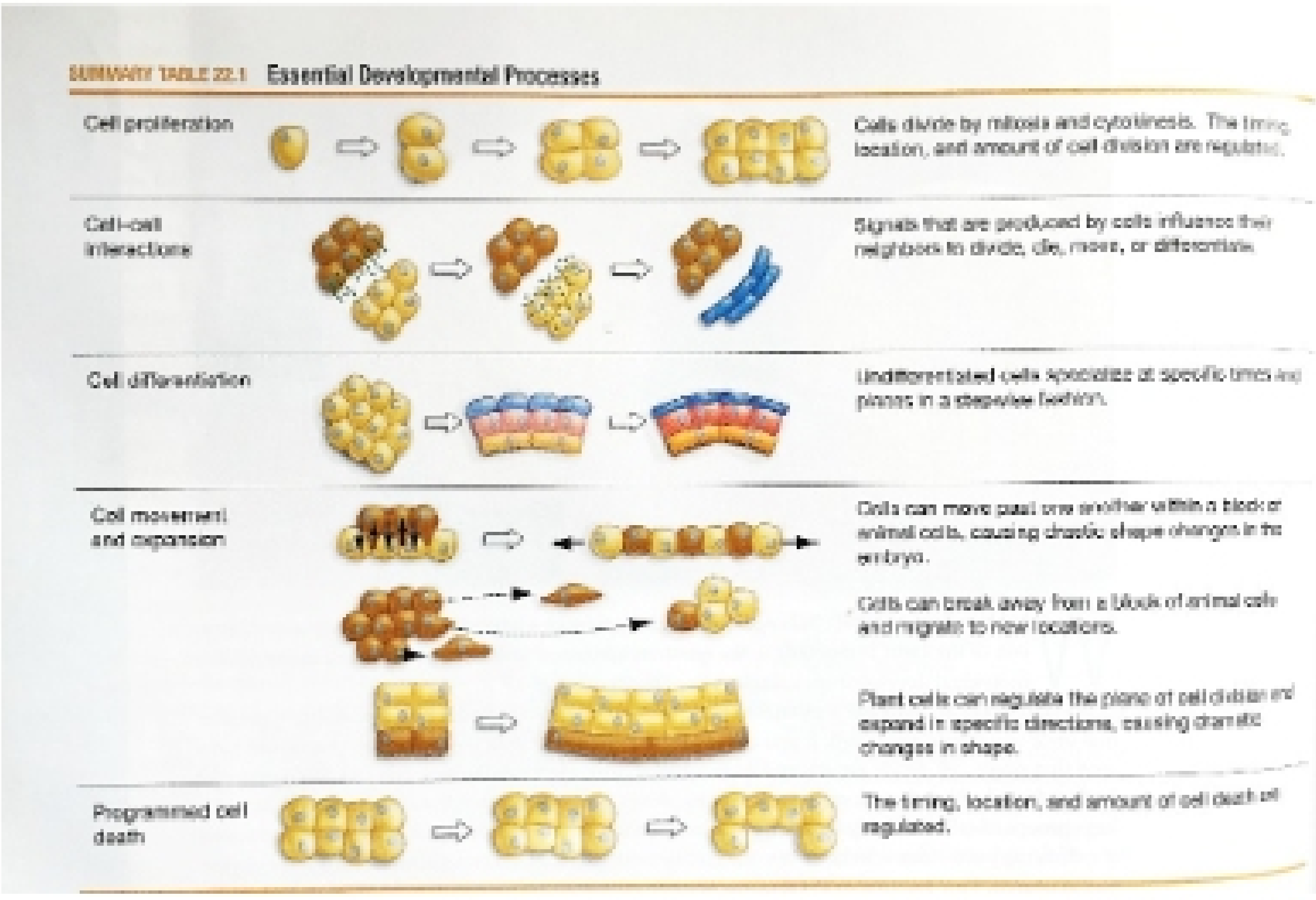
I. Chapter 22 Principles of Development

- **Embryo**: a young developing organism; the stage after fertilization and zygote formation.

A. 22.1 Shared Developmental Processes

- An individual develops as cells divide; signal to one another about where they are, and what type of cell they are becoming; begin to express certain genes rather than others, move or expand in specific directions; and in the case of some cells, die.
- The location, timing, and extent of cell division is tightly controlled.



- **Stem cells**: any relatively undifferentiated cells that can divide to produce a daughter cell that can differentiate into specific cell types.
  - In plants, located in *meristems*.
  - In animals, located in specific part of the body. In adults, stem cells proliferate to replace skin, blood, and gut cells that die; wound repair; and create a constant supply of disease-fighting cells in the immune system.
- As development progresses, most cells undergo **differentiation**- the process of becoming a specialized type of cell.
- Many animal cells have to move to new location for normal development to occur. In plants, cells cannot move because of their cell wall. However, plants are master at controlling both the direction of **cell expansion**- the growth of an individual cell- and the orientation of cell division to determine where cells are added.
- **Gastrulation**: cells in different part of the mass rearrange themselves into three distinct layers, which the give rise to skin, gut, and other basic parts of the body.
- Cell death is a highly regulated aspect of plan and animal development.
- **Apoptosis**: programmed cell death used in development.

B. 22.2 Genetic Equivalence and Differential Gene Expression in Development

- **Genetic equivalence**: all cells share the same genes
- *Dolly the cloned sheep*; the lamb that resulted from the experiment was genetically identical to the white-faced individual that donated the nucleus, not the black-faced egg donor or surrogate mother.

- Taken together, research on cloning plants and animals has shown that cellular differentiation typically *does not involve changes in genetic makeup of cell*. Instead, it results from differential gene expression.
- Transcription is the fundamental level of control during differentiation. In eukaryotes, transcription is controlled primarily by the presence of regulatory transcription factors that influence chromatin remodeling and bind to promoter-proximal elements, enhancers, silencers, and other regulatory site in DNA.

C. 22.3 Chemical Signals Trigger Differential Gene Expression

- Axis of developing cells:
  - 1. **Anterior** (towards head) and **posterior** (towards tail).
  - 2. **Dorsal** (toward the back) and **Ventral** (toward the belly).
  - 3. **Left** to **right**.
- Chemical signals tell cells where they are in time and space. This information works through signal receptors and signal transduction cascades to activate transcription factors that turn specific genes on or off.
- **Patter of formation**: the events that determine the spatial organization of an embryo.
- Many molecules that work in patter formation are present in a concentration gradient, with high concentration near the source of the molecule and lower concentrations farther away. If cells detect the different concentrations to learn their position, then this molecule is a **morphogen**.
- Experiments showed that the "*bicoid gene*" possessed position information.
- *Nussleinvholhard* used *insitu hybridization* to find where the bicoid mRNAs were located.
- **Insitu hybridization**: adding a label to single-stranded DNA or RNA molecules to create a probe that is complementary in sequence to the mRNA of interest.
- Later work showed that the bicoid morphogen is a regulatory transcription factor.
- <u>Morphogens in plants</u>: **auxin** is produced in the embryo's *meristem cells* that lie at the top of what will become a s<u>tem</u>. *Low auxin concentration in the <u>root</u>*.
- Mutants with altered segments have defective *segmentation genes*.
- <u>There are four classes of segmentation genes that act in cascade:</u>
  - **1. Maternally expressed genes** deposit morphogen mRNAs in egg. These morphogens control the formation of large groups of segments that span the anterior of the posterior halves of the embryo.
  - **2. Gap genes** are expressed second, in broad regions along the head and tail axis. Gap genes control the formation of groups of segments that define large body regions.
  - **3. Pair-rule genes** are expressed next, in altering bands along the embryo.
  - **4. Segment polarity genes** are expressed later, in a restricted band within every segment. That patter and order of expression imply that segment polarity genes create specific regions with each segment.
- **Hox genes**: products specify each segment's identity by activating effector genes.
- **Homeoosis**: body parts in the wrong place. Caused by homeotic mutations.
- Hox genes are distinguished by a sequence call the **homeobox** that encodes a DNA-binding domain.

- More generalized: Morphogens- produced by maternally expressed genes and deposited in the egg- trigger the production of other regulatory signals and transcription factors, which initiate the production of another set of signals and regulatory proteins, and so on down the chain.
- Animals and plants each have a conserved set of tool-kit genes that code for signals, signal transduction pathways, and regulatory proteins that are used to direct related aspects of elopement in many different species.

D. 22.4 Changes in Developmental Gene Expression Underlie Evolutionary Changes

- Mutations in genes responsible for development can lead to the evolution of new body sizes, shapes, and structures.
- Mutations in regulatory sequences of DNA are especially important because they can change when, where, and to what levels key regulators are expressed.