Cell-cell interaction & communication

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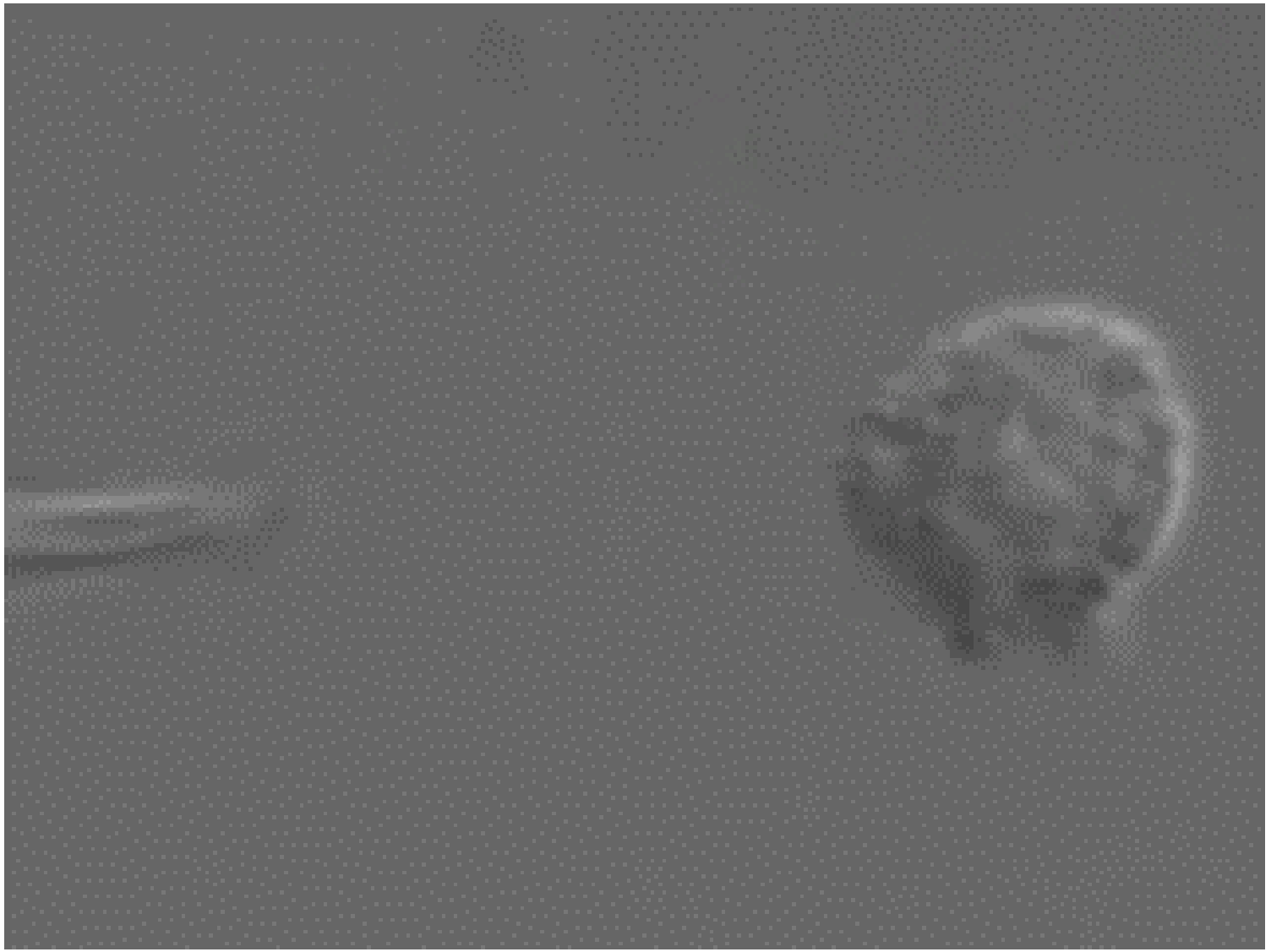
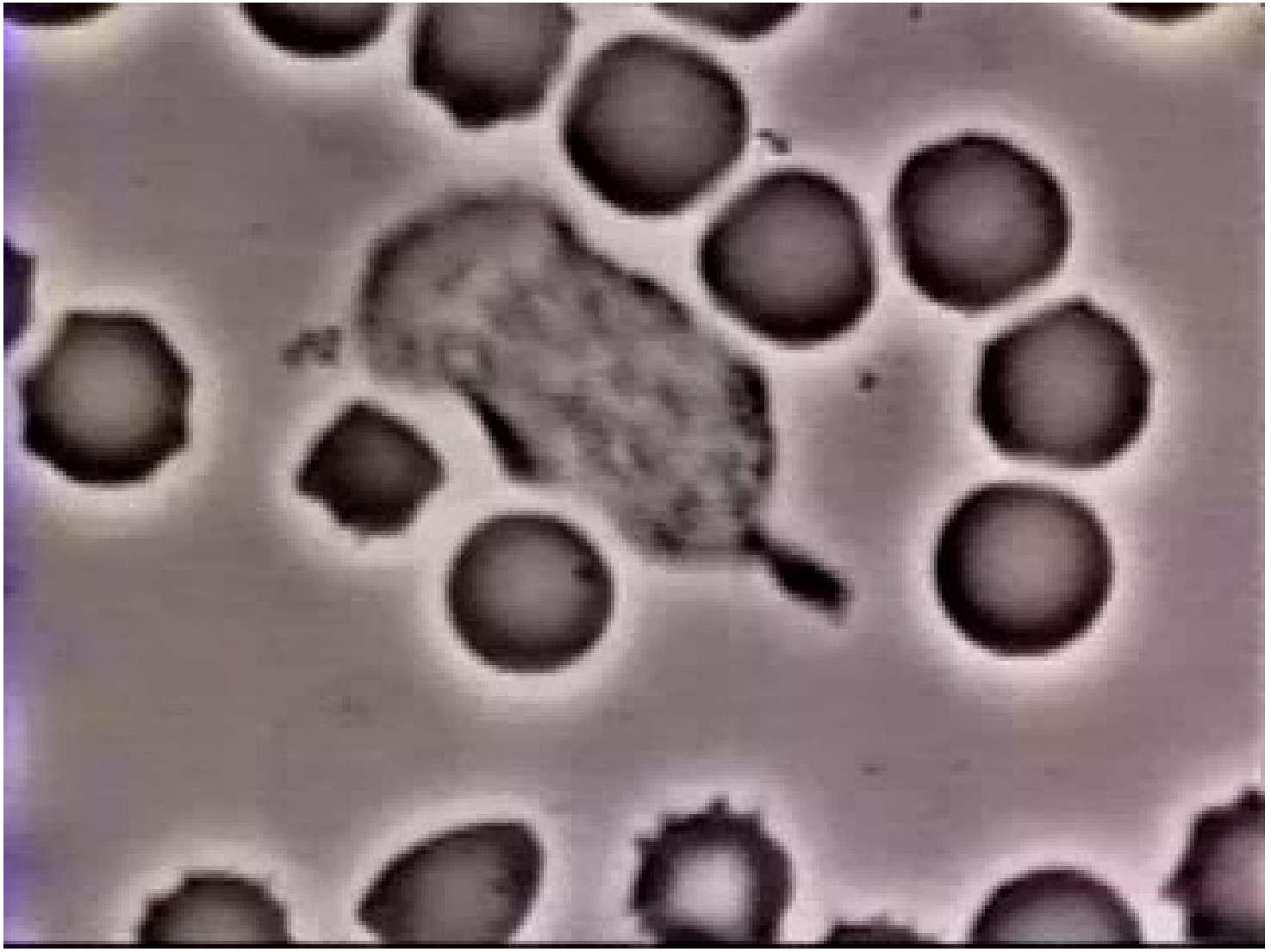
White blood cell response to chemotactic substance



Neutrophil polarize and migrate to the Chemotactic substance

Communication: bacteria vs white blood cell

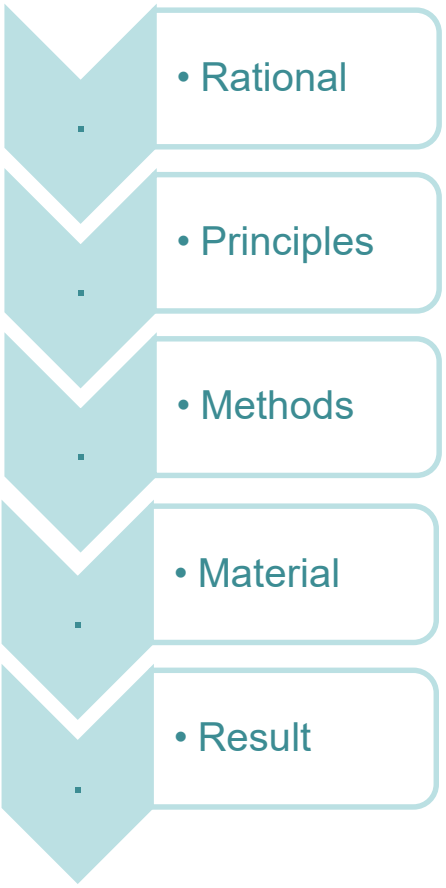


Cocci bacteria secrete some signals detected by neutrophil

Objectives of Learning

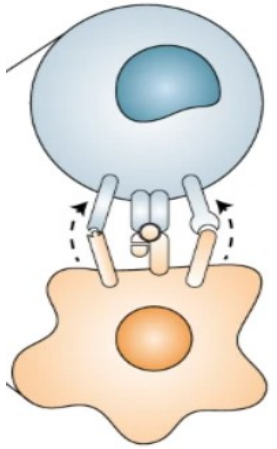
Students would be able to **describe and discuss** the following:

1. An importance of cell-cell interaction & communication
2. General principles of cell-cell interaction & communication
3. How do cells interact & communicate to others?
4. Function of adhesion molecules, extra-cellular matrix and cell-cell communication molecules
5. Cells response to the communication & interaction



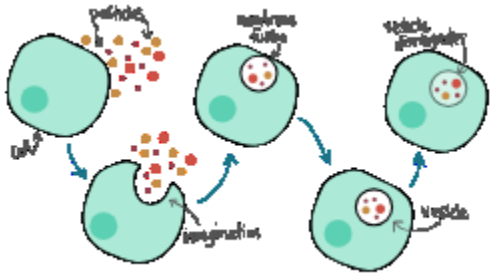
Definition

- Cell-cell interaction:
  - ✓Cells contact each others or
  - ✓contact with extracellular matrix (ECM)
  - ✓in order to form an organ or
  - ✓facilitate communication.



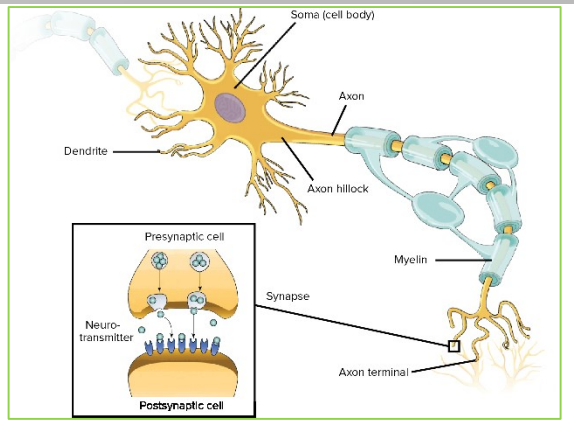
Cell–cell interaction

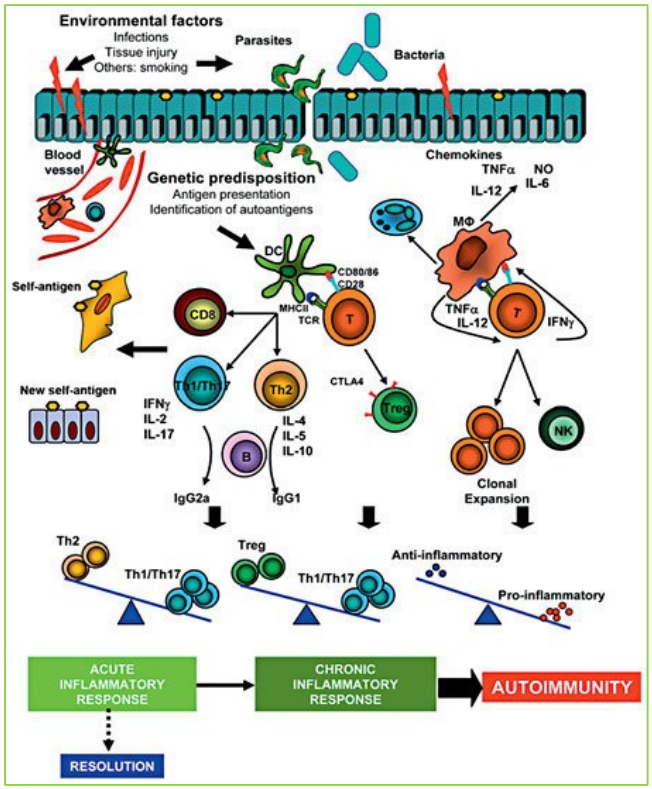
- Cell-cell communication:
  - ✓Ways of living cells (of an organism) communicate with one another,
  - ✓By direct contact between cells or by means of chemical signals
  - ✓e.g. : neurotransmitter substances, hormones, cykinds, and cyclic AMP.

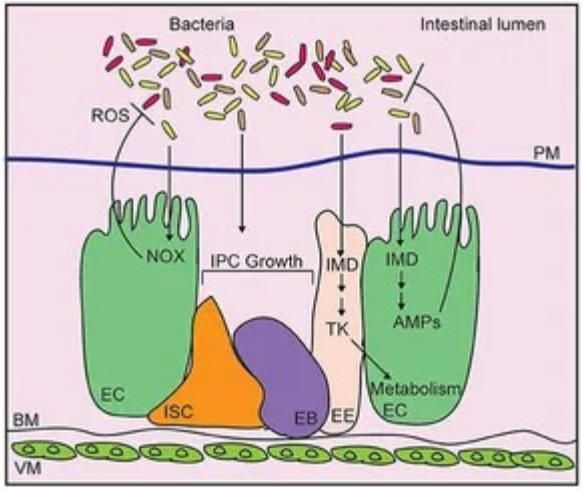


Which cells communicate?

- Immune-immune cells
- Neuron-neuron cells
- Hormone glands-target cells/organs
- Neighbor cells in each organ
- Host - microbe cells
- All living cells

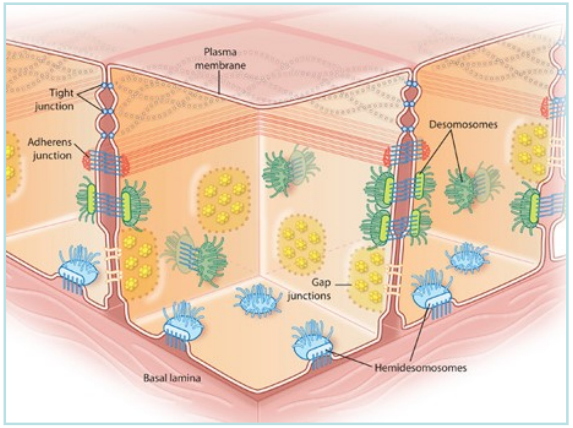


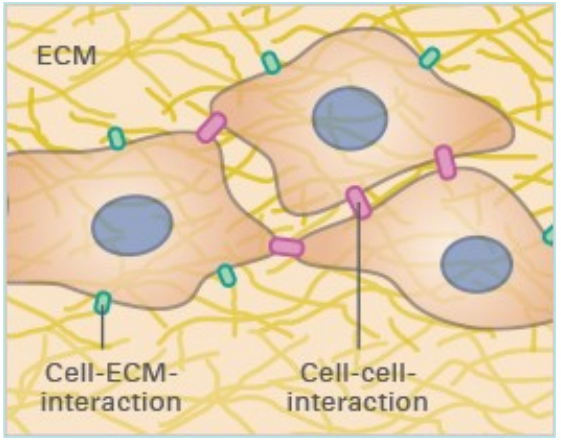




Why cells have to interact each other?

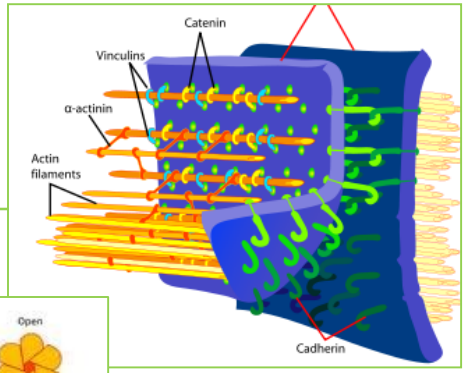
1. To <u>combine cells</u> together
   - to form part of organ
   - hold cells in its proper place,
   - carry out a structural role
2. Be able <u>to communicate</u> with its neighbor cells
3. <u>To facilitate biological process</u>:
   - growth,
   - permeability,
   - tissue repair,
   - embryogenesis,
   - differentiation.

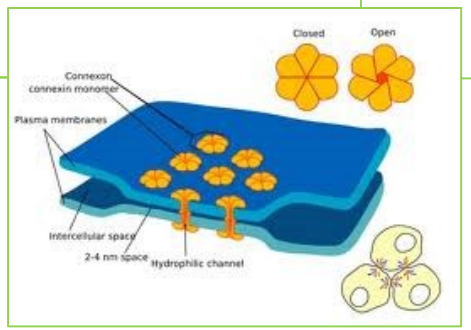




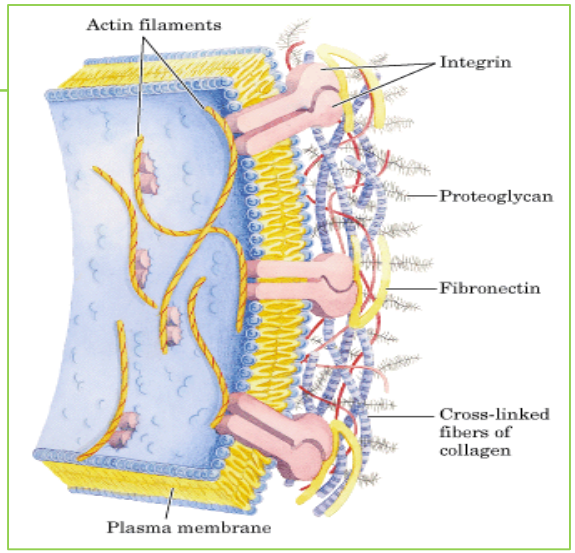
Principles of cell-cell interaction

1. Direct contact of cells:
   a. cell adhesion molecules
   b. Gap junction: exchange signal molecules

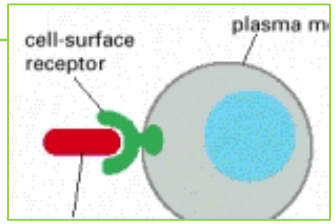




2. Cells-extracellular matrix (ECM) contact

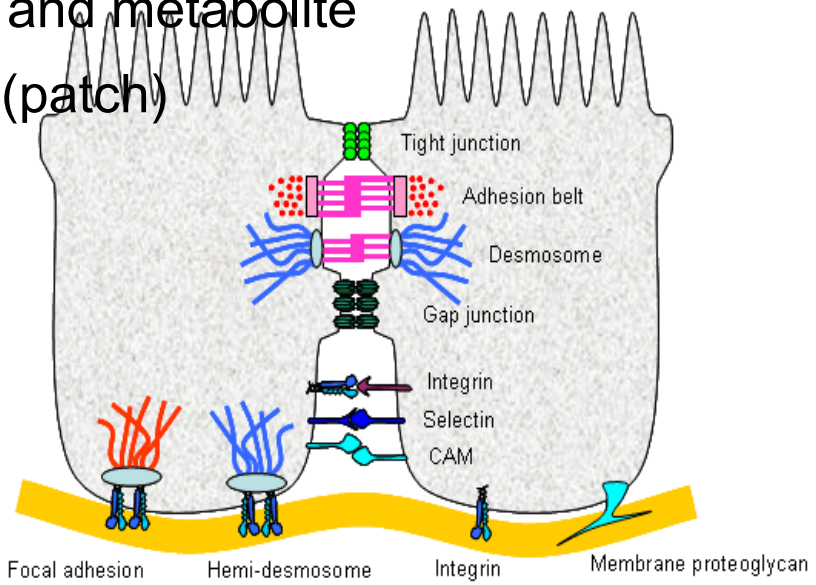


3. Ligand and its specific receptor molecule



Cell:Cell Direct Contact

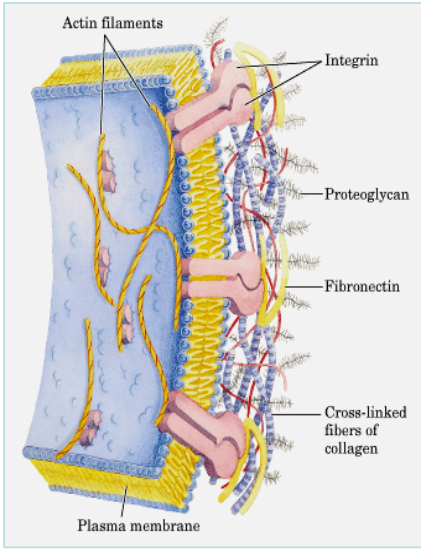
- The contacts are vital in multicellular organisms.
- Facilitate transport and communication
- 4 kinds of cell junction in vertebrate cells.
  1. Tight junctions: hold cell together, barrier
  2. Adherent junction: stability and integrity (belt)
  3. Gab junction: small channels for ion and metabolite
  4. Desmosomes: stability and integrity (patch)
  5. Integrin
  6. Selectin
  7. CAM

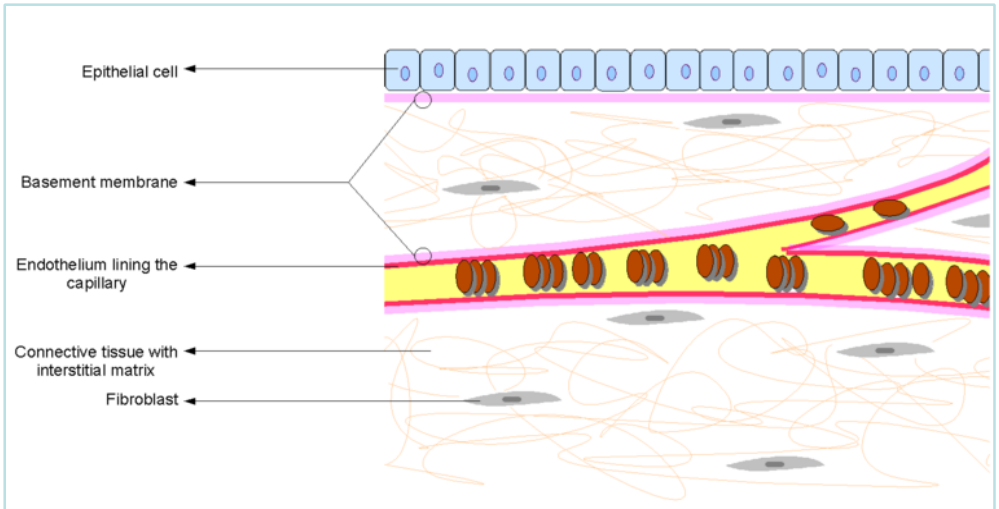


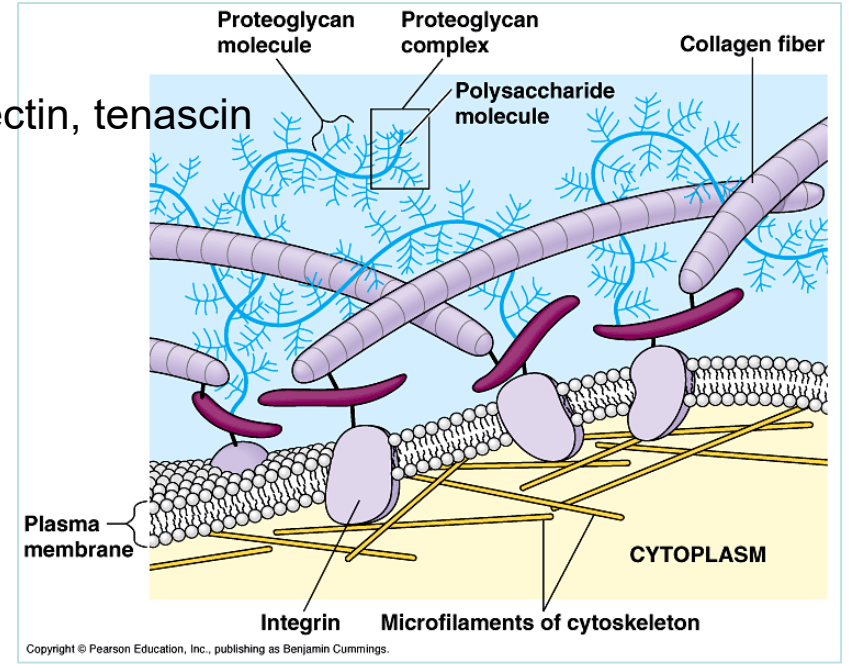
http://cellbiology.med.unsw.edu.au/units/science/lecture05

Extracellular matrix (ECM)

- Extracellular part of animal tissue
- Produced intracellularly, secrete via exocytosis
- Providing support and anchorage for cells
- Segregating tissues from one another
- 3 types
  1. Proteoglycan: polysaccharide gel
  2. Structural proteins: collagen, elastin:
  3. Fibrous adhesive protein: laminin, fibronectin, tenascin

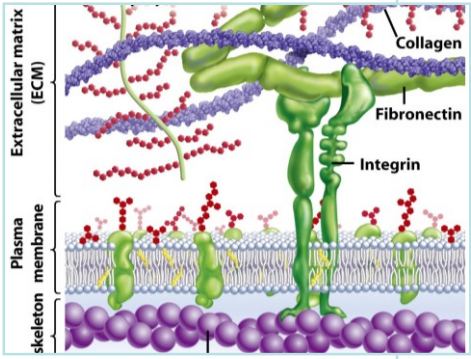


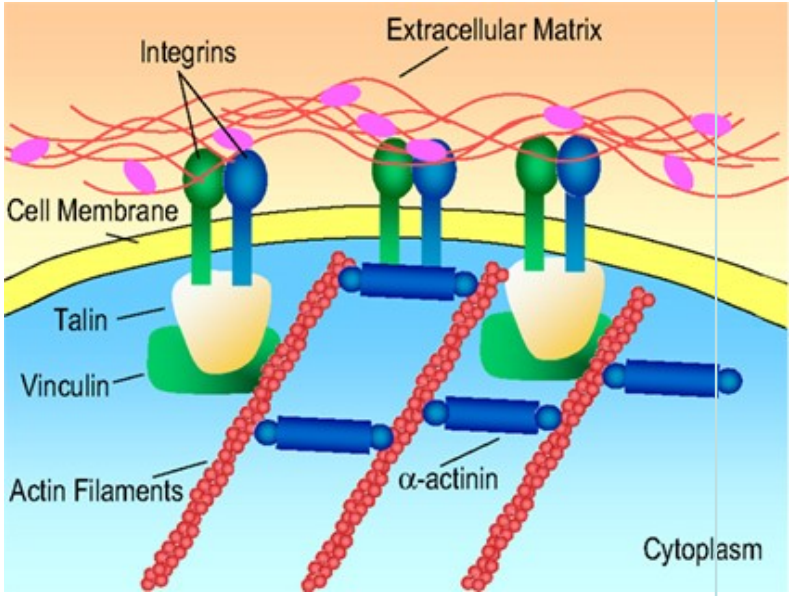




Cell-ECM Functions

- Regulating intercellular communication
- trap and store (relay) signals
- control cell shape and motility
- Cell use integrins to bind ECM
- Essential for processes like
  - ✓growth,
  - ✓wound healing,
  - ✓Fibrosis
  - ✓tumor invasion
  - ✓metastasis





www.frontiersin.org/neuroengineering/10.3389/neuro.16.006.2009/full

Principle of cellular communication

A. Reception

1. Extracellular signal molecules bind to *specific* receptor
2. They can act over either short or long *distance*
3. Autocrine signaling can *coordinate decision*
4. Many types of cell communication *molecules*

B. Transduction

1. signal transduction *pathway*
2. Cross talk *network*

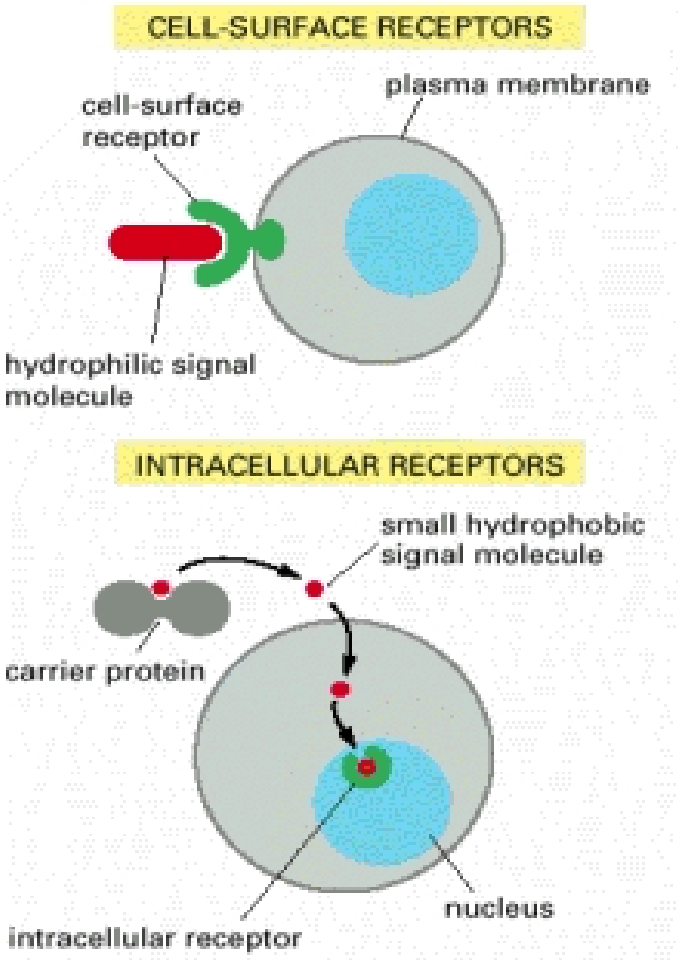
C. Response

1. Each cell response to specific *combination of signal* molecules
2. Different cell can *response differently* to the same signal molecule
3. The *responses can vary* from turning on a gene, activating an enzyme, rearranging the cytoskeleton

A. Reception

PRINCIPLE OF CELLULAR COMMUNICATION

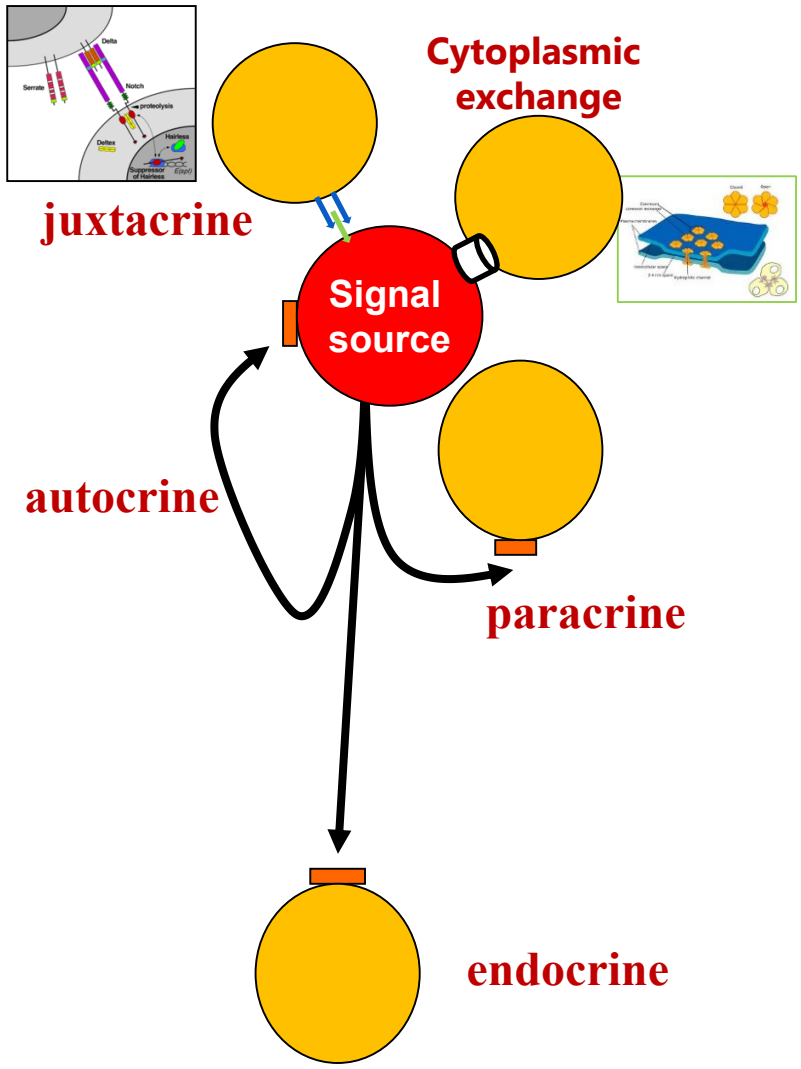
1. Extracellular Signal Molecules Bind to Specific Receptors



- Specificity ***
- Two types of signal molecules
  1. Hydrophilic signal molecules
     - *bind to cell-surface specific receptors*
     - turn one or more signals inside the target cell.
  2. Hydrophobic signals
     - *bind to carrier proteins*
     - dissociate, diffuse across membrane
     - bind to specific receptors inside the target cell
     - either in the cytosol or in the nucleus

Molecular Biology of the Cell. 4th edition. Alberts B, Johnson A, Lewis J, et al.; 2002

2. Extracellular Signal Molecules Act Over Either Short or Long Distances



1. Cytoplasmic exchange:

- electro-chemical signal
- through gap junction
- e.g. ion, cAMP

2. Juxtacrine:

- contact-dependent signaling
- transmission via components of a cell membrane, integrin or ephrin
-e.g. growth factors, Immune celll

3. Autocrine:

- regulates on the same cell of signal source
- both short or long distance

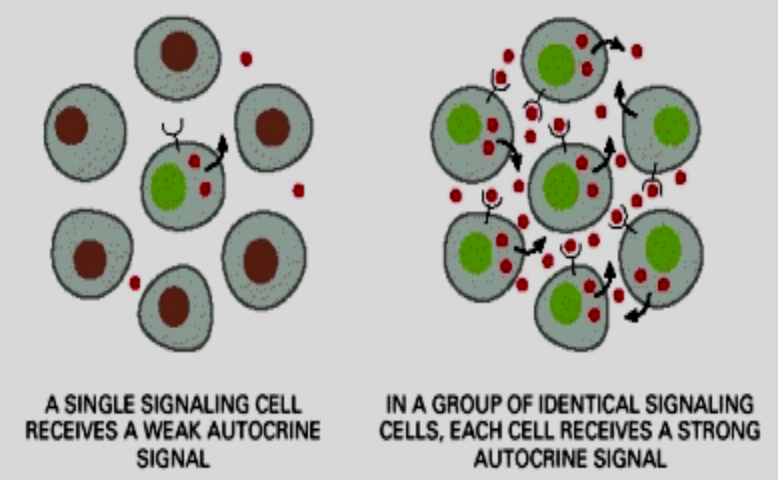
4. Paracrine:

- cells in the immediate area (local)
- e.g. *neurotransmitter*

5. Endocrine:

- cells in the distance area
- Blood vessel dependent
- e.g. hormone

★3. Autocrine Signaling Coordinate Decisions by Groups of Identical Cells



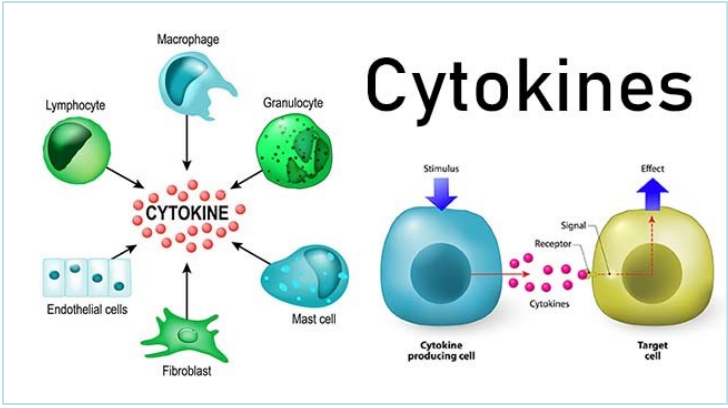
- A group of identical cells produces a higher concentration of a secreted signal than does a single cell.
- encourages the cells to respond coordinately as a group.
- <u>quorum sensing</u>
- Pathogenesis of bacterial pathogen, biofilm production, drug resistance

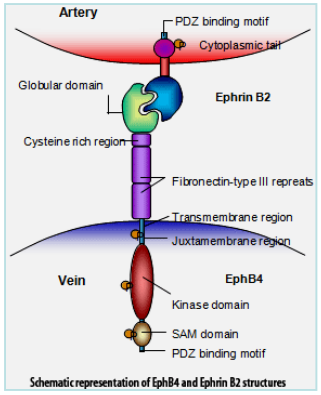
4. Cell communication molecules

"soluble molecules that transmit biological signals between cells"

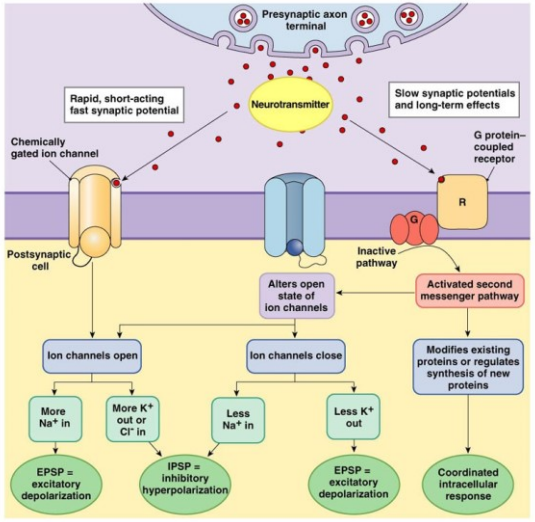
Types of the signaling molecules

1. Cytokines: interferon, interleukin, lymphokine
2. Growth factors
3. Hormones
4. Neurotransmitter
5. Ephrin

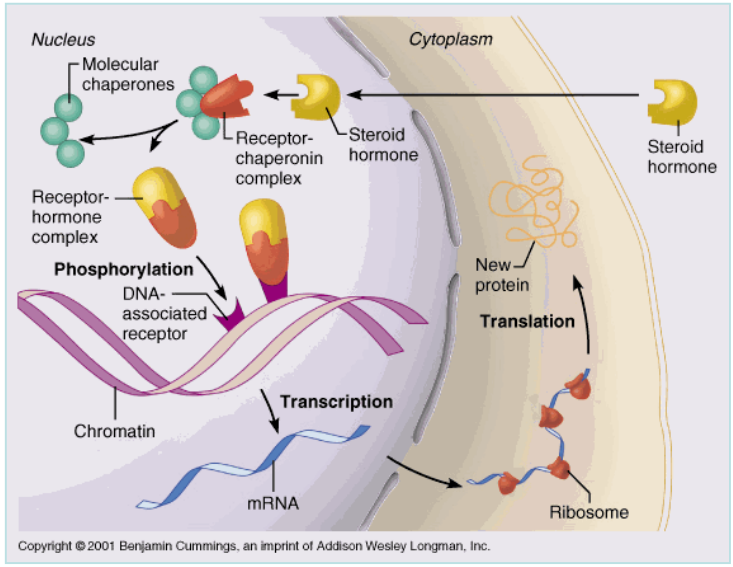




"Jaxtacrine"



"paracrine"



"Endocrine"

B. Transduction

PRINCIPLE OF CELLULAR COMMUNICATION

1. Signal transduction pathway

- Cascade transduction
- G protein/ phosphorylation
- Finally reach its target gene/enzyme
- Regulate expression of its target gene/enzyme.

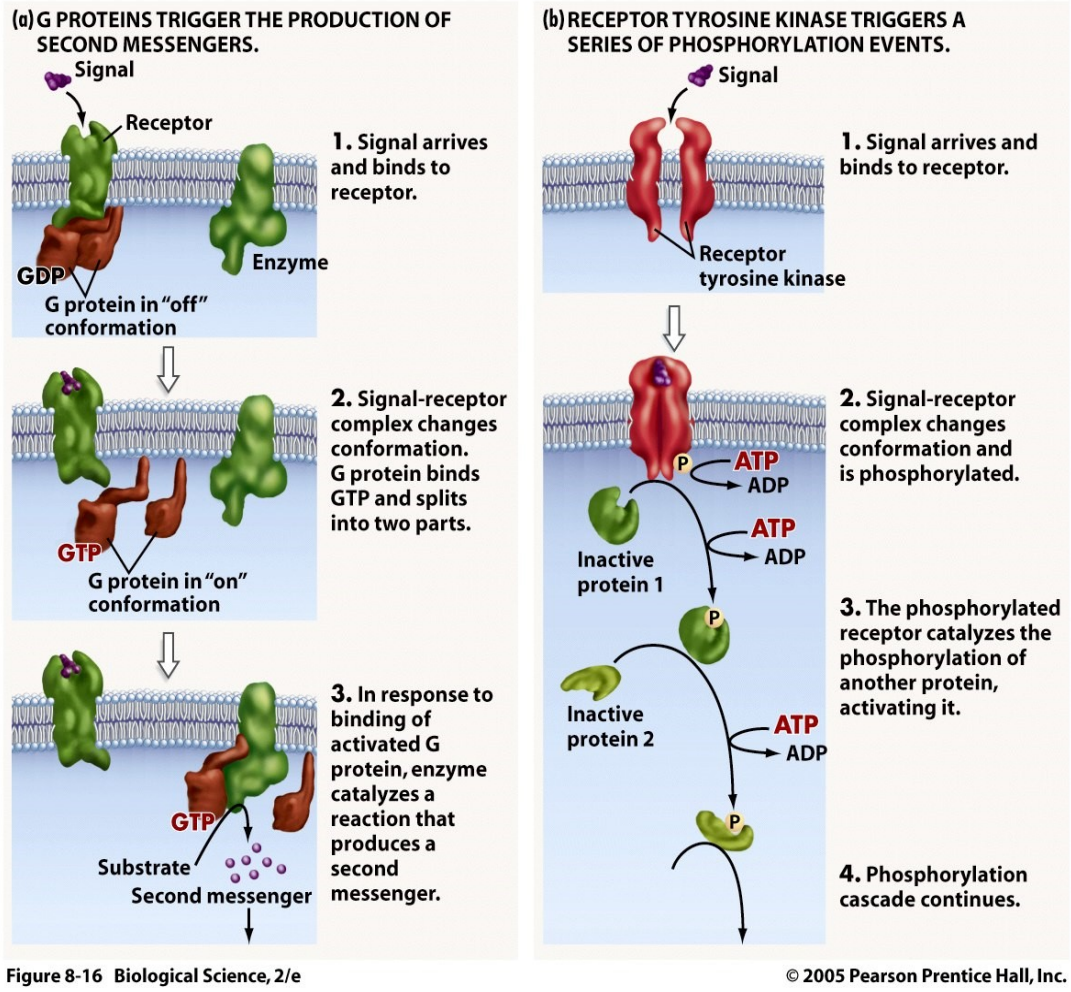
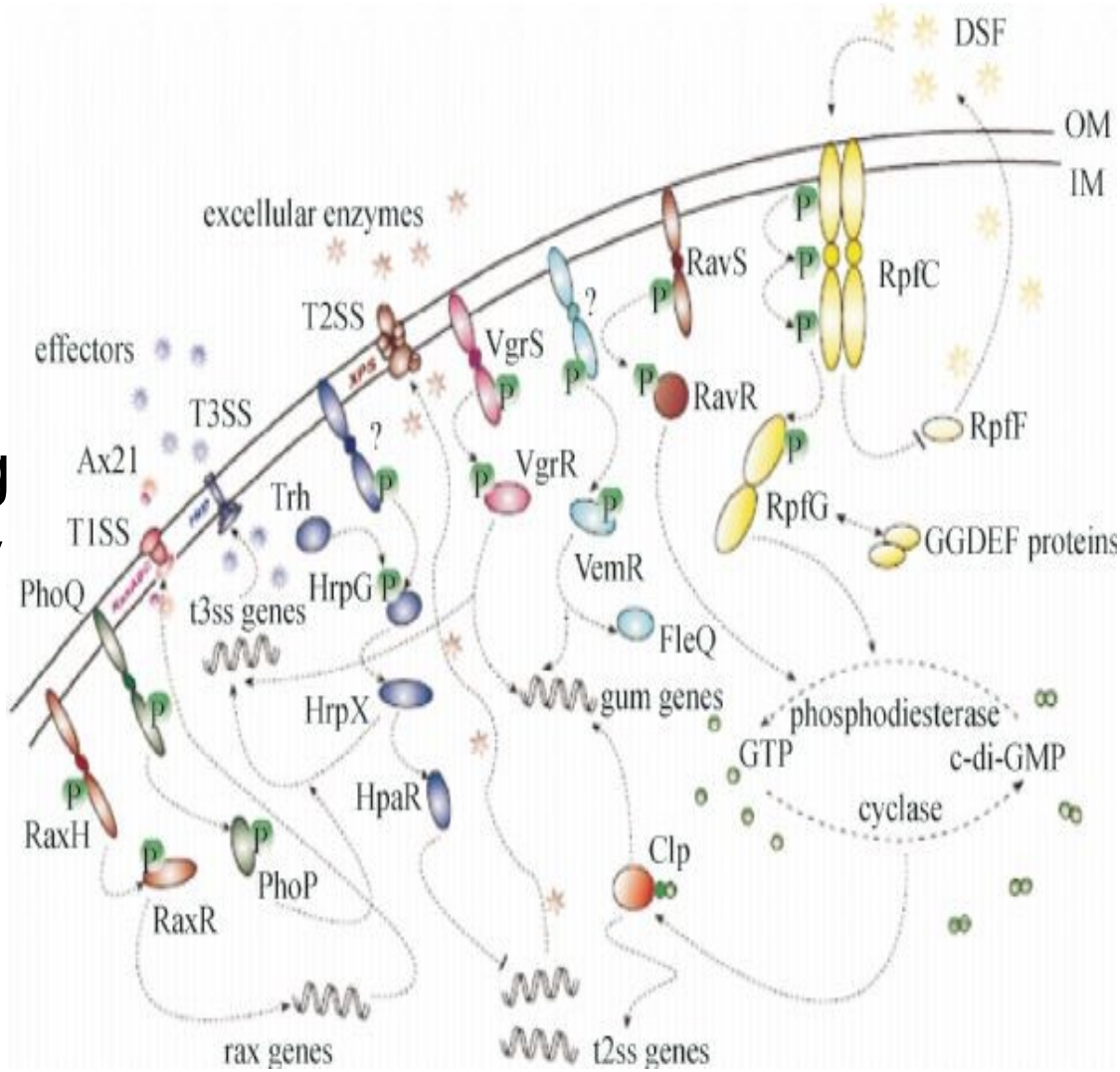


Figure 8-16 Biological Science, 2/e

2. Cross talk network transduction

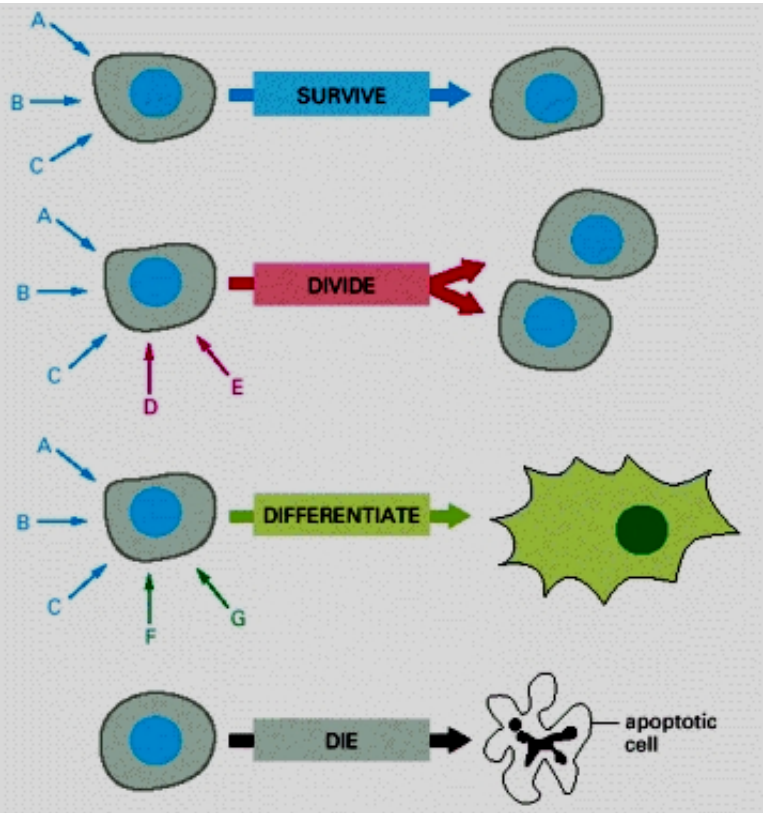
- Cross signaling between pathway
- To compensate some defect
- To make fine tuning for response properly

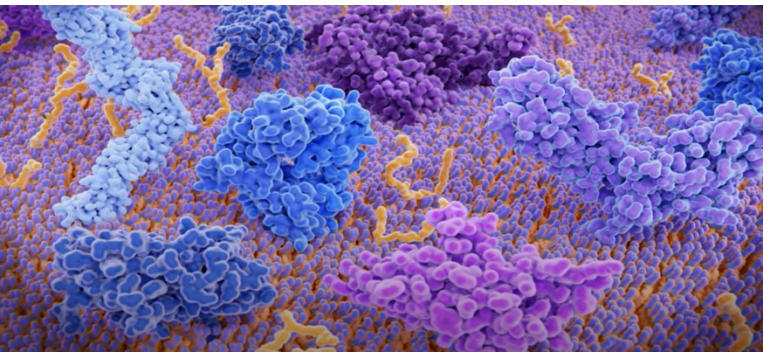


C. Response

PRINCIPLE OF CELLULAR COMMUNICATION

★1. Each cell is programmed to response to specific combination of extracellular signal molecules

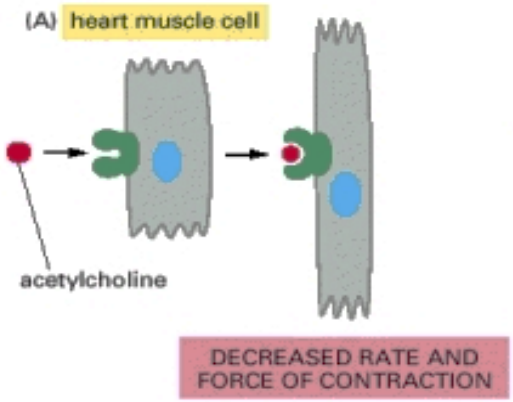


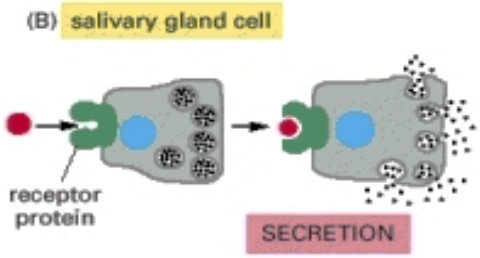


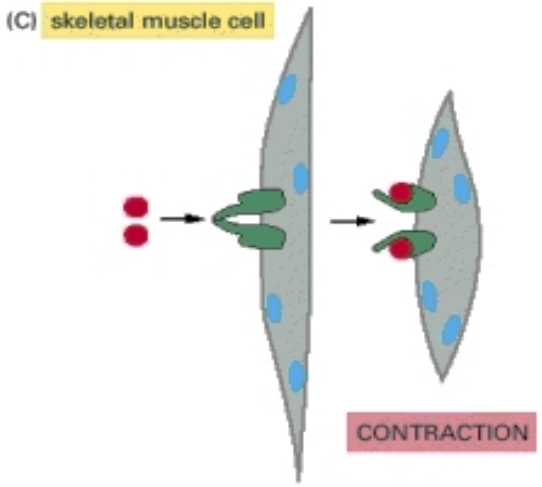
- cell's dependence on multiple extracellular signals
- Each cell type displays a set of receptors
- respond to a corresponding set of signal molecules.
- These signal molecules work in combinations
- to regulate the behavior of the cell.

★2. Different cell can response differently to the same extracellular signal molecule

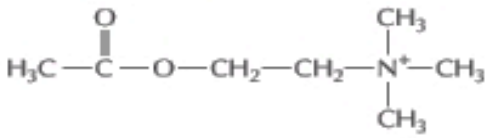
- Different cell types respond to acetylcholine in different ways.
- (A) and (B) similar receptor
- (A) Heart muscle cell: decrease rate & force of contraction,
- (B) Salivary gland cell: secretion
- (C) Muscle cell with distinct type of receptor: Contraction







(D) acetylcholine



3. Cells respons to the interaction & communication

Regulate target-gene expression to response in many ways

- Signal amplification
  - ✓autocrine
- Survival of the cells
  - ✓Differentiation: growth factors
  - ✓Maintain or change biochemical mechanism
  - ✓Cell dead: apoptosis
- Changes in cytoskeletal
  - ✓Conformation change: for movement

What happen in case of miscommunication

- **Metastasis of Cancer**
  - Metastasis: impaired cell interaction facilitating spread to other organs

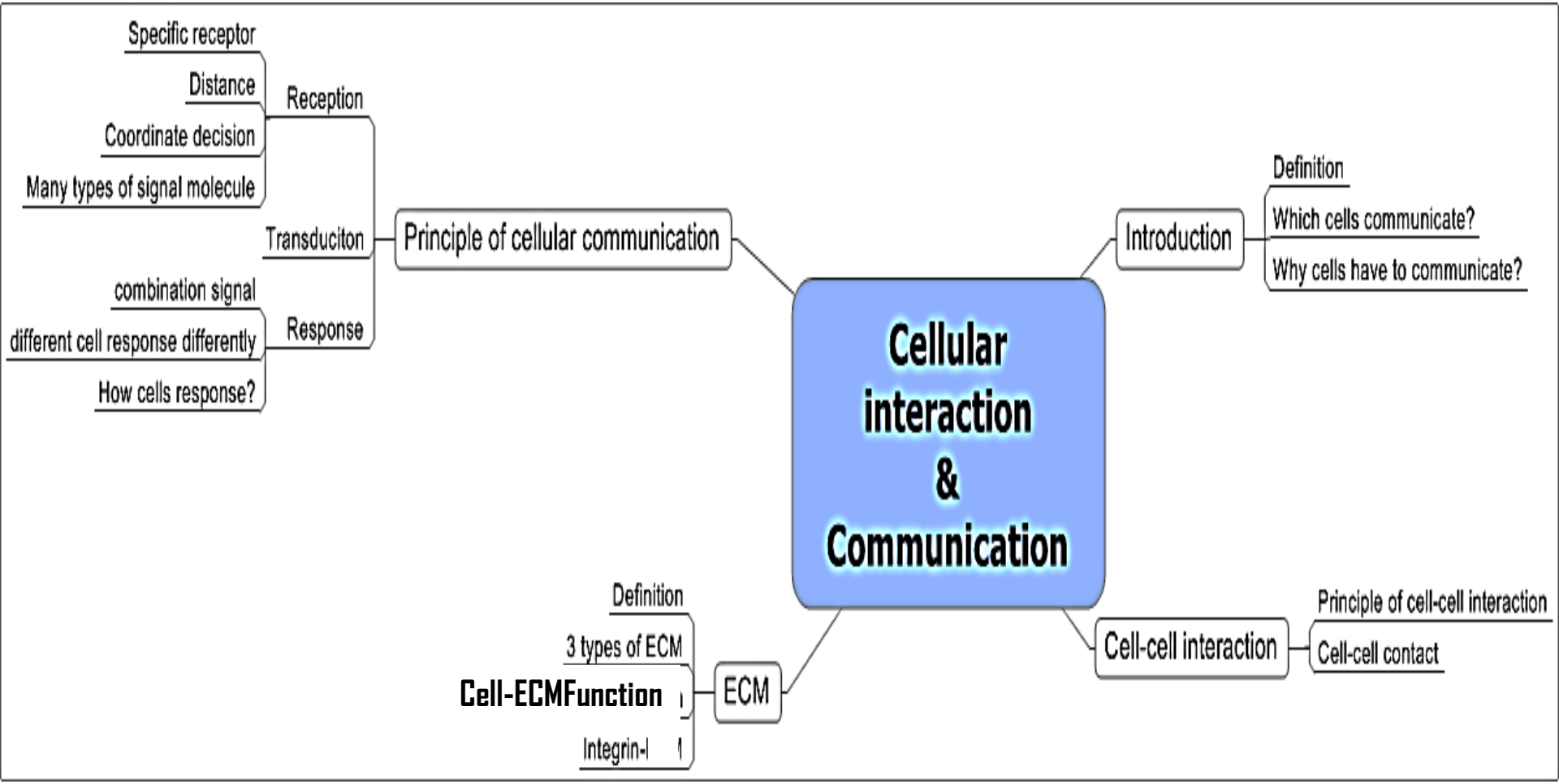
- **Type II Diabetes Mellitus**
  - impaired insulin signaling (resistance)
  - Insufficient signaling
  - poor regulation of blood glucose levels

- **Breast Cancer**:
  - Abnormal signaling receptors: HER2
  - lead to uncontrolled cell proliferation.

- **Rheumatoid Arthritis**:
  - abnormal immune signaling
  - inflammation and joint damage

- **Duchenne Muscular Dystrophy**: Involves
  - mutations that affect signaling pathways
  - Affect muscle maintenance and repair

Mind map for Conclusion



References

- Molecular Biology of the Cell. 4th edition. Alberts B, Johnson A, Lewis J, et al.; 2002
- Wikipedia.org
- Internet resources