Principles of Development
7.22/7.72 Fall 2005

Principles are in **boldface**, specific terms you should know are in ***boldface italic.***

1. **Development occurs in four dimensions: in three-dimensional space and over time**.

2. **Complexity of the embryo increases over time, in a stepwise, hierarchical fashion.**

3. **Symmetry must repeatedly be broken** to allow formation of different daughter cells or functionally distinct regions.

4. **The progression of a naïve cell towards its final function (*fate)* includes the decision to assume a fate (*determination*) and formation of the final fate (*differentiation*).**

5. **Determination and differentiation each involve multiple, sequential steps.**

6. There are **many possible *cell fates***.

7. **Information that controls *cell type* can be distinct from information that indicates the *position* or *shape* of a cell** in an embryo.

8. **Development is controlled by spatially and temporally regulated *differential gene expression***.

9. **Different cells express different *regulatory genes* that control fate decisions, and different *differentiation genes* that control final cell function.**

10. A ***combinatorial code* of gene expression** allows many different developmental decisions using a limited number of genes.

11. **Gene function is conserved through evolution (*homologs, orthologs)***.

12. **Chromatin structure plays a crucial role in regulating gene expression (*epigenetics*).**

13. **Embryonic regulatory molecules may be stored in the egg (*maternal factors*) or produced by new transcription after fertilization (*zygotic factors*).**

14. **Cells can read and interpret chemical, electrical and mechanical signals** originating from other cells or the environment.

15. **Cell communication can alter cell fate (*induction*). Thus, regulatory molecules can act between cells, that is, non-autonomously (*inducers).***

16. **Cell fate can be controlled by inherited regulatory molecules, which act cell autonomously (*determinants).***

17. **Cells respond differently to the same signal when it is presented at different concentrations (*morphogen*).** Continuous information contained within a concentration gradient is converted to a discrete outcome through ***thresholds*** of activation.

18. Cell fate can be regulated by independent *initiation* and *maintenance* mechanisms.

19. The number of cell fates that a cell has the potential to assume progressively diminishes as development proceeds (*potency*).

20. Cell fate decisions are generally stable.

21. Cells can have restricted temporal and spatial ability to respond to signals (*competence*).

22. **Groups of cells have the potential to assume a particular fate (*equivalence group, field*)**, but often only part of the group does so.

23. **Cell fate decisions often involve both stimulatory and inhibitory signals**. Stimulatory signals encourage cells to adopt a specific fate whereas inhibitory signals prevent a cell from adopting an alternate fate.

24. Cells may inhibit their neighbors from assuming the same fate (*lateral inhibition*).

25. Similar cells may cooperate to promote formation of their fate (*community effect*).

26. Cells that can generate replacements for a specific cell type may be present in many embryonic and adult tissues (*stem cells*).

27. **Development requires both cell division (*proliferation*) and cell death (*apoptosis*).**

28. **Cells can form sheets (*epithelia)* or persist as single cells (*mesenchyme).***

29. Single cells can move (*migrate).* Direction of migration can be regulated (*guidance molecules*).

30. Cells can *sort* into groups of like cells, through selective adherence to each other and to the extracellular matrix.

31. Groups of similar cells can become a functional unit (*tissue*).

32. Boundaries are established to keep cells where they need to be **(*compartments*).**

33. Groups of tissues can work together for a common function (*organ).*

34. Cells move or change shape to build three-dimensional structures ***(morphogenesis).***

35. **Three-dimensional organization of tissues is required for organ function (*morphogenesis*).**