

# **DEVELOPMENTAL BIOLOGY**

## **TOPIC: PAIR RULE GENES**

III SEM M.SC ZOOLOGY

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# Pair rule genes

In drososophila A-P axis formation

# Pair rule genes

- A segmentation gene whose expression subdivides the embryo into series of stripes, and sets the boundaries of the parasegments.
- It also regulates the subsequent expression of segment polarity genes.

# Pair rule genes

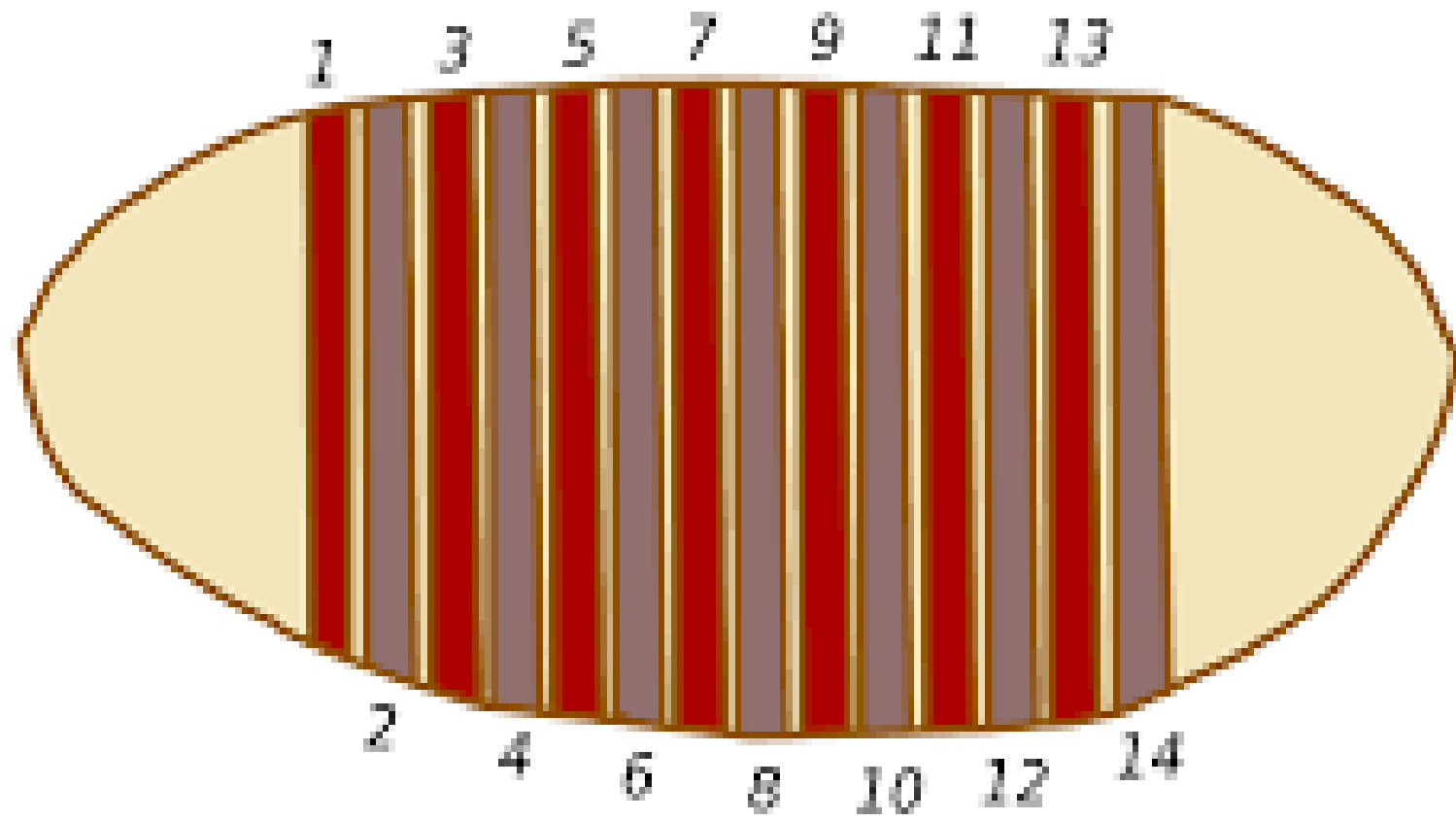
- Hairy
- Even skipped
- Runt
- Fushi tarazu
- Odd skipped
- Sloppy paired
- Paired
- Odd paired



# Pair rule genes

- The expression and function of the pair rule genes reveals the periodic patterns in the drosophila embryo.
- Differing concentrations of the gap gene proteins cause transcription of pair rule genes, which divide the embryo periodic units

# Pair rule genes

- Like the gap genes, the pair class of genes was originally defined through their loss of function phenotypes. In this case deletions with a two segment periodicity.
- The transcription of a different pair rule genes results in a striped pattern of seven vertical bands perpendicular to the anterior posterior axis.



 *even-skipped*       *fushi tarazu*

- 3 genes are known to be the **primary pair rule genes** are **hairy, even-skipped, and runt** are controlled by the gap gene proteins.
- The enhancers of the primary pair rule genes are recognized by gap gene proteins, and it is thought that the different concentration of gap gene protein determine whether a pair rule gene is transcribed or not.

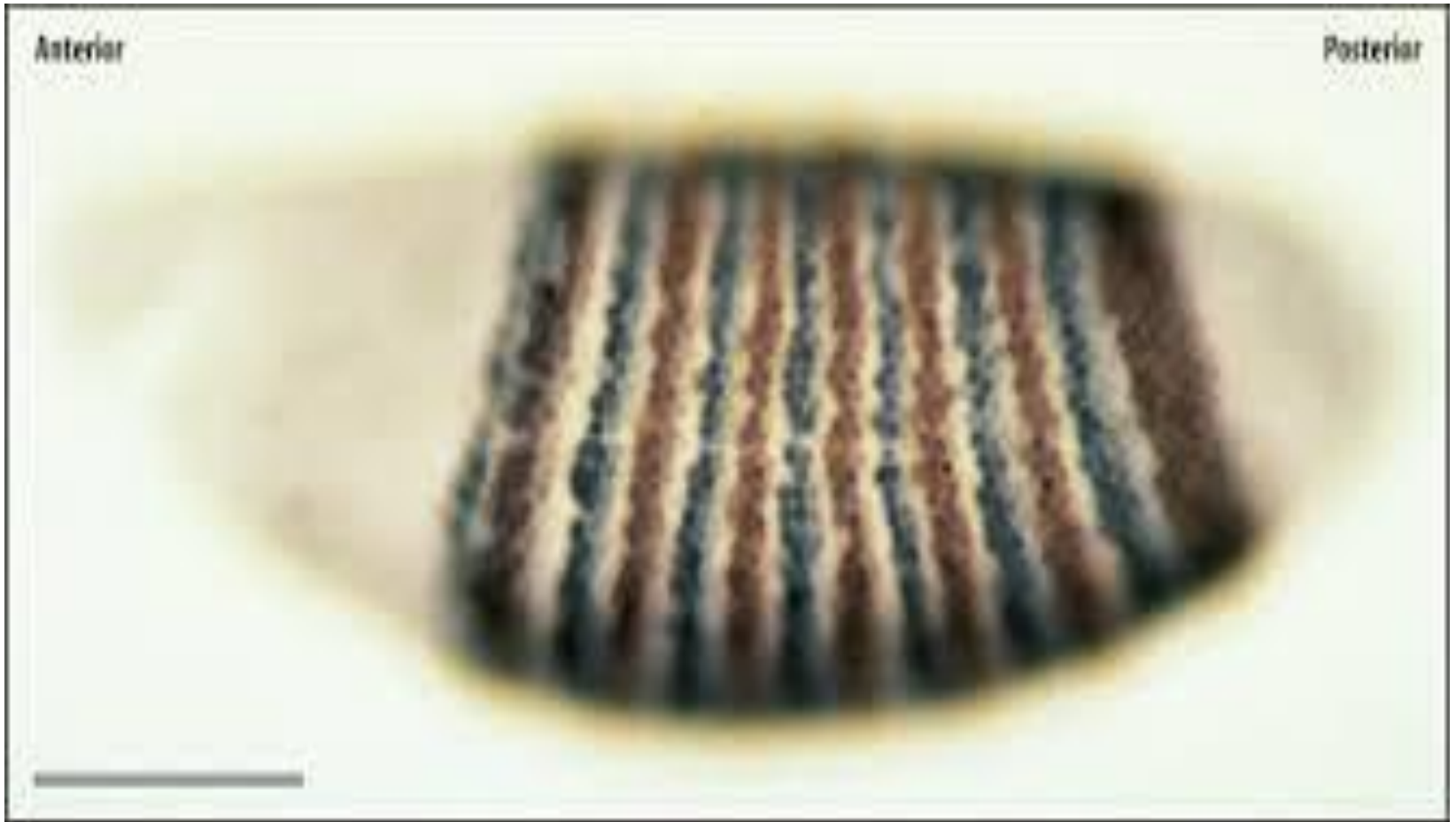


- Pair rule genes were identified genetically by their pattern defects in alternate segments.
- The expression of the each pair rule gene in seven stripes divides the embryo into **fourteen parasegments** ,with each pair rule gene being **expressed in alternate parasegments**.

# Zebra stripe

- One vertical band of nuclei expresses a pair rule gene, then another band of nuclei does not express it, and then another band of nuclei expresses it again. The result is a **zebra stripe**.

# ZEBRA STRIPE



- Pair rule genes are defined by the effect of a mutation in that gene, which causes the loss of the normal development pattern in alternating segments.

- Expression of the pair rule genes even skipped and fushi tarazu in alternating bands in the drosophila in the early embryo.
- Each band corresponds to one parasegment.
- Pair rule genes sets a boundary for parasegments.

# Segment polarity genes

- SPG specify the anterior and posterior polarities of each parasegments in embryo
- Through cell to cell signalling , cell fate are established within each parasegments.

# SPG

## **Anterior polarity**

- Wingless(wg)
- Cubitus interruptus(ci)
- Patched

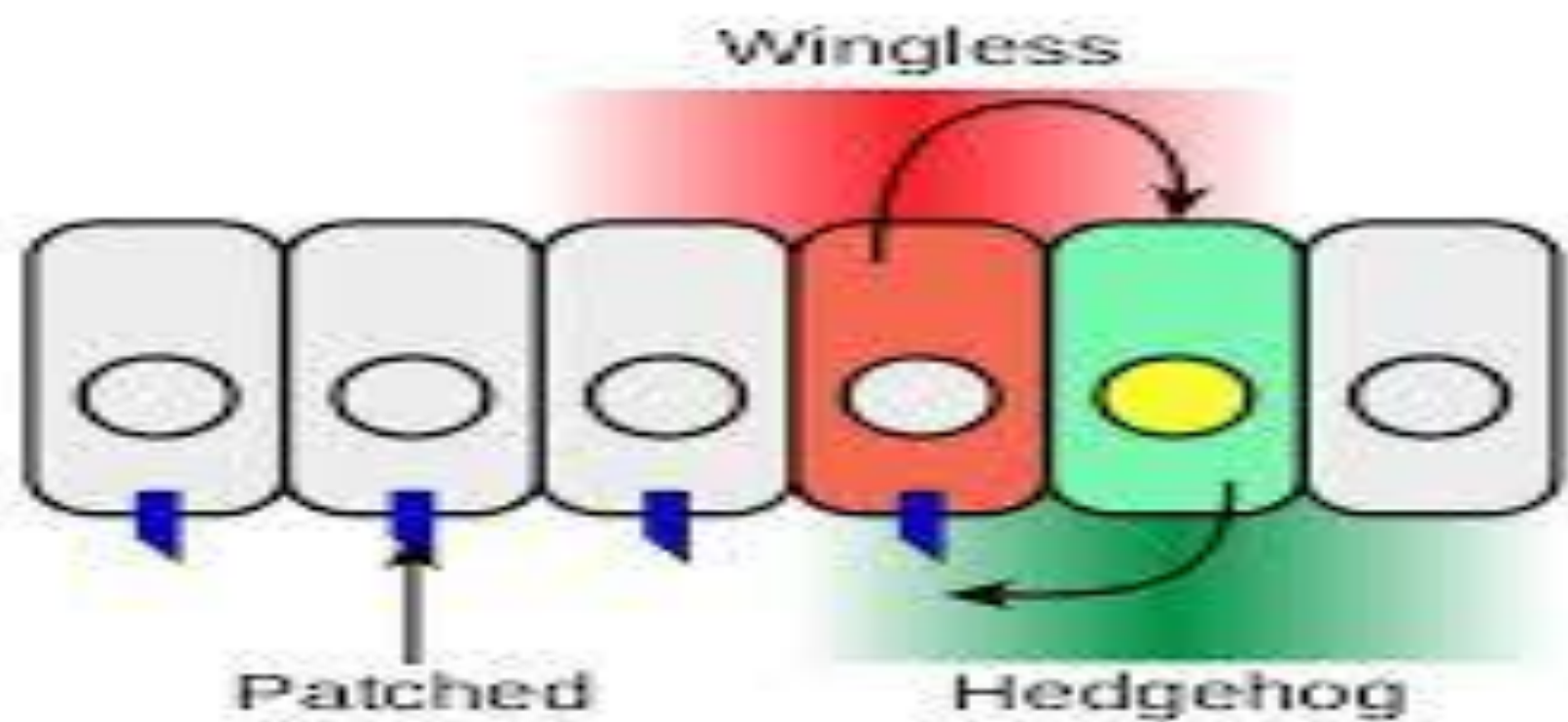
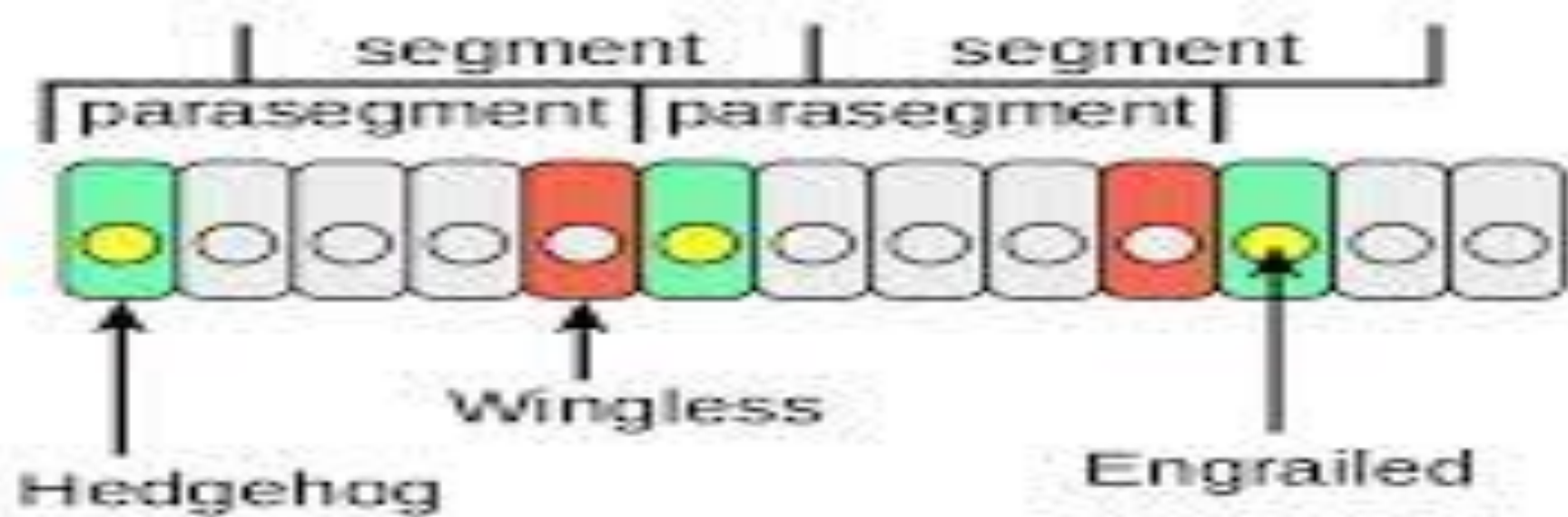
## **Posterior polarity**

- Engrailed (en)
- Hedgehog(hh)
- Armadillo(arm)

# Segment polarity genes

- Wg-secreted molecule → signaling molecule
- En – nuclear protein(TF)
- Patched receptor- for hedgehog
- Frizzled receptor-for wg
- En produced hedgehog
- Patched on wg expressing cells
- Frizzled on En expressing cells





# Signalling pathway

- **Wg** protein secreted from wg expressing cells and diffuse to adjacent cell.
- Cell expressing **en** have frizzled receptor for binding to wg protein.
- **Hh** gene expressed /produced in **en** expressing cells.
- **Hh** bind to patched receptor on wg cells so binding will help in expression of wg cells.

# Signalling pathway

- Wg have receptor on en (frizzled) expressing cells, so wg binding to frizzled will express the en cells.
- In this way the two cells (en and wg) maintain the expression of each other.

- The key to this pattern is the activation of the engrailed gene in those cells that are going to express the Hedgehog protein. The engrailed gene is activated when cells have high levels of the Even-skipped, Fushi tarazu, or Paired transcription factors. Moreover, it is repressed in those cells that receive high levels of Odd skipped, Runt, or Sloppy-paired proteins.

# Signalling pathway

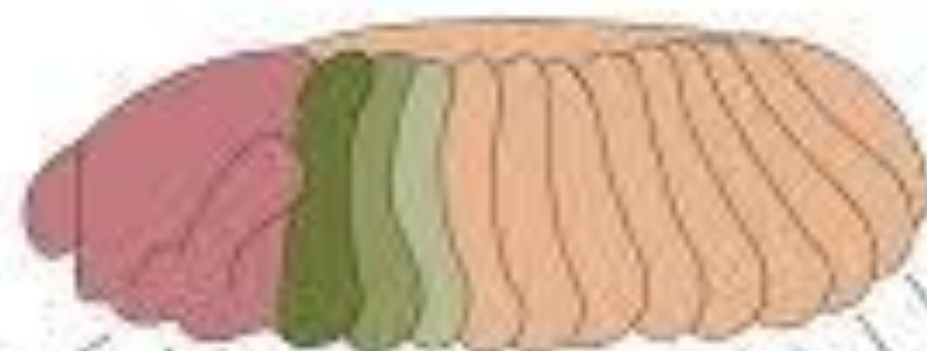
- Wg protein is going to bind with in frizzle receptor on the en gene. This mediate the wnt signalling pathway
- This leads to the activation of armadillo genes.
- This armadillo enter into nucleus and helps in the transcription of hedgehog Mrna
- This Hh mrna translated into hedgehog secrectory protein.

# Signalling pathway continued...

- And make an exit from the nucleus
- Hedgehog protein bind with the patched receptor present on the surface of wg gene.
- Hh also have an binding partner smoothed gene
- This activates the cubitus interruptus gene
- This gene helps to transcribe the wg gene and then to wg mrna → wg protein
- Wg protein again ready to bind with the frizzled receptor on the En gene.

- Engrailed prtn is helps to decide the posterior polarity of a segment and anterior polarity of the parasegment.
- That means same factor is helps to form the different polarities.

# Segments and Parasegments



Segments	Ma	Ms	Lb	T1	T2	T3	A1	A2	A3	A4	A5	A6	A7	A8	A9			
Compartments	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A
Parasegments	1	2	3	4	5	6	7	8	9	10	11	12	13	14				
<i>ftz</i> <sup>+</sup>		█		█		█		█		█		█		█		█		█



- The engrailed gene is activated when cells have high levels of the Even skipped, fushi tarazu, or paired transcription factors
- The wingless gene is activated in those bands of cells that receive little or no even skipped or fushi tarazu proteins
- This causes wingless to be transcribed solely in the row of cells directly anterior to the cells where engrailed is transcribed.

# SUMMARY – ZYGOTIC GENES

