cell to cell communication

control cell makes and sends the signal
target cell receives message and responds
target cells must have the appropriate receptor

types of cell to cell communication

local  
- target cell adjacent to control cell
  - gap junctions
  - cell-to-cell contact
  - interstitial space

 distant
- target cell not adjacent
  - endocrine system via blood
  - nervous system via axon + synapse

types of chemical signals

paracrines affect adjacent cells
- local inflammation
- blood clotting
- tissue growth
- development

autocrines affect same cells that secreted them
- smooth muscle

neurotransmitters cross a synapse

hormones travel through blood

chemical classes of hormones

steroids made from cholesterol
- estrogen, progesterone, testosterone
- cortisol, aldosterone

amines made from tyrosine
- epinephrine, norepinephrine
- thyroid hormone

polypeptides longer chains than amines
- insulin, growth hormone

glycoproteins
- FSH, LH, TSH

mechanisms of hormone action

The mechanism depends on location of the receptors.

gene activation mechanism
- receptor in nucleus or cytoplasm
- acts as transcription factor / activates genes
- steroid hormones; thyroid hormones

2-messenger system
- receptor on cell membrane
- transduction
- affects enzymes, protein channels
- amines, peptide hormones

gene activation mechanism

hormone enters cell
binds to and activates the receptor (in cytoplasm or nucleus)
hormone-receptor complex moves to the nucleus
binds to a hormone-response element (on DNA)
turns on/off a specific gene - acts as transcription factor
gene directs protein synthesis of:
- enzymes
- structural protein
- secretory protein
- membrane channels
2 messenger systems - general

problem? some hormones can’t get through cell membrane

1st messenger hormone
2nd messenger chemical in cytoplasm
transduction 1st messenger activates 2nd messenger

2nd messenger triggers target cell’s response

note: hormone effect based on enzymes present in target cell

cAMP as 2nd messenger

hormone binds to receptor
receptor activates G-protein = transducer
G protein activates adenylate (adenylyl) cyclase
adenylate cyclase converts ATP → cAMP
cAMP activates protein kinase
protein kinase triggers cell’s response
turns on/off enzymes in cell
open/close ion channels
secretions

cAMP inactivated by phosphodiesterase

other 2nd messengers

1st messenger hormone
membrane enzyme Phospholipase C

2nd messenger IP₃ (inositol triphosphate)
Calcium - w/ calmodulin
DAG (diacylglycerol)

exocytosis / secretions
open/close membrane channels
muscle contraction

effects of Ca as 2nd messenger

hormone affects on target cell

change plasma membrane permeability
activate / deactivate genes
activate / deactivate enzymes
control protein synthesis
stimulate secretion
mitosis

level of response depends on blood levels of hormone

hormone characteristics

specificity require specific receptor on target cell
can only affect cell/organ with receptor
hormone’s effect depends on the receptor

agonist hormone stimulates receptor/ target cell
antagonist hormone inhibits receptor/ target cell

up-regulation hormone effect increases over time  ↑ # receptors on target cell
down-regulation hormone effect decreases over time  ↓ # receptors on target cell
control of hormones

control of hormones

change in conditions stimulates hormone production
humoral changes
neural changes
hormonal changes

response/return to normal inhibits hormone production

change in conditions / stimuli:

humoral changes/ change in body condition
glucose, Ca^{2+}, NaCl, temperature

neural changes neurotransmitters
neuron controls / modulates endocrine gland
eg. adrenal medulla; pancreas; hypothalamus

hormonal changes other hormones
one endocrine gland controls another endocrine gland
hypothalamus controls pituitary gland
anterior pituitary controls other endocrine glands

another look at genetics

A cell’s gene is controlling the functions in a distant cell
cytoplasm of a distant cell
distant cell’s genes and protein synthesis
its cell membrane