

LECTURE 30

Body plan genes, *Drosophila* as model, part 2

From CHAPTER 21: DEVELOPMENT OF MULTICELLULAR ORGANISMS

p. 1185-1190

Figures covered: Fig. 21-36 to 21-40

Quick summary of last lecture:

- Products of egg polarity (aka, maternal effect) genes provide global positional information in early *Drosophila* embryo:
 - opposing gradients of Bicoid and Nanos to specify AP axis
 - activation of Torso signaling at two poles/termini of embryo
 - activation of Toll signaling ventrally to set up opposing Dorsal and Dpp gradients along DV axis

Between syncytial blastoderm and cellular blastoderm stages, div. cycles slow down, transcript'n of zygotic genes (ie., from embryo's own genome) begins.

Two groups of zygotic genes required to refine positional inform'n set up by maternal products:

1. Segmentation Genes (today's lecture)
2. Homeotic genes (next lecture)

Segmentation Genes:

- **3 Classes** (each involved in activating/delimiting expression of next):
 - Gap genes
 - Pair-rule genes
 - Segment polarity genes
- ident. by mutant screens begun late 1970's by Christiane Nusslein-Volhard & Eric Wieschaus; they won Nobel Prize in Medicine in 1995 for this work (shared w/ Edward Lewis who studied *Drosophila* homeotic genes (next lecture))
- "Basic research", but HUGE impact: ident. & study of homologous genes & pathways in higher animals (incl. humans) bringing new insights/maj. progress in biomed. science

Gap genes (e.g., *hunchback*, *Krüppel*):

- mutant phenotype: multi-segmt. "gap" in larval body plan (Fig. 21-36)
- activated by specific concentrat'ns & combinat'ns of maternal TFs (e.g., Bicoid & others); expressed in large sub-domains of AP axis (Fig. 21-37)
- encode TFs (repressors) that cross-regulate each other (sharpen boundaries) & act combinatorially w/ maternal TFs to activate pair-rule genes

Pair rule genes (e.g., *even-skipped* [*eve*], *ftz*)

- mutant phenotype: lack 1/2 of body segmts (all even or all odd segm'ts missing in most cases)
- expressed in 7 alternating stripes (every other segm't) (21-37)
- encode TFs (activators &/or repressors) that cross-regulate each other and act combinatorially w/ gap TFs to activate segm't polarity genes
- complex gene promoters!
 - Example: (Fig. 21-38) dissection of **eve** regulatory DNA reveals indep't control regions (enhancers) for individual stripes
 - genomic DNA fragm'ts each ligated to *lacZ* reporter gene

- produce transgenic fly lines (*lacZ* is non-toxic) for each
- co-stain transgenic embryos for *lacZ* RNA and endogenous Eve protein. Identify those w/ *eve*-like expression

Segment polarity genes (e.g., *engrailed*, *gooseberry*, *wingless*, *hh*)

- mutant phenotype: part of each segm't deleted or replaced by mirror-image of remaining half
- encode TFs (e.g., Engrailed) as well as ligands, receptors & other components of **Wingless & Hedgehog signaling pathways**
- expression begins AFTER cellulariz'n
- expressed in 14 evenly spaced, narrow stripes (**Fig. 21-37**) representing sub-region of **EVERY segment** (each s.p. gene expressed at characteristic position in every segmt; each s/p. gene in slightly different register).
- End result: unique combination of s.p. genes define polarity of segment/parasegment (eg. Wg is always produced and secreted from the .

SUMMARY of *Drosophila* SEGMENTATION GENES

- their products are TF & signal pathway proteins that greatly refine positional (spatial) inform'n set up by maternal products, channel embryonic cell fate potential to increasing finer, local options
- most are only **transiently expressed** (*engrailed* is one exception, **Fig. 21-40**), but effects are "remembered/maintained" by **homeotic gene products** (NEXT)