A Vaccine for Cancer?

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1. What is a virus?

2. What is cancer?

3. How are cancer cells different from normal cells?

4. How do viruses cause cancer?

4. How can a vaccine protect against virus caused cancers?
What is a Virus?

- A virus is
  - a set of genes (or “chromosomes”), either DNA or RNA,
  - packaged in a protein coat

- It is an infectious agent and it relies totally on the cell it infects for the ability to reproduce (replicate) and make new viruses.
Human Papilloma Virus (HPV)

- Human papilloma viruses cause skin warts *(papilloma = wart = abnormal growth = tumor)*

- Our bodies are covered by *epithelium* (skin), outside, and in many cavities - oral, genital

- Different HPV "types" cause warts on the skin of different areas of our bodies; HPVs are transmitted by breaks in the skin

- Some of the warts (tumors) can become cancerous
How do HPVs cause warts (tumors)?

Infected cells grow faster than normal cells.

Skin

Normal cells  Wart (Tumor) Development
How are TUMOR cells different from "normal" cells?

NORMAL CELL DIVISION
NORMAL APOPTOSIS (CELL DEATH)

INCREASED CELL DIVISION
NORMAL APOPTOSIS

NORMAL CELL DIVISION
DECREASED APOPTOSIS

HOMEOSTASIS
TUMOR
TUMOR

Molecular Biology of the Cell (© Garland Science 2008)
Cancer development requires multiple rounds of mutation and proliferation

$\approx 5$ DNA mutations

Benign tumor

Malignant tumor = cancer
Cancer is a Multi-Step Process

- Proliferation
- Growth Advantage

- Increased cell division (proliferation)
- Decreased cell death (apoptosis)

- Spread (metastasis)

Initiation → Selection → Angiogenesis → Invasion → Progression → Metastasis

Mutation #1 → Mutation #2 → Mutation #3 → Mutation #4 → Mutation #5

Often a viral or bacterial infection is the “initiating event”
Cervical cancer progression

Pap smear
Why was the HPV vaccine developed?

- More than 80% of Americans (women & men) will contract HPV by age 50; most common STD in US
- HPV infections cause (initiate) virtually all cervical cancers, also many penile, anal, head-&-neck cancers
- In the US: 11,900 new cervical cancer cases/year & 3,850 deaths/year; screening costs $4-5 BILLION/yr
- 80% of cervical cancer deaths occur in poor countries
- Widespread vaccination could reduce screening costs (eventually) and two-thirds of cervical cancer deaths around the world

Source: US Centers for Disease Control (CDC) 2004
How can a vaccine protect against viral-caused cancers?

- HPV vaccines are based on hollow virus-like particles; they are not infectious.
- Targets HPV types that cause about 70% of all cervical cancers; the current vaccine Gardasil® also targets HPV types that cause about 90% of genital warts.
- They elicit virus-neutralizing antibody responses that prevent initial infection with the HPV types represented in the vaccine.
- The vaccine offers ≈100% protection against infections, cervical precancers, and genital warts.
Important Issues

1. **Three doses** of the vaccine are required.

2. Recommended routinely for girls 11-12 y.o.; and 13-26 y.o. unvaccinated females.

3. Must continue Pap screening to ensure effectiveness (other HPV types can cause cancer).

4. Unclear how long immunity will last (could require booster shots).

5. Most expensive routine vaccine in history.
Discussion Questions

1. Will the vaccine protect people who are already infected with HPV?
   - Why?
   - Why not?

2. Should the vaccine be required?

3. What are the roadblocks associated with vaccination implementation in the US?

4. What are the roadblocks associated with global vaccination implementation?