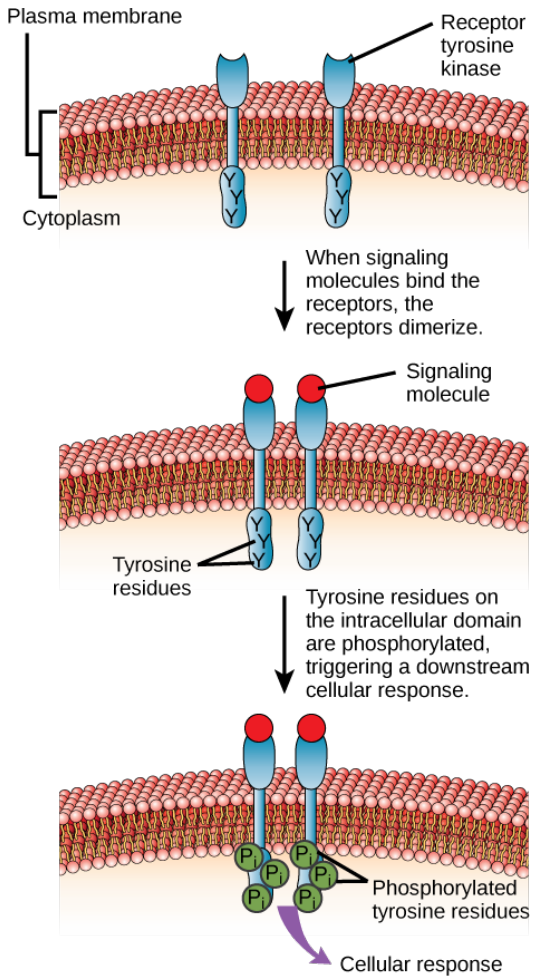
Biology 2e
Unit 2: The Cell
Chapter 9: Cell Communication

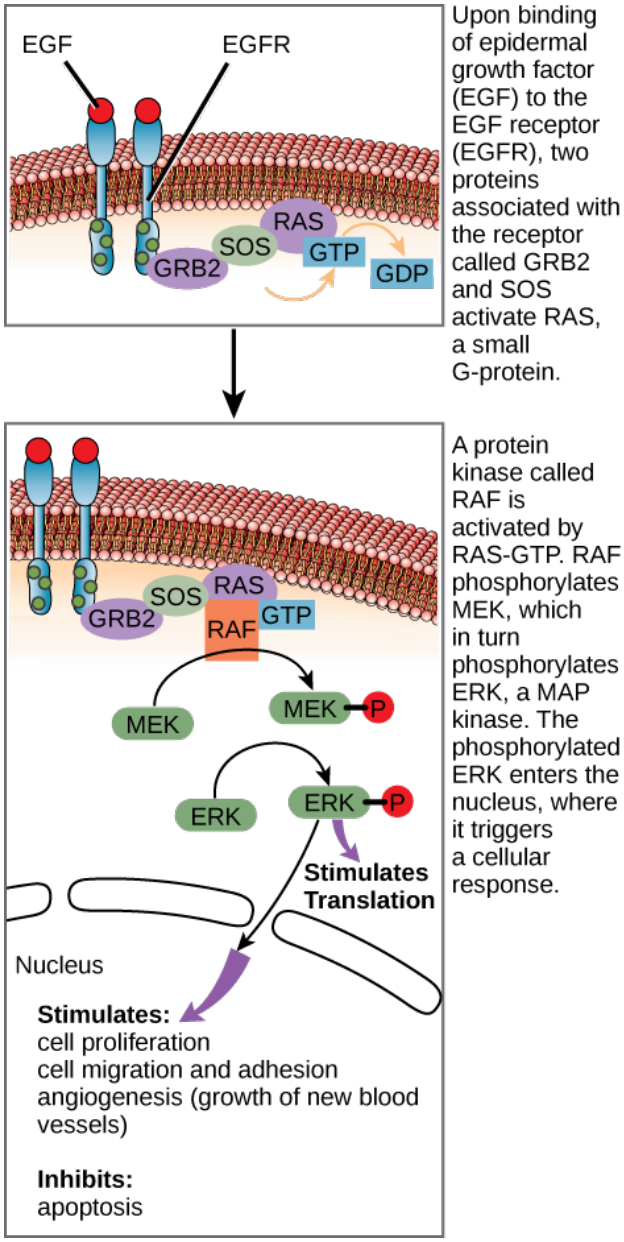
Visual Connection Questions

1. HER2 is a receptor tyrosine kinase. In 30 percent of human breast cancers, HER2 is permanently activated, resulting in unregulated cell division. Lapatinib, a drug used to treat breast cancer, inhibits HER2 receptor tyrosine kinase autophosphorylation (the process by which the receptor adds phosphates onto itself), thus reducing tumor growth by 50 percent. Besides autophosphorylation, which of the following steps would be inhibited by Lapatinib?



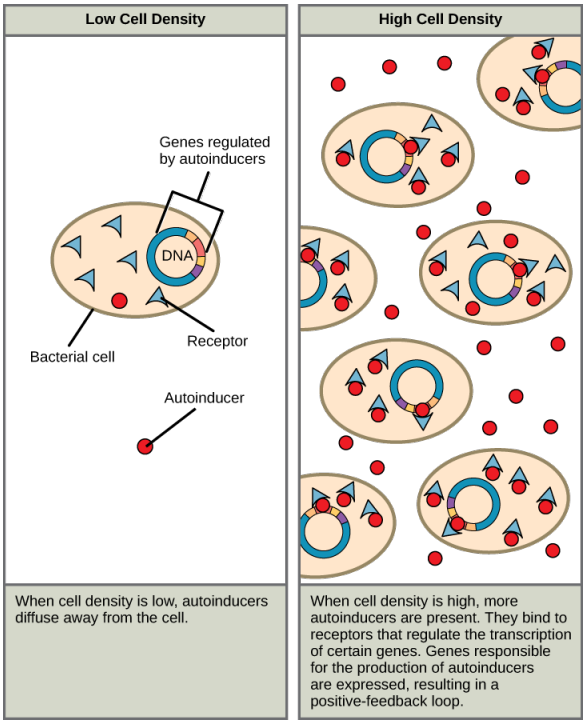
c. The downstream cellular response would be inhibited.

2. In certain cancers, the GTPase activity of the RAS G-protein is inhibited. This means that the RAS protein can no longer hydrolyze GTP into GDP. What effect would this have on downstream cellular events?



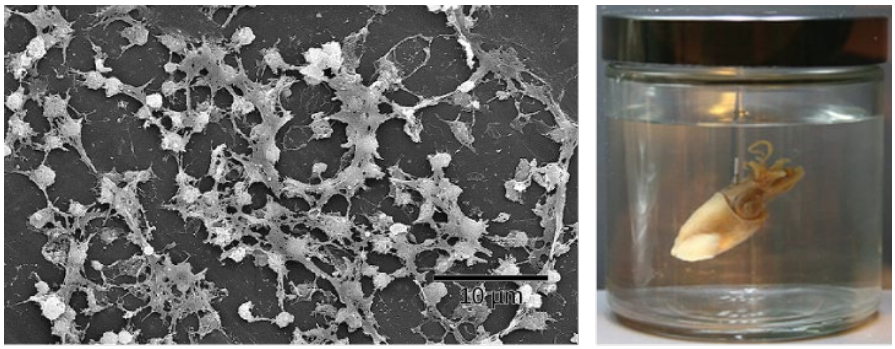
ERK would become permanently activated, resulting in cell proliferation, migration, adhesion, and the growth of new blood vessels. Apoptosis would be inhibited.

3. Which of the following statements about quorum sensing is false?



c. Autoinducer can only act on a different cell: it cannot act on the cell in which it is made.

4. What advantage might biofilm production confer on the *S. aureus* inside the catheter?



(a) (b)

S. aureus produces a biofilm because the higher cell density in the biofilm permits the formation of a dense surface that helps protect the bacteria from antibiotics.

Review Questions

5. What property prevents the ligands of cell-surface receptors from entering the cell?

a. The molecules are hydrophilic and cannot penetrate the hydrophobic interior of the plasma membrane.

6. The secretion of hormones by the pituitary gland is an example of _____.
c. endocrine signaling

7. Why are ion channels necessary to transport ions into or out of a cell?
b. Ions are charged particles and cannot diffuse through the hydrophobic interior of the membrane.

8. Endocrine signals are transmitted more slowly than paracrine signals because _____.
a. the ligands are transported through the bloodstream and travel greater distances

9. A scientist notices that when she adds a small, water-soluble molecule to a dish of cells, the cells turn off transcription of a gene. She hypothesizes that the ligand she added binds to a(n) _____ receptor.
c. Enzyme-linked

10. Where do DAG and IP_3 originate?
d. They are the cleavage products of the inositol phospholipid, PIP_2.

11. What property enables the residues of the amino acids serine, threonine, and tyrosine to be phosphorylated?
c. They contain a hydroxyl group.

12. Histamine binds to the H1 G-protein-linked receptor to initiate the itchiness and airway constriction associated with an allergic response. If a mutation in the associated G-protein's alpha subunit prevented the hydrolysis of GTP how would the allergic response change?
a. More severe allergic response compared to normal G protein signaling.

13. A scientist observes a mutation in the transmembrane region of EGFR that eliminates its ability to be stabilized by binding interactions during dimerization after ligand binding. Which hypothesis regarding the effect of this mutation on EGF signaling is most likely to be correct?
b. EGF signaling cascades would be active for a shorter period of time in the cell.

14. What is the function of a phosphatase?
b. A phosphatase removes the phosphate group from phosphorylated amino acid residues in a protein.

15. How does NF-κB induce gene expression?
b. Phosphorylation of the inhibitor Iκ-B dissociates the complex between it and NF-κB, and allows NF-κB to enter the nucleus and stimulate transcription.

16. Apoptosis can occur in a cell when the cell is _____.
d. all of the above (damaged, no longer needed, infected by a virus)

17. What is the effect of an inhibitor binding an enzyme?
c. The enzyme is inactivated.

18. How does PKC's signaling role change in response to growth factor signaling versus an immune response?
b. PKC interacts directly with signaling molecules in growth factor cascades, but interacts with signaling inhibitors during immune signaling.

19. A scientist notices that a cancer cell line fails to die when he adds an inducer of apoptosis to his culture of cells. Which hypothesis could explain why the cells fail to die?
d. All of the above.

20. Which type of molecule acts as a signaling molecule in yeasts?
c. mating factor

21. Quorum sensing is triggered to begin when _____.
d. a sufficient number of bacteria are present

22. A doctor is researching new ways to treat biofilms on artificial joints. Which approach would best help prevent bacterial colonization of the medical implants?
d. Inhibit quorum sensing

Critical Thinking Questions

23. What is the difference between intracellular signaling and intercellular signaling?
Intracellular signaling occurs within a cell, and intercellular signaling occurs between cells.

24. How are the effects of paracrine signaling limited to an area near the signaling cells?
The secreted ligands are quickly removed by degradation or reabsorption into the cell so that they cannot travel far.

25. What are the differences between internal receptors and cell-surface receptors?
Internal receptors are located inside the cell, and their ligands enter the cell to bind the receptor. The complex formed by the internal receptor and the ligand then enters the nucleus and directly affects protein production by binding to the chromosomal DNA and initiating the making of mRNA that codes for proteins. Cell surface receptors, however, are embedded in the plasma membrane, and their ligands do not enter the cell. Binding of the ligand to the cell-surface receptor initiates a cell signaling cascade and does not directly influence the making of proteins; however, it may involve the activation of intracellular proteins.

26. Cells grown in the laboratory are mixed with a dye molecule that is unable to pass through the plasma membrane. If a ligand is added to the cells, observations show that the dye enters the cells. What type of receptor did the ligand bind to on the cell surface?
An ion channel receptor opened up a pore in the membrane, which allowed the ionic dye to move into the cell.

27. Insulin is a hormone that regulates blood sugar by binding to its receptor, insulin receptor tyrosine kinase. How does insulin's behavior differ from steroid hormone signaling, and what can you infer about its structure?

Insulin's receptor is an enzyme-linked transmembrane receptor, as can be determined from the "tyrosine kinase" in its name. This receptor is embedded in the plasma membrane, and insulin binds to its extracellular (outer) surface to initiate intracellular signaling cascades.

Normally, steroid hormones cross the plasma membrane to bind with intracellular receptors. These intracellular hormone-receptor complexes then interact directly with DNA to regulate transcription. This limits steroid hormones to be small, non-polar molecules so they can cross the plasma membrane. However, since insulin does not have to cross into the cell it could be large or polar (it is a small, polar molecule).

28. The same second messengers are used in many different cells, but the response to second messengers is different in each cell. How is this possible?

Different cells produce different proteins, including cell-surface receptors and signaling pathway components. Therefore, they respond to different ligands, and the second messengers activate different pathways. Signal integration can also change the end result of signaling.

29. What would happen if the intracellular domain of a cell-surface receptor was switched with the domain from another receptor?

The binding of the ligand to the extracellular domain would activate the pathway normally activated by the receptor donating the intracellular domain.

30. If a cell developed a mutation in its *MAP2K1* gene (encodes the MEK protein) that prevented MEK from being recognized by phosphatases, how would the EGFR signaling cascade and the cell's behavior change?

EGF binding to EGFR initiates a signaling cascade that activates protein kinases through phosphorylation. Active Raf phosphorylates MEK, activating MEK's kinase activity. If MEK cannot be dephosphorylated, the signaling cascade downstream of MEK will continue to be active after the EGF signal is gone. Therefore, the cell will continue to proliferate, and be resistant to cell death (apoptosis).

31. What is a possible result of a mutation in a kinase that controls a pathway that stimulates cell growth?

If a kinase is mutated so that it is always activated, it will continuously signal through the pathway and lead to uncontrolled growth and possibly cancer. If a kinase is mutated so that it cannot function, the cell will not respond to ligand binding.

32. How does the extracellular matrix control the growth of cells?

Receptors on the cell surface must be in contact with the extracellular matrix in order to receive positive signals that allow the cell to live. If the receptors are not activated by binding, the cell will undergo apoptosis. This ensures that cells are in the correct place in the body and helps to prevent invasive cell growth as occurs in metastasis in cancer.

33. A scientist notices that a cancer cell line shows high levels of phosphorylated ERK in the absence of EGF. What are two possible explanations for the increase in phosphorylated ERK? Be specific in which proteins are involved.

Possible explanations:
1. EGFR dimer cannot separate.
2. An upstream mutation (in Ras, Raf, MEK) constitutively activates the signaling cascade.
3. ERK has a mutation that prevents it from binding to its phosphatase.
4. The cell has a mutation preventing the expression or function of the ERK-specific phosphatase.

34. What characteristics make yeasts a good model for learning about signaling in humans?

Yeasts are eukaryotes and have many of the same systems that humans do; however, they are single-celled, so they are easy to grow, grow rapidly, have a short generation time, and are much simpler than humans.

35. Why is signaling in multicellular organisms more complicated than signaling in single-celled organisms?

Multicellular organisms must coordinate many different events in different cell types that may be very distant from each other. Single-celled organisms are only concerned with their immediate environment and the presence of other cells in the area.

36. *Pseudomonas* infections are very common in hospital settings. Why would it be important for doctors to determine the bacterial load before treating an infected patient?

Doctors would need to determine if the patient is simply infected with free bacteria, or has developed a biofilm. Biofilms of *Pseudomonas aeruginosa* have a different pattern of gene expression than free bacteria, leading to increased virulence and resistance to many antibiotics.