulation of RAR $\gamma$  during the early larval period

Consequences mainly evidenced after the larval period

# Effect of the Vit A dietary level on sea bass larvae morphogenesis

Diets containing increased levels in retinyl acetate



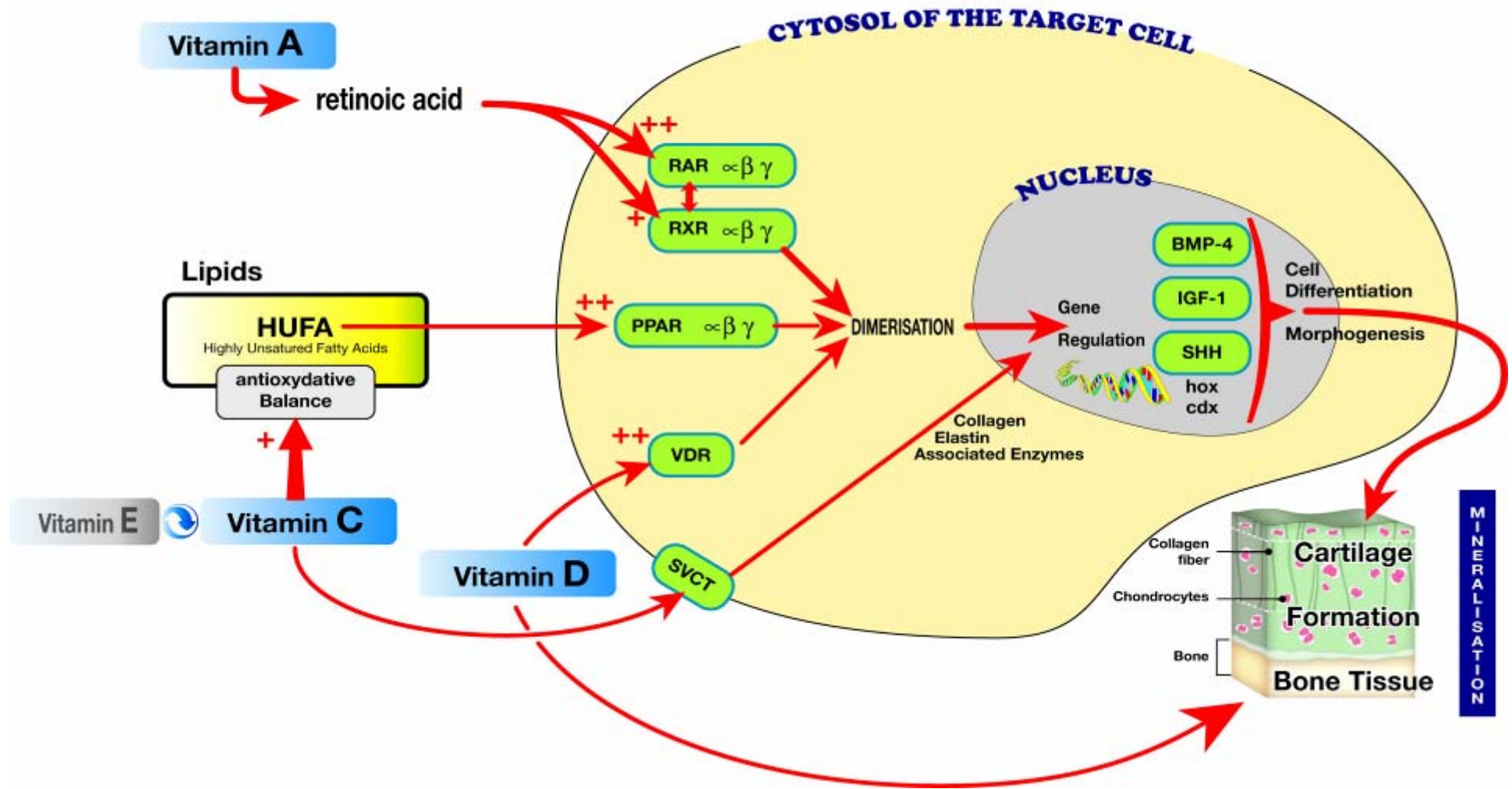
Inappropriate levels of dietary vitamin A  
➔ effect on RAR receptors  
➔ alteration of head organization

# Recommendations for diet formulations

- Optimal level in retinyl acetate ~31 mg/kg DM
- Cross-talks between Vit A signalling pathway and others (involving PUFA) ➔ global approach necessary to better define nutritional requirements



Involvement of several metabolic pathways mediating the influence of



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# Conclusions

- Fish larvae should not be considered as primitive organisms but represent a transitional period with substantial changes
  - Nutrition is one of the parameters influencing the larval development
- Determination of the nutritional requirements is more complicated than just finding the right combination of nutrients, as it cannot be only based on growth and survival data ➔ necessity to consider physiological indicators of development
- Cross-talks between metabolic pathways controlling development ➔ necessity of global knowledge

