Chapter 5

Cancer:

DNA Synthesis, Mitosis, and Meiosis
What Is Cancer?

- **Benign** tumors do not invade surrounding tissue

- **Malignant** tumors invade surrounding structures:
  - are cancer

- Properties of Cancer cells
  - Promote Angiogenesis
  - Loss of contact inhibition
  - Loss of anchorage dependence
Properties of Cancer cells

- **Angiogenesis**
  - growth of blood vessels caused by secretions from cancer cells
    - Increases the blood supply to cancer cells:
      - more oxygen and nutrients
- Cancer cells can divide more
- Tumors develop, sometimes filling entire organs
Properties of Cancer cells

- **Contact inhibition**
  - in normal cells prevents them from dividing all the time
  - Divisions would force the new cells to pile up on each other

![Contact Inhibition Diagram](image-url)
Properties of Cancer Cells: Lack of contact inhibition

Normal skin cells
Grow in monolayer

Skin cancer cells
Do not grow in monolayer
Pile up on each other
Properties of Cancer cells

- **Anchorage dependence** in normal cells keeps the cells in place

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**Anchorage Dependence**

**Normal cells** always stay anchored to other cells (or to a surface).

**Cancer cells** lose their anchorage dependence and can travel to new locations.

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*Figure 5-16b Biology: Science for Life, 2/e © 2007 Pearson Prentice Hall, Inc.*
Multiple Hit Model of Cell Transformation to Cancer

• Many mutations, or hits, in a cell are required for it to become malignant or cancer

• **Multiple hit model** describes the process of cancer development from a normal cell

• Mutations can be inherited and/or can stem from environmental exposures
Most cancers result from exposures to mutagens

- If one sib or twin gets cancer, other usually does not
- Populations that migrate – profile of cancer becomes more like people indigenous to new location

### TABLE 18.2
The Incidence of Some Common Cancers Varies Between Countries

<table>
<thead>
<tr>
<th>Site of Origin of Cancer</th>
<th>High-Incidence Population</th>
<th>Low-Incidence Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Location</td>
<td>Incidence*</td>
</tr>
<tr>
<td>Lung</td>
<td>USA (New Orleans, blacks)</td>
<td>110</td>
</tr>
<tr>
<td>Breast</td>
<td>Hawaii (Hawaiians)</td>
<td>94</td>
</tr>
<tr>
<td>Prostate</td>
<td>USA (Atlanta, blacks)</td>
<td>91</td>
</tr>
<tr>
<td>Cervix</td>
<td>Brazil (Recife)</td>
<td>83</td>
</tr>
<tr>
<td>Stomach</td>
<td>Japan (Nagasaki)</td>
<td>82</td>
</tr>
<tr>
<td>Liver</td>
<td>China (Shanghai)</td>
<td>34</td>
</tr>
<tr>
<td>Colon</td>
<td>USA (Connecticut, whites)</td>
<td>34</td>
</tr>
<tr>
<td>Melanoma</td>
<td>Australia (Queensland)</td>
<td>31</td>
</tr>
<tr>
<td>Nasopharynx</td>
<td>Hong Kong</td>
<td>30</td>
</tr>
<tr>
<td>Esophagus</td>
<td>France (Calvados)</td>
<td>30</td>
</tr>
<tr>
<td>Bladder</td>
<td>Switzerland (Basel)</td>
<td>28</td>
</tr>
<tr>
<td>Ovary</td>
<td>New Zealand (Polynesians)</td>
<td>26</td>
</tr>
<tr>
<td>Pancreas</td>
<td>USA (Los Angeles, Koreans)</td>
<td>16</td>
</tr>
<tr>
<td>Lip</td>
<td>Canada (Newfoundland)</td>
<td>15</td>
</tr>
</tbody>
</table>
Multiple Hit Model of Cell Transformation to Cancer
The Multiple Hit Model for Colon Cancer

Tumor suppressor genes: APC, DCC, p53
Oncogene: ras

Normal colon cells

APC gene loss

Increased cell growth

DNA hypomethylation

Adenoma class I

ras gene mutation

Adenoma class II

DCC gene loss

Adenoma class III

p53 gene loss

Carcinoma

Other gene losses

Metastasis
5.5 Cancer Detection and Treatment

• Earlier detection and treatment of cancer greatly increase the odds of survival

• Knowing the warning signs of cancer is important to health

• Cancer screenings extremely important

• Self exams can catch early tumors both benign and malignant
Cancer Detection

- Change in bowel or bladder habits
- Sore that does not heal
- Unusual bleeding or discharge
- Thickening or lump
- Indigestion or difficulty swallowing
- Obvious change in wart or mole
- Coughing or hoarseness

Figure 5-17  Biology: Science for Life, 2/e

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Cancer Detection Methods

• **Blood tests** for
  - High blood cell counts
    – May indicate a leukemia or lymphoma
  - High protein concentration
    – May indicate a tumor is making lots of protein
      • Prostate cancer PSA
      • Ovarian cancer CA125

• **Biopsy**
  – When a tumor is found and cancer is suspected
  – the surgical removal of cells, tissue, or fluid for analysis
    • Under a microscope:
      – benign tumors appear orderly and resemble other normal cells
      – Malignant tumors do not resemble normal tissue
Cancer Detection Methods: Biopsy

Normal ovarian tissue

Benign ovarian tumor

Malignant ovarian tumor
Treatment Methods

• When possible, surgeons remove tumors with a laparoscope through small incisions
  – generally lead to quicker, easier recoveries
    • 1 to 2 weeks
  – are possible only when growths are small

• Others are surgically removed and require much longer recovery time
  • 6-8 weeks

• Continued monitoring and other treatments may come after surgery
Treatment Methods: Chemotherapy

- **Chemotherapy** is used for cancer that cannot be surgically removed or that has metastasized
  - Any Chemical or drug that kills cancer cells is considered chemotherapy

- Classical chemotherapy kills all dividing cells and is usually injected into the bloodstream

- Combinations of chemical agents are usually used since cancer cells can become resistant

- Adverse effects on chemotherapy patients during treatment
  - Hair loss
  - Nausea
  - Immunosuppression
  - Fatigue
Treatment Methods: Chemotherapy

• Newer chemotherapy drugs target just cancer cells
  – Not all dividing cells

• Successful tumor specific drugs
  – Her2/neu = Herceptin for Breast Cancer
  – Bcr/abl = Gleevec for CML
  – CD20 = Rutuxan for Non Hodgkin Lymphoma (NHL)

• Block necessary component for tumor cell growth

• Does not harm normal cells

• Very few if any side effects

• Activate our own immune system to specifically kill tumor cells
Treatment Methods: Radiation

• **Radiation therapy**
  – High energy radioactive particles damage DNA and kill cells
  – Highly focused on tumor area

• Radiation therapy is can be administered with or without chemotherapy

• A patient is in **remission** if the patient is no longer suffering negative impacts from cancer after a given period
## Essay 5.1 Cancer Risk Factors

Known risk factors are linked to particular cancers...

<table>
<thead>
<tr>
<th>Cancer Location</th>
<th>Risk Factors</th>
<th>Detection</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Ovary           | • Smoking<br>
|                 | • Mutation to BRCA2 gene<br>
|                 | • Advanced age<br>
|                 | • Oral contraceptive use and pregnancy decrease risk<br>                      | • Blood test for elevated CA125 level<br>
|                 | • Gynecological exam<br>                                                     | • Fifth leading cause of death among women in the United States |
| Ovary           | • Smoking<br>
|                 | • Mutation to BRCA1 gene<br>
|                 | • High-fat, low-fiber diet<br>
|                 | • Use of oral contraceptives may slightly increase risk.<br>                 | • Monthly self exams, look and feel for lumps or changes in contour | • Only 5% of breast cancers are due to BRCA1 mutations<br>
|                 | • Mammogram                                                                  |                                               | • Second-highest cause of cancer-related deaths<br>
|                 |                                                                             |                                               | • 1% of breast cancer occurs in males                           |

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**Essay 5.1 Cancer Risk Factors**

Known risk factors are linked to particular cancers...

<table>
<thead>
<tr>
<th>Cancer Location</th>
<th>Risk Factors</th>
<th>Detection</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cervix</strong></td>
<td>• Smoking&lt;br&gt;• Exposure to sexually transmitted Human Papilloma Virus (HPV)</td>
<td>• Annual Pap-smear tests for the presence of pre-cancerous cells</td>
<td>• Precancerous cells can be removed by laser surgery or cryotherapy (freezing) before they become cancerous.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Skin</strong></td>
<td>• Smoking&lt;br&gt;• Fair skin&lt;br&gt;• Exposure to ultraviolet light from the sun or tanning beds</td>
<td>• Monthly self-exams, look for growths that change in size or shape</td>
<td>• Skin cancer is the most common of all cancers and is usually curable if caught early.</td>
</tr>
</tbody>
</table>

*Table E5-1 part 2 Biology: Science for Life, 2/e © 2007 Pearson Prentice Hall, Inc.*
Essay 5.1 **Cancer Risk Factors**

Known risk factors are linked to particular cancers…

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<th>Risk Factors</th>
<th>Detection</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lung</strong></td>
<td>• Smoking</td>
<td>• X-ray</td>
<td>• Lung cancer is the most common cause of death from cancer, and the best prevention is to quit, or never start, smoking.</td>
</tr>
<tr>
<td></td>
<td>• Exposure to second-hand smoke</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Asbestos inhalation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table E5-1 part 3  Biology: Science for Life, 2/e © 2007 Pearson Prentice Hall, Inc.
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<th>Cancer Location</th>
<th>Risk Factors</th>
<th>Detection</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colon and rectum</td>
<td>• Smoking</td>
<td>• Change in bowel habit</td>
<td>• Benign buds called polyps can grow in the colon; removal prevents them from mutating and becoming cancerous.</td>
</tr>
<tr>
<td></td>
<td>• Polyps in the colon</td>
<td>• Colonoscopy is an examination of the rectum and colon using a lighted instrument.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Advanced age</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• High-fat, low-fiber diet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small intestine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rectum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prostate</td>
<td>• Smoking</td>
<td>• Blood test for elevated level of prostate specific antigen (PSA)</td>
<td>• More common in African-American men than Asian, white, or Native American men.</td>
</tr>
<tr>
<td></td>
<td>• Advanced age</td>
<td>• Physical exam by physician, via rectum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• High-fat, low-fiber diet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bladder</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prostate</td>
<td></td>
<td></td>
<td></td>
</tr>
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<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Testicle</strong></td>
<td>• Abnormal testicular development</td>
<td>• Monthly self exam, inspect for lumps and changes in contour</td>
<td>• Testicular cancer accounts for only 1% of all cancers in men, but is the most common form of cancer found in males between the ages of 15 and 35.</td>
</tr>
<tr>
<td><img src="image1.png" alt="Diagram of testicle" /></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Blood (Leukemia)</strong></td>
<td>• Exposure to high-energy radiation such as that produced by atomic bomb explosions in Japan during World War II</td>
<td>• A sample of blood is examined under a microscope.</td>
<td>• Cancerous white blood cells cannot fight infection efficiently; people with leukemia often succumb to infections.</td>
</tr>
<tr>
<td><img src="image2.png" alt="Diagram of blood cells" /></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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