UNIT 1: CELL BIOLOGY

TOPIC G: CELL CYCLE & CANCER

**Essential Idea(s)**
- Cell division is essential, but must be controlled.

**IB Assessment Statements and Class Objectives:**

1.6 U5 Cyclins are involved in the control of the cell cycle.
   - Explain the role of cyclin and cyclin-CDK complexes in controlling the cell cycle.
   - State the role of cyclins D, B, A and E in the cell cycle.

1.6 NOS Serendipity and scientific discoveries- the discoveries of cyclins was accidental.
   - Outline the discovery of cyclins including the role of serendipity.

1.6 U6 Mutagens, oncogenes and metastasis are involved in the development of primary and secondary tumors.
   - Define tumor, benign, malignant, metastasis, cancer, mutagen and carcinogen.
   - Describe how cancer arises, referring to accumulation of mutations over time.
   - Explain the relationship between oncogenes, tumor suppressor genes and cancer.

1.6 A1 The correlation between smoking and incidence of cancers.
   - Explain the use of correlations to determine the relationship between two variables (inclusive of positive and negative correlations).
   - Explain why the existence of a correlation does not necessitate a causal relationship between two variables.
   - Calculate a correlation coefficient using Pearson's R.
   - Determine if a correlation coefficient value is significant.
   - Define significant as related to the relationship between two variables.
   - Use epidemiological case study information to outline the relationships between smoking and cancer.

   - Outline the causes of lung cancer.
   - List symptoms of lung cancer.

6.4 NOS Obtain evidence for theories- epidemiological studies have contributed to our understanding of the causes of the lung cancer.
   - Define epidemiology.
   - Outline how epidemiological studies contributed to understanding the association between smoking and lung cancer.

D.1 A3 Lack of Vitamin D or calcium can affect bone mineralization and cause rickets or osteomalacia.
   - Explain the relationship between vitamin D, calcium, osteomalacia, and skin cancer.
**Cyclins Control Progression through the Cell Cycle**

- Cyclins are ____________ that control ________________ of cells through the cell cycle.
- Cyclins activate cyclin-dependent kinase (__________) enzymes.
- Active CDK complexes ____________________________ target proteins that do jobs related to moving the cell through the phases of the cell cycle.

**HOW CYCLINS WORK:**

There are four types of cyclins (A, B, D and E) that each activate a different set of target proteins.

 inactive
  Cyclin
  "the switch" (protein)

 inactive
  Cyclin Dependent Kinase
  must attach to cyclin to work

 inactive
  Kinase Complex
  enzyme that attaches phosphates to another molecule

 inactive
  Target Protein

 inactive
  Inorganic Phosphate
  (PO₄⁻)
  molecule with lots of potential energy

 active
  Cyclin Dependent Kinase
  can be used again

 active
  Target Protein
  can go do jobs to cause cell cycle

 active
  CDK complex
  phosphorylates target protein

 active
  Cyclin Dependent Kinase
  Kinase Complex
  with target protein

 active
  Complex can "phosphorylate" other molecules (add a phosphate to...)

 inactive
  not functional
  Target Protein

 inactive
  not functional
  Cyclin

 inactive
  Cyclin Dependent Kinase
  must attach to cyclin to work
• Made in G₁
  - Triggers transition to S phase
  - Phosphorylates a tumor suppressor

• Made during G₁
  - Triggers transition to S phase
  - Phosphorylates a protein that gets DNA ready for replication

• Regulates multiple steps
  - Activates 2 CDKs
  - S phase - initiates DNA replication
  - G₂ phase - prepares centrosome for mitosis

• Allows mitosis to start
  - Triggers entry into prophase
  - Phosphorylates a protein that creates mitotic spindle
  - Must break down to finish process

Concentration

Cyclin E
Cyclin A
Cyclin B

Cyclin D

G₁ Phase  S Phase  G₂ Phase  Mitosis
### Discovery of Cyclins

<table>
<thead>
<tr>
<th>WHO?</th>
<th>Tim Hunt</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHEN?</td>
<td>1980's</td>
</tr>
<tr>
<td></td>
<td>2001 Nobel Prize</td>
</tr>
</tbody>
</table>
| WHAT?              | - Studying embryo development in sea urchins  
|                    | - Found some proteins cycled as cells divided  
|                    | - Named proteins cyclins  
|                    | - Discovered they bind to CDK molecules and deal with phosphorylation |

**ROLE OF SERENDIPITY**

- Finding something good without looking for it
- Must be observant and curious when unusual findings appear
<table>
<thead>
<tr>
<th>TERM</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>tumor</td>
<td>abnormal mass of tissue; growth</td>
</tr>
<tr>
<td>malignant</td>
<td>infectious, uncontrollable, deadly</td>
</tr>
<tr>
<td>benign</td>
<td>not harmful; harmless</td>
</tr>
<tr>
<td>metastasis</td>
<td>development of secondary malignant growths; spread of cancer</td>
</tr>
<tr>
<td>cancer</td>
<td>disease involving abnormal cell growth that destroys body tissue</td>
</tr>
<tr>
<td>mutagen</td>
<td>physical or chemical agent that changes genetic material and causes mutation</td>
</tr>
<tr>
<td>carcinogen</td>
<td>substance capable of causing cancer in living tissue</td>
</tr>
<tr>
<td>mutation</td>
<td>changing of the structure of a gene</td>
</tr>
<tr>
<td>Oncogene</td>
<td>gene that can transform a cell into a tumor cell</td>
</tr>
<tr>
<td>Tumor suppressor gene</td>
<td>normal genes that slow down cell division, repair DNA mistakes, or tell cells when to die</td>
</tr>
</tbody>
</table>
Definition of Epidemiology:

branch of medicine that deals with the incidence, distribution, and possible control of diseases and other factors relating to health

Risk for Vitamin D Deficiency

Risk for Skin Cancer

Vitamin D

found in foods

eggs

oily fish

fortified dairy/grains

needed for Ca^{2+} absorption from food

more melanin reduces Vitamin D synthesis

UV light

naturally synthesized in the skin

only with

intercepted and absorbed by

skin pigment melanin

skeletal deformity "rickets"

dna mutation

causes

reduces

can lead to

DNA mutation

CANCER

Lighter Skin decreased

increased

Darker Skin increased

decreased
UNIT 1: CELL BIOLOGY  
TOPIC G: CELL CYCLE & CANCER

Important Things Correlation Coefficients Tell You

- *It Tells You The Direction Of A Relationship:*  
  If your correlation coefficient is a negative number you can tell that there is an indirect, negative relationship between the two variables. A negative relationship means that as values on one variable increase (go up), the values on the other variable decrease (go down) in a predictable manner. If your correlation coefficient is a positive number, you have a direct, positive relationship. This means that as one variable increases (or decreases) the values of the other variable tend to go in the same direction. If one increases, so does the other. If one decreases, so does the other in a predictable manner.

- *Correlation Coefficients Always Fall Between -1.00 and +1.00:*  
  A correlation coefficient of -1.00 tells you that there is a perfect negative relationship between the two variables. As values on one variable increase there is a perfectly predictable decrease in values on the other variable. In other words, as one variable goes up, the other goes down. A correlation coefficient of +1.00 tells you that there is a perfect positive relationship between the two variables. As values on one variable increase, there is a perfectly predictable increase in values on the other variable. A correlation coefficient of 0.00 tells you that there is a zero correlation, or no relationship, between the two variables. In other words, as one variable changes (goes up or down), you can’t really say anything about what happens to the other variable.

- *Larger Correlation Coefficients Mean Stronger Relationships*  
  Most correlation coefficients tend to be somewhat lower than plus or minus 1.00, but are somewhat above 0.00. Remember that a correlation coefficient of 0.00 means that there is no relationship between your two variables based on the data you are looking at. The closer a correlation coefficient is to 0.00, the weaker the relationship is and the less able you are to tell exactly what happens to one variable based on knowledge of the other variable. The closer a correlation coefficient approaches plus or minus 1.00, the stronger the relationship is and the more accurately you are able to predict what happens to one variable based on the knowledge you have of the other variable.

<table>
<thead>
<tr>
<th>Values of &quot;r&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
</tr>
<tr>
<td>0.50</td>
</tr>
<tr>
<td>0.00</td>
</tr>
<tr>
<td>-0.50</td>
</tr>
<tr>
<td>-1.00</td>
</tr>
</tbody>
</table>

- If $r = 1.00$ there is a perfect positive relationship between the two variables (Allows best predictions).

- If $r$ is greater than 0.00 but less than 1.00, there is a positive relationship between the two variables. The bigger the number, the stronger the relationship (Bigger numbers mean better predictions).

- If $r = 0.00$ there is no relationship between the two variables (Allows no predictions).

- If $r$ is between 0.00 and -1.00, there is a negative relationship between the two variables. The bigger the number (in absolute value), the stronger the relationship (Bigger numbers mean better predictions).

- If $r = -1.00$ there is a perfect negative relationship between the two variables (Allows best predictions).
UNIT 1: CELL BIOLOGY

Causes of Lung Cancer
- Smoking (87%)
- Secondhand Smoke (37%)
- Air Pollution (57%)
- Radon Gas
- Solids

Symptoms of Lung Cancer
- difficulty breathing
- persistent coughing
- coughing up blood
- chest pain
- loss of appetite
- weight loss
- fatigue

Correlations
- statistical measure that indicates the extent to which two or more variables fluctuate together
  - Positive - fluctuate in parallel
  - Negative - fluctuate opposite
- We have to be able to determine if our correlations are significant!

\[
\begin{align*}
Y' &= \frac{\Sigma Y' - (\Sigma Y')(\Sigma Y)}{n} \\
&\quad \sqrt{\left[\left(\Sigma Y'^2 - (\Sigma Y')^2\right)\left(\Sigma Y^2 - (\Sigma Y)^2\right)\right]} \\
\end{align*}
\]

- $\Sigma X$ This simply tells you to add up all the X scores
- $\Sigma Y$ This tells you to add up all the Y scores
- $\Sigma X^2$ This tells you to square each X score and then add them up
- $\Sigma Y^2$ This tells you to square each Y score and then add them up
- $\Sigma XY$ This tells you to multiply each X score by its associated Y score and then add the resulting products together (this is called a "cross-products")
- n This refers to the number of "pairs" of data you have.

Example of a way to set up data to make sure you don't make mistakes when using the computational formula to calculate Pearson's r

<table>
<thead>
<tr>
<th>X</th>
<th>X^2</th>
<th>Y</th>
<th>Y^2</th>
<th>XY</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td>45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>33</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$\Sigma X =$ \quad $\Sigma X^2 =$ \quad $\Sigma Y =$ \quad $\Sigma Y^2 =$ \quad $\Sigma XY =$