

What is cancer?

Cancer is a disease in which cells grow out of control and invade, erode, and destroy normal tissue.

Cancer is Unregulated Cell Division

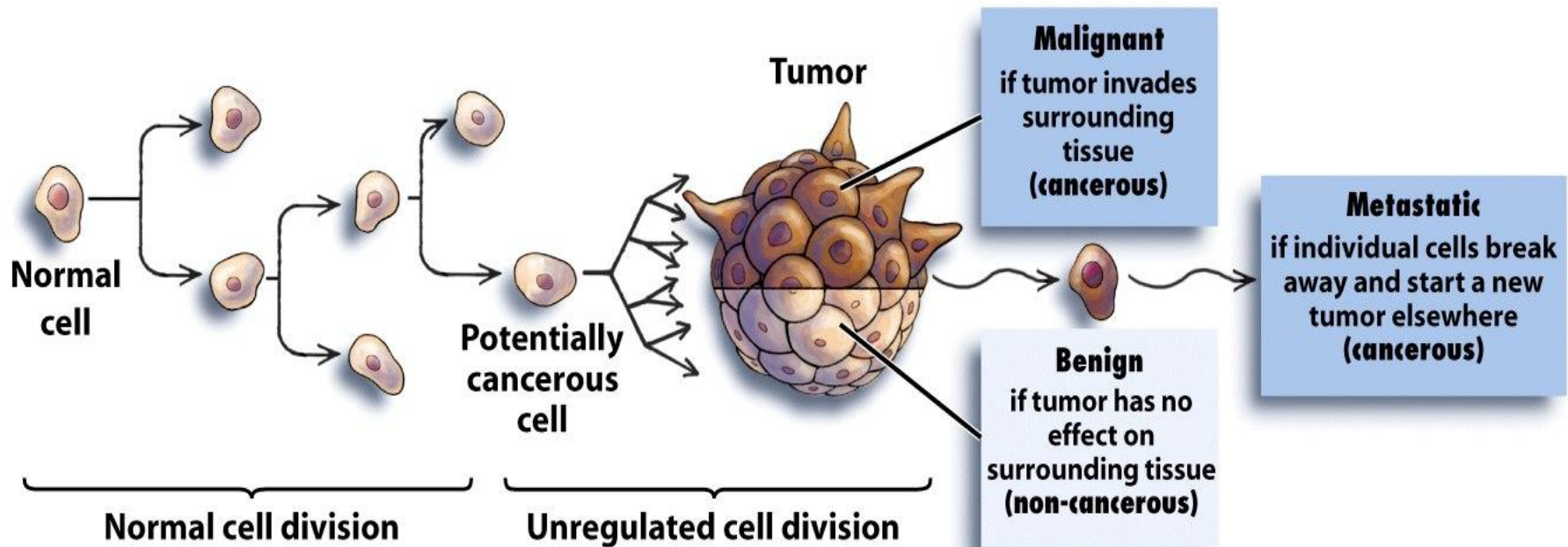


Figure 5-1 Biology: Science for Life, 2/e
© 2007 Pearson Prentice Hall, Inc.

What causes cancer?

Heredity Causes

- 5-10% of cancers are heredity
- The cancer itself is ***not*** inherited
- The cancer ***risk is*** inherited

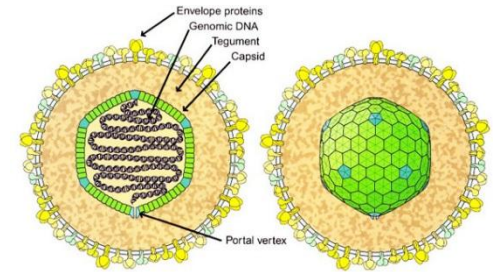


Environmental Causes

- Alcohol
- Asbestos
- Industrial Pollution
- Tobacco
- UV Radiation
- Others



Pathogens Can Increase the Risk of Cancer



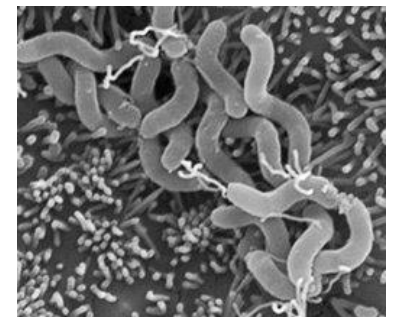
<http://cullenlab.duhs.duke.edu/research/ebv/>

- Viruses

- Human Papilloma Virus (HPV) & cervical, anal & oral cancers
- Hepatitis B Virus (HBV) & liver cancer
- Human T Lymphotropic Virus-1 (HTLV-1) & adult T cell leukemia
- Epstein Barr Virus (EBV) & lymphoma, nasopharyngeal cancer

- Bacterial

- *H. pylori* & gastric cancer

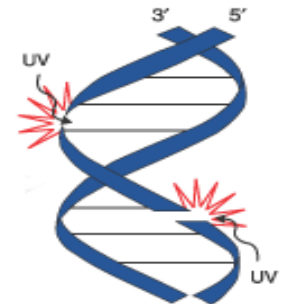
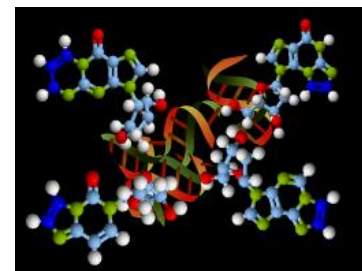
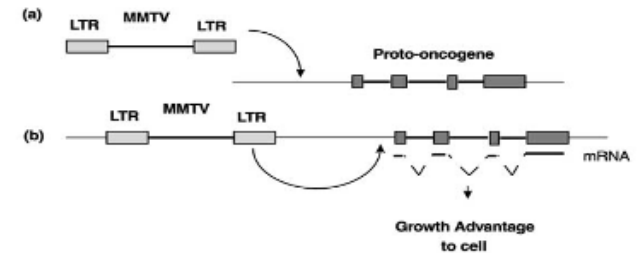
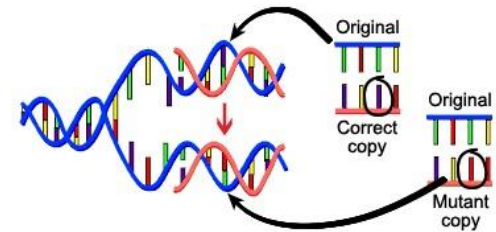


<https://www.researchgate.net/publication/272803728>

What do these cancer causes have in common?

DNA Damage

- Genetic: Mutation in a gene or genes
- Viruses: insertional mutagenesis
- Chemicals: DNA adducts
- UV and ionizing radiation: single and double strand DNA breaks



SIX DIABOLICAL SUPERPOWERS OF CANCER

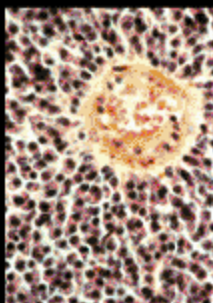
1. GROWTH EVEN IN THE ABSENCE OF NORMAL "GO" SIGNALS

Most normal cells wait for an external message before dividing. Cancer cells (*image*) often counterfeit their own pro-growth messages.



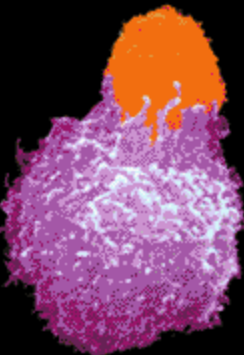
2. GROWTH DESPITE "STOP" COMMANDS ISSUED BY NEIGHBORING CELLS

As the tumor (*yellow*) expands, it squeezes adjacent tissue, which sends out chemical messages that would normally bring cell division to a halt. Malignant cells ignore the commands.



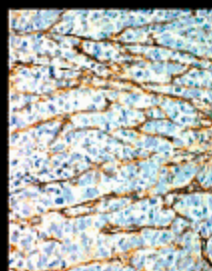
3. EVASION OF BUILT-IN AUTODESTRUCT MECHANISMS

In healthy cells, genetic damage above a critical level usually activates a suicide program. Cancerous cells (*magenta*) bypass this mechanism, although agents of the immune system (*orange*) can sometimes successfully order the cancer cells to self-destruct.



4. ABILITY TO STIMULATE BLOOD VESSEL CONSTRUCTION

Tumors need oxygen and nutrients to survive. They obtain them by co-opting nearby blood vessels to form new branches (*brown streaks*) that run throughout the growing mass.



5. EFFECTIVE IMMORTALITY

Healthy cells can divide no more than 70 times. Malignant cells need more than that to make tumors. So they work around systems—such as the telomeres (*yellow*) at the end of chromosomes (*blue*)—that enforce the reproductive limit.



6. POWER TO INVADE OTHER TISSUES AND SPREAD TO OTHER ORGANS

Cancers usually become life-threatening only after they somehow disable the cellular circuitry that confines them to a specific part of the particular organ in which they arose. New growths (*orange and yellow*) appear and eventually interfere with vital systems.



Clockwise from top right: CHRIS JONES Corbis; PETER LANSDORP University of British Columbia; SCIENCE PHOTO LIBRARY; FRANK LYNCH QualTek Molecular Laboratories; ANDREJS LIEPINS/SPL; CNRI/SPL; SPL

Cancer Cells have altered Chromosome Numbers

Karyotype from Breast Cancer Cell



Figure 16-5 Cell and Molecular Biology, 5/e (© 2008 John Wiley & Sons)

***Loss of checkpoint control = faulty
chromosome segregation***

What are two classes of genes that can contribute to the generation of cancer?

Genes that Contribute to Cancer

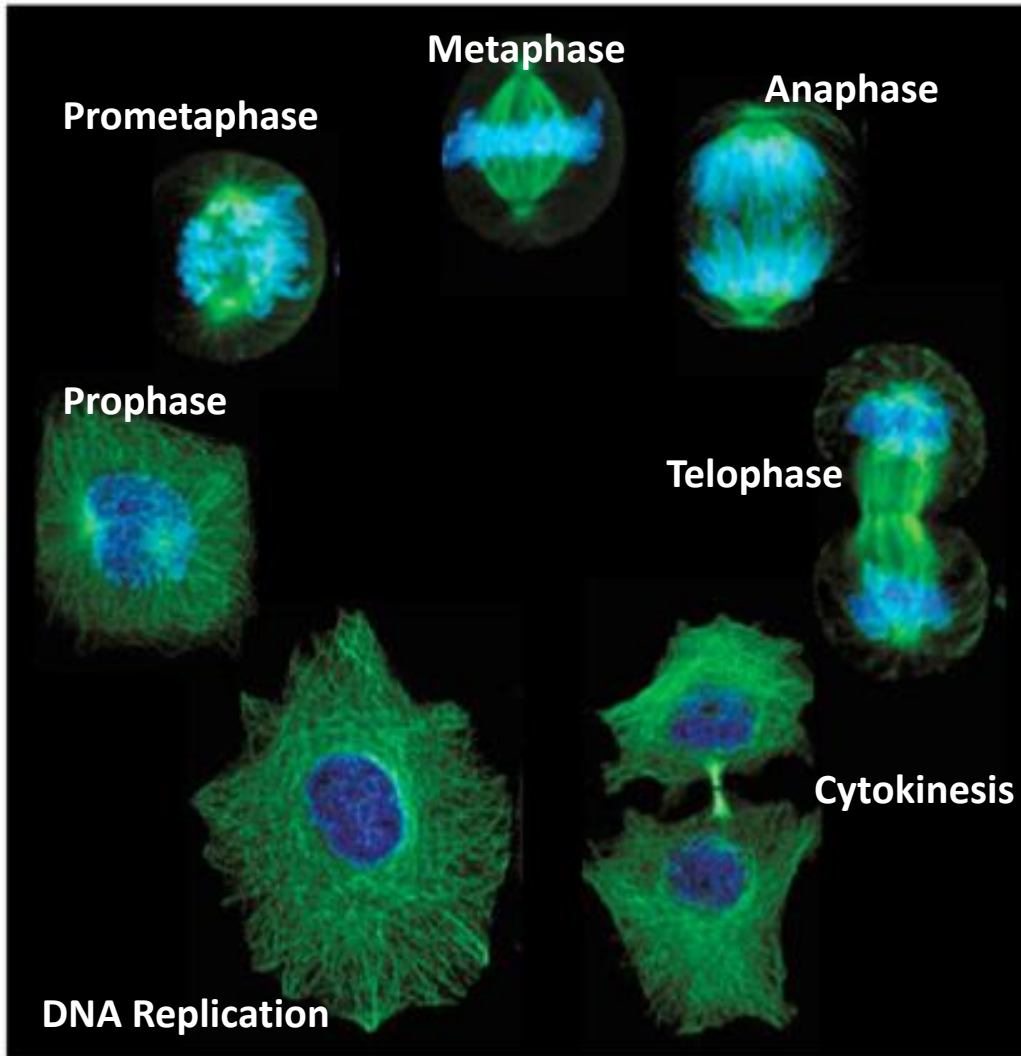
Tumor Suppressors

- “Guardian(s) of the genome”
- Often involved in maintaining genomic integrity (DNA repair, chromosome segregation)
- Often the 1st mutation in a developing cancer
- **p53**: Stops cell cycle if DNA is damaged
- **BRCA1**: fixes broken DNA

Proto-Oncogenes

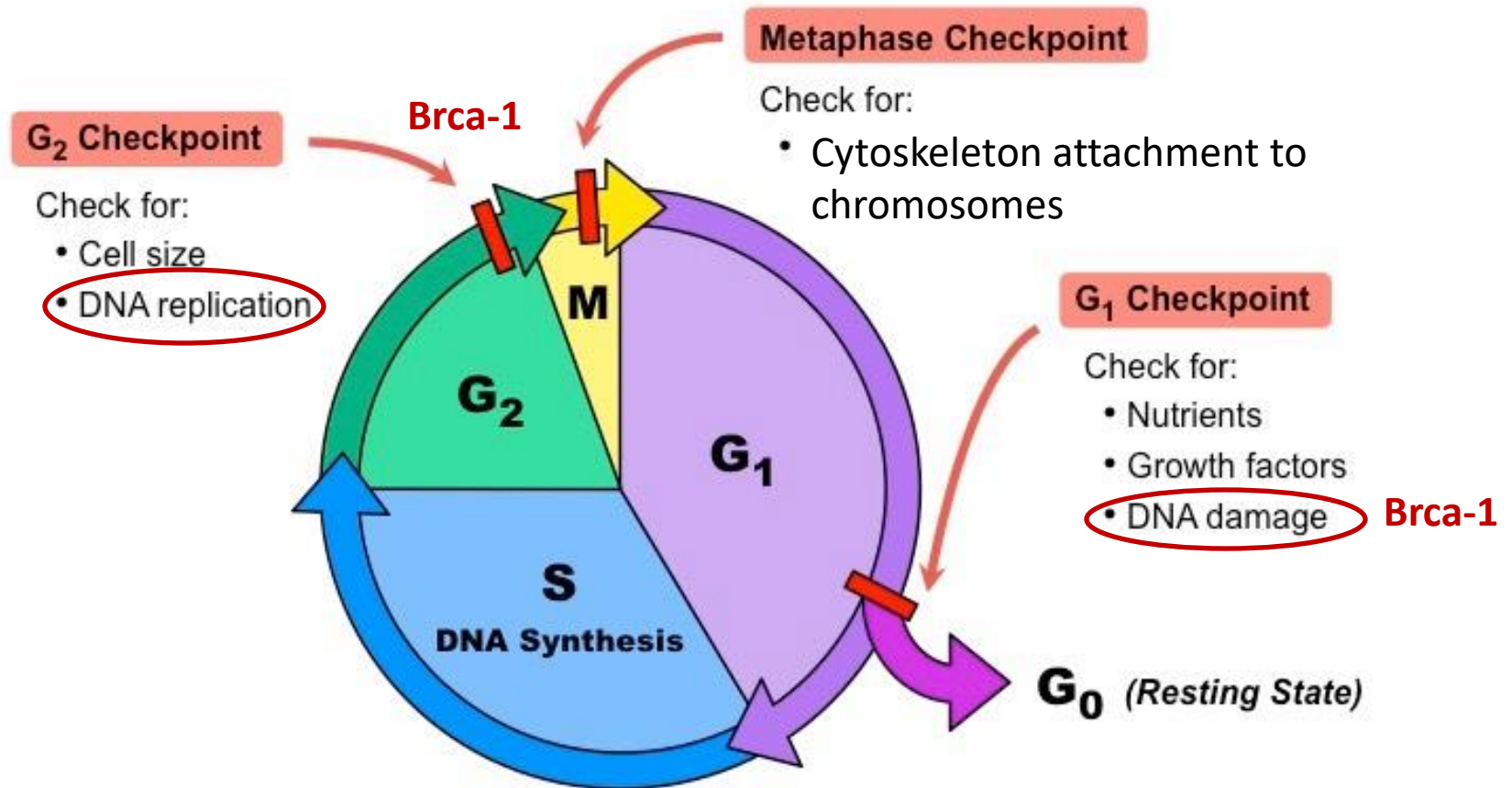
- Proto-Oncogenes become oncogenes though:
 - Mutation (‘always on’)
 - Gene duplication (‘too much’)
- Involved in cell growth and proliferation (division)
- Most cannot cause cancer alone
- **HER2**: growth factor receptor, 25-30% of breast cancers make too much HER2 (gene duplication)

Cell Cycle Review



- Blue: DNA
- Green: Cytoskeleton
- The cytoskeleton is assembled & reassembled during the cell cycle

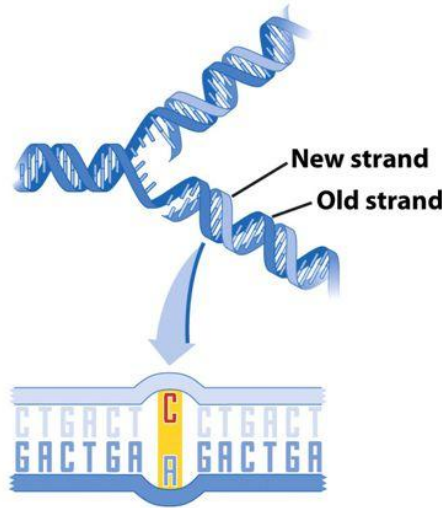
Cell Cycle Regulation is Required for Normal Cell Growth



During DNA Replication Mistakes Can Be Made

DNA Repair

- DNA polymerases often insert incorrect bases
 - DNA mismatch
- Proofreading enzymes correct mistakes



- It can be helpful
→ survival advantage
- It can have no effect = silent mutation.
- It can be harmful → disadvantage, malfunctioning protein

Is a mutation always bad?

No. Why?

Understanding Cancer Causes

What is cancer?

- Cancer is not a single disease with a single cause
- Many processes control cell growth
- Multiple control mechanisms must go wrong for a cell to become cancerous

Can a gene cause cancer?

- Genes are like instructions to build proteins
- Proteins do work
- Mutations may prevent the protein from working properly
- If the job of the mutated protein is genome maintenance or cell division, cancer can develop

Cancer is *Extremely* Heterogeneous

- Neoplasm* – Greek *neo* = new, *plasm* = creation, formation
– a.k.a. tumor (Latin "tumere" to swell), suffix “-oma”
- **Hematopoietic cancers** (i.e., individual cells) versus **solid tumors** (masses)
 - Lymphoid & myeloid neoplasms vs. breast, colon, etc
 - Transformed **mesenchymal** cells (sarcomas) vs. transformed **epithelial** cells (carcinomas).
 - Muscle, vascular & hematopoietic neoplasms vs. most breast, colon and lung neoplasms

Classification of a disease is paramount in understanding its **etiology** and how to **effectively treat it**.