Understanding the Latest in Cancer Therapies

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Lecture Goals

1. What is cancer?
2. How has cancer been historically treated? How do these therapies work?
3. What is the latest in cancer therapies?
    a. Precision Imaging for Surgery
    b. Immunotherapy: CAR T-cells and cancer vaccines
    c. Targeted therapies: RAS inhibitors and menin
    d. Use of artificial intelligence for detection and treatment

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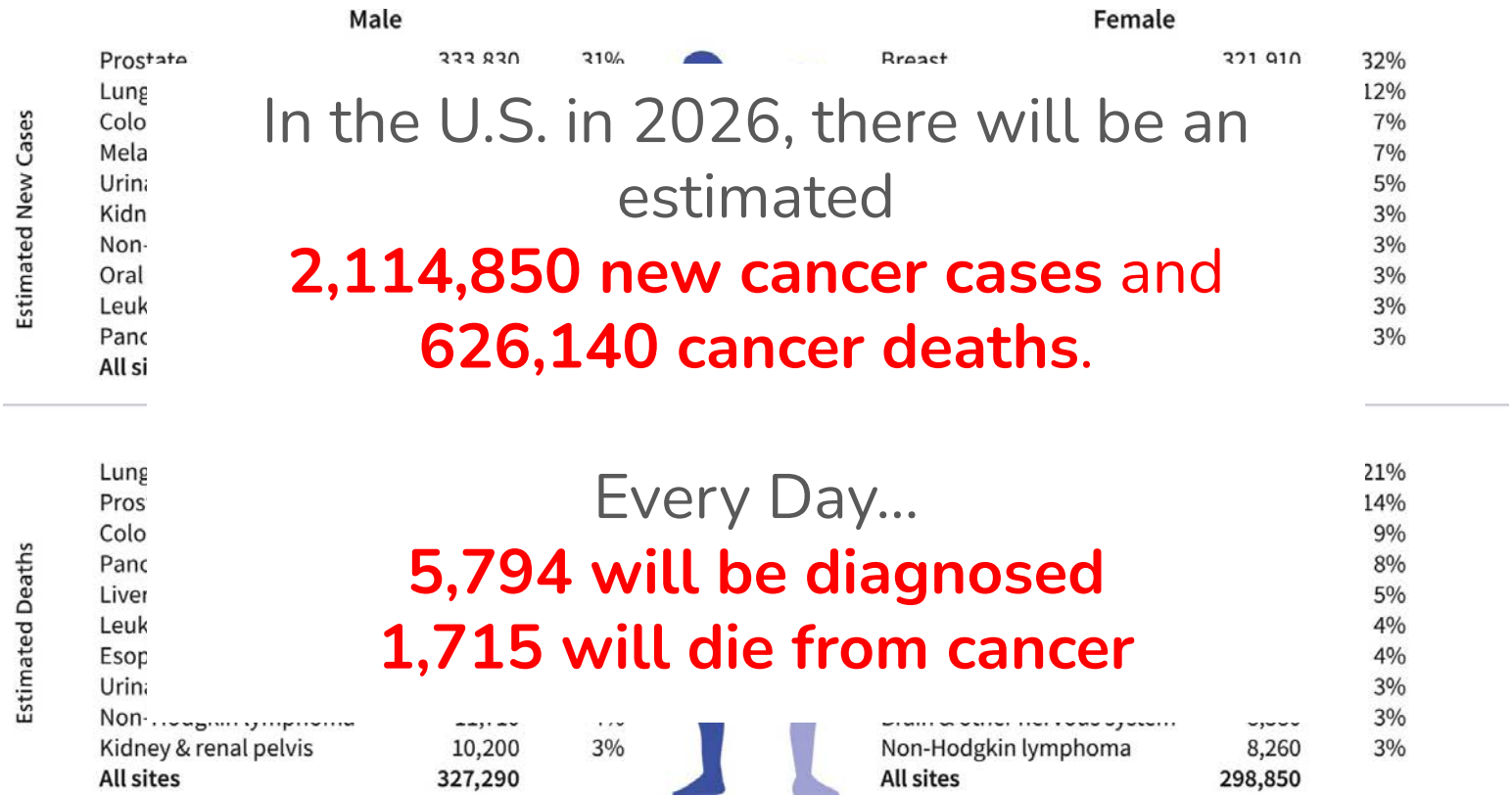
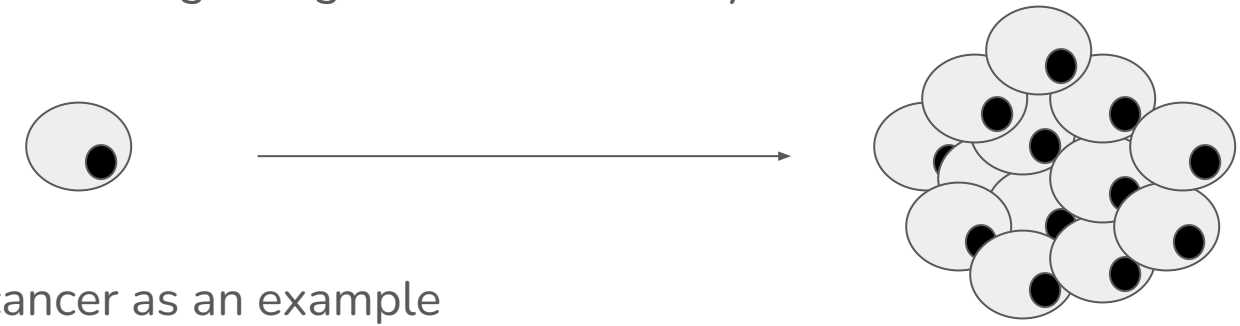
Why do we study cancer?



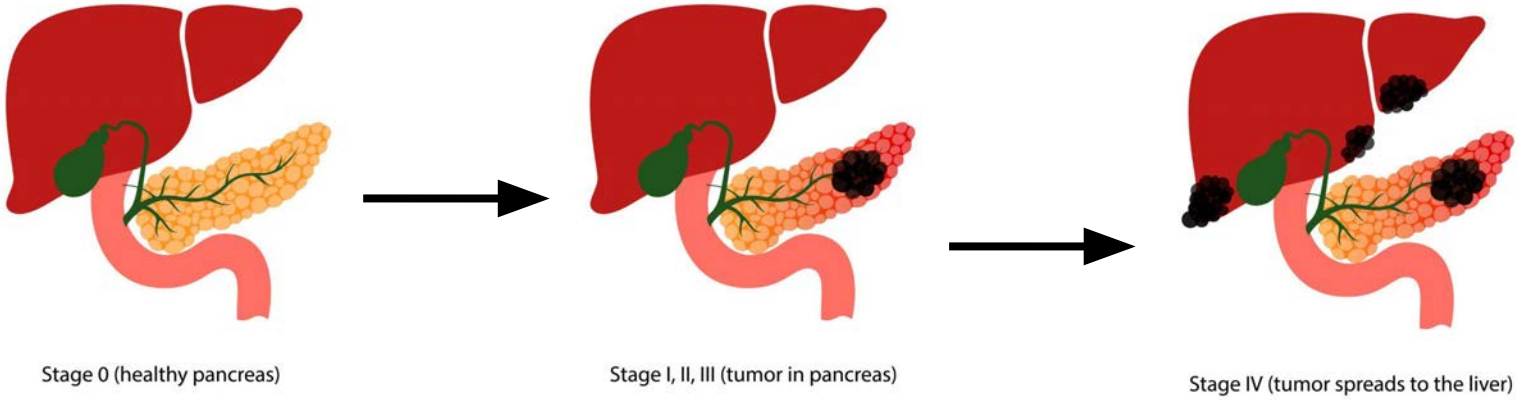
Siegel et al ACS 2026

What is cancer?

When body **cells** begin to grow uncontrollably

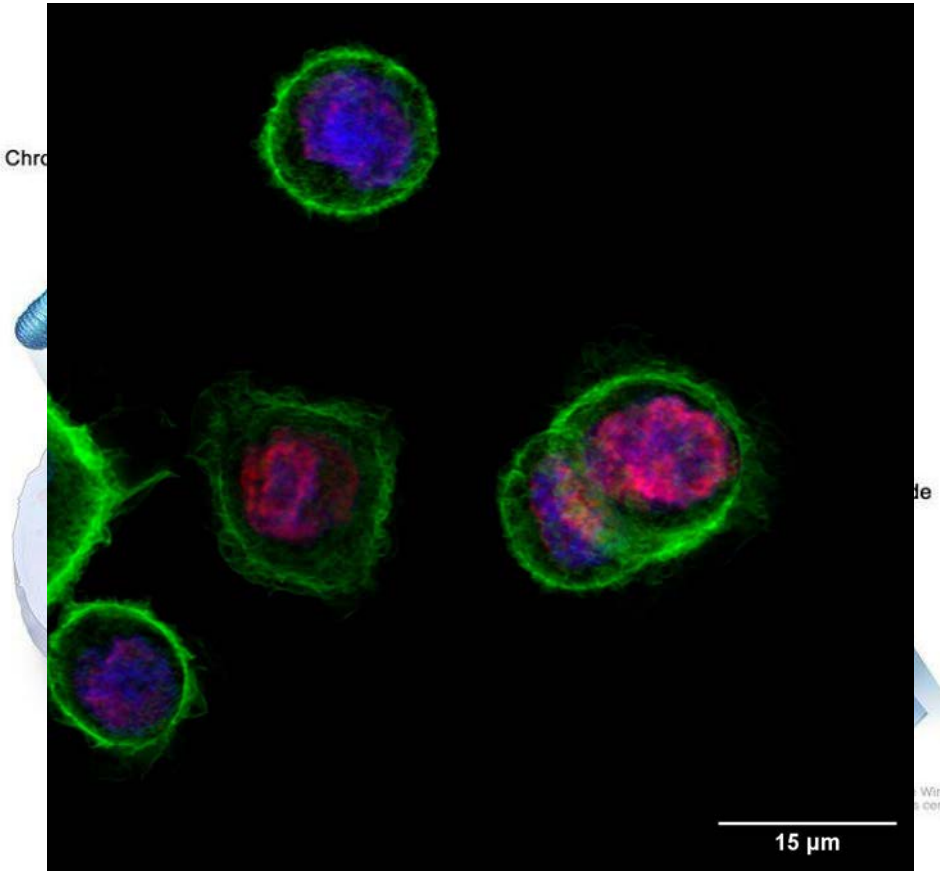


Pancreatic cancer as an example



National Pancreatic Cancer Foundation

What is a cell?



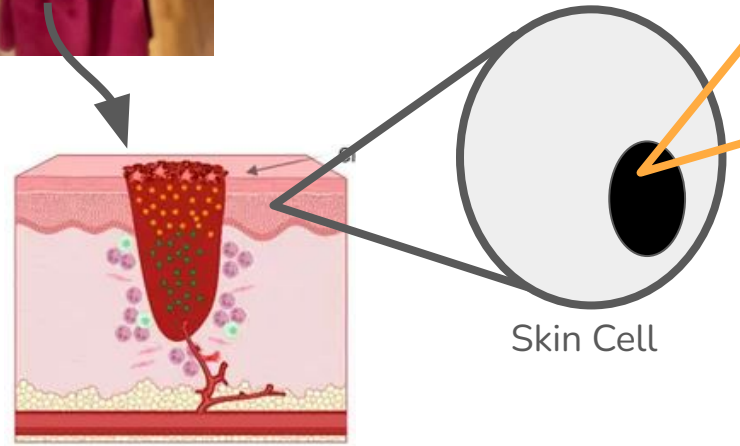
- Smallest unit of life that can live on its own
- Make up the tissues of the body
- Human cells contain cell membranes, organelles, cytoplasm, nucleus
- **Nucleus** houses our genome
  - Genome is comprised of **DNA**

DNA provides the code for making proteins

DNA → RNA → Protein
(genes)

Workers!

RNA → **Cell proliferation protein expressed**



Cell proliferation gene

Skin Cell

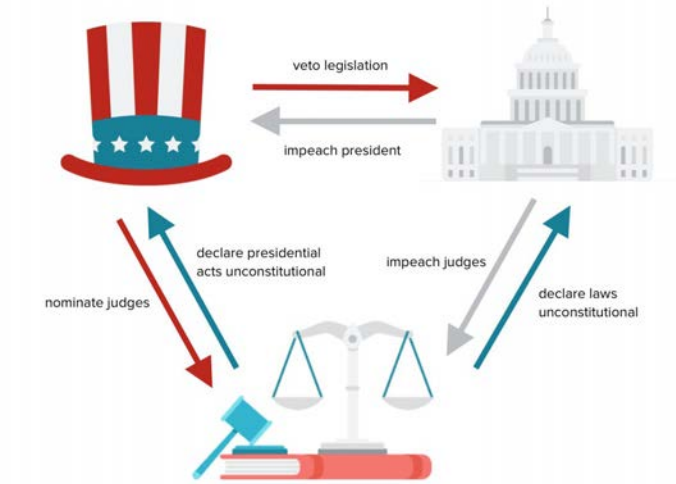
Skin Images Adapted from Hunt et al Cell Dev Bio 2023

The DNA contains oncogenes that drive cell proliferation

Oncogenes: genes that code for proteins that **DRIVE** cell proliferation, division and growth

Tumor suppressor genes: genes that code for proteins that **STOP** cell proliferation and promote cell death

Checks and balances for the cell



So...how does cancer develop?

- Unfortunately, when our cells synthesize DNA they often make mistakes...

Mistakes/Errors in DNA → Gene Mutations in oncogenes or tumor suppressors → Cancer

- Everytime a cell divides that makes them susceptible to acquiring a genetic mutation
- **What else can cause gene mutations/cells to proliferate?**
  - Inherited mutations
  - Endogenous reactions (normal cellular reactions)
  - Viruses
  - Harmful substances in the environment

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Not all cancers are *treated* equally

1. Is the cancer a solid tumor or hematological (blood) cancer? Where did it arise from?

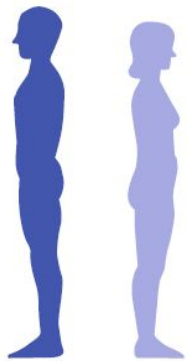
Solid Tumors arise from tissues or organs

VS

Hematological cancers arise from cells in lymphatic system, blood or bone marrow

Estimated New Cases

Male			Female		
* Prostate	313,780	30%	* Breast	316,950	32%
* Lung & bronchus	110,680	11%	* Lung & bronchus	115,970	12%
* Colon & rectum	82,460	8%	* Colon & rectum	71,810	7%
* Urinary bladder	65,080	6%	* Uterine corpus	69,120	7%
* Melanoma of the skin	60,550	6%	* Melanoma of the skin	44,410	4%
* Kidney & renal pelvis	52,410	5%	* Non-Hodgkin lymphoma	35,210	4%
* Non-Hodgkin lymphoma	45,140	4%	* Pancreas	32,490	3%
* Oral cavity & pharynx	42,500	4%	* Thyroid	31,350	3%
* Leukemia	38,720	4%	* Kidney & renal pelvis	28,570	3%
* Pancreas	34,950	3%	* Leukemia	28,170	3%
All sites	1,053,250		All sites	988,660	



Not all patients receive the same treatment

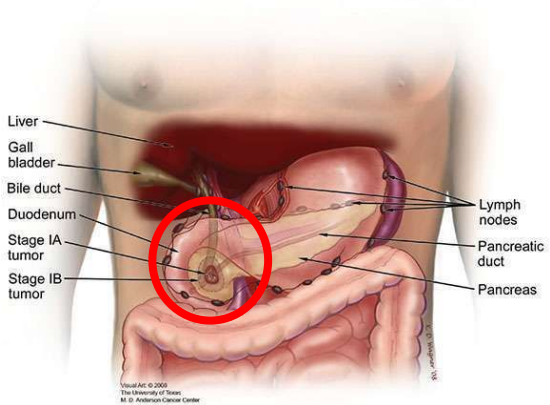
2. Has the cancer spread? What stage? Is this a recurrence?

3. Other factors…

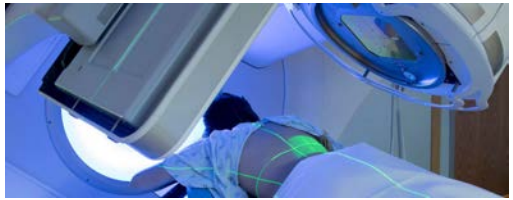
   a. Health of the patient and medical history
   b. Risk factors
   c. Age of the patient
   d. Patient’s personal desires and support
   e. Facility being treated/Accessibility to care

How are solid tumors treated?

Surgical Removal



Radiation

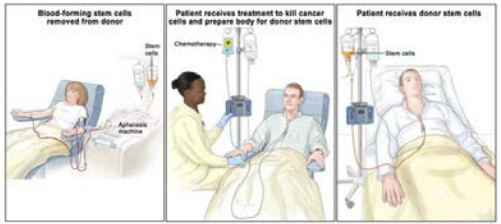


Chemotherapy

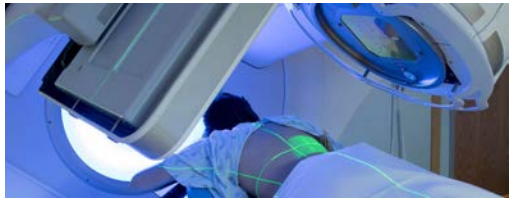
Photo Creds: NCI

How are hematological cancers treated?

Stem Cell Transplants



Radiation



Chemotherapy

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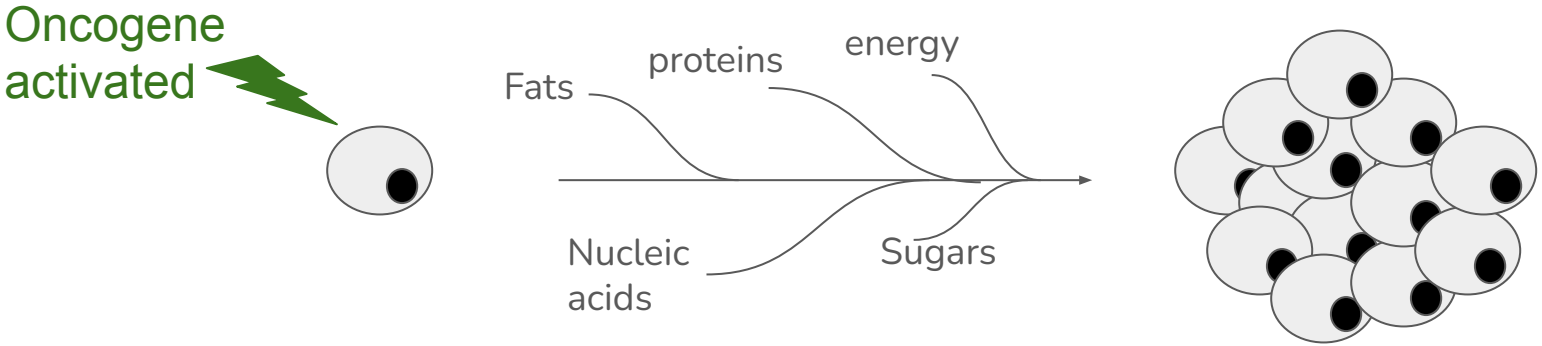
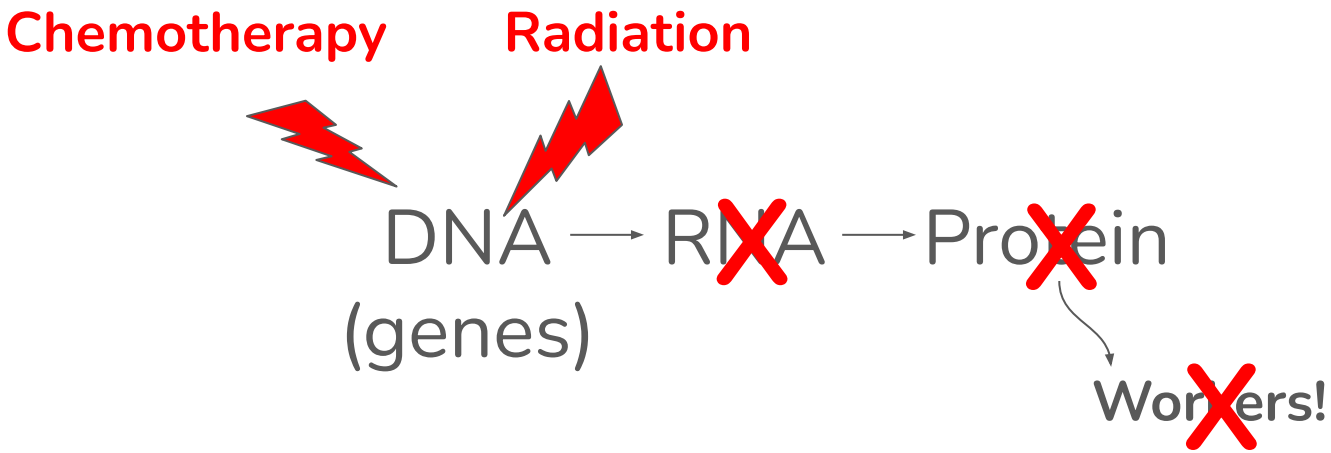
Cancer cells need A LOT of “stuff” to make more cells



- Cell proliferation requires energy and building blocks to generate new cells
- Cells require nutrients to undergo normal metabolic processes

Chemotherapy & Radiation leverages cancers drive to proliferate towards a therapy



Side effects????

Why don’t the same treatments work for all cancers?

Cancer is NOT ONE disease

It is MANY diseases

Depending on where the cancer arises and how mutations occur can dictate aggressiveness

AND

We are all genetically unique, that means for each person that develops cancer, their cancer (because it arises from their own cells) is genetically unique

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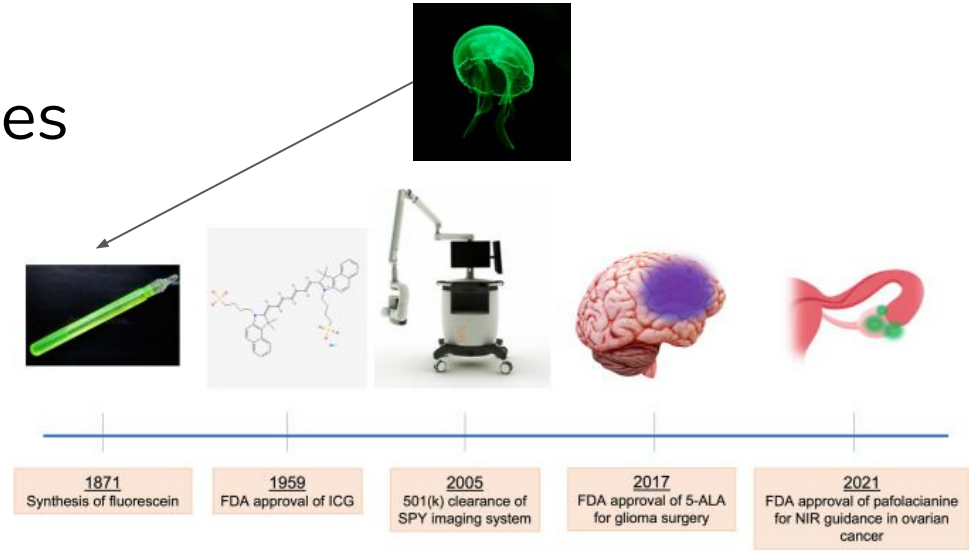
Improving surgery outcomes

Precision imaging for surgeries

Fluorescence-guided surgery

1. Inject patients with dye that fluoresces and is **taken up** the tumor
2. Wait ~7 hours, any tumor cells will then fluoresce
3. Surgeon removes all areas that are fluorescing



Jellyfish Photo Credit: Getty Images/iStockphoto
Timeline: Keulen et al Mol Imaging Biol, 2022
Surgical Photo Credit: Univ Pittsburg, Neurosurgery

Immunotherapy:
Harnessing the power of the immune system

Immunotherapies harness the patient's own immune system

Immune System: contains tissues, cells & organs that defend against harmful pathogens AND cancerous cells

CAR T-cell therapy uses the patient's own T cells and *trains* them to kill cancer cells

FDA Approved for: B-ALL, CLL, SLL, non-Hodgkin lymphoma, Multiple Myeloma, mantle cell lymphoma, follicular lymphoma

In clinical trials for: Solid Tumors

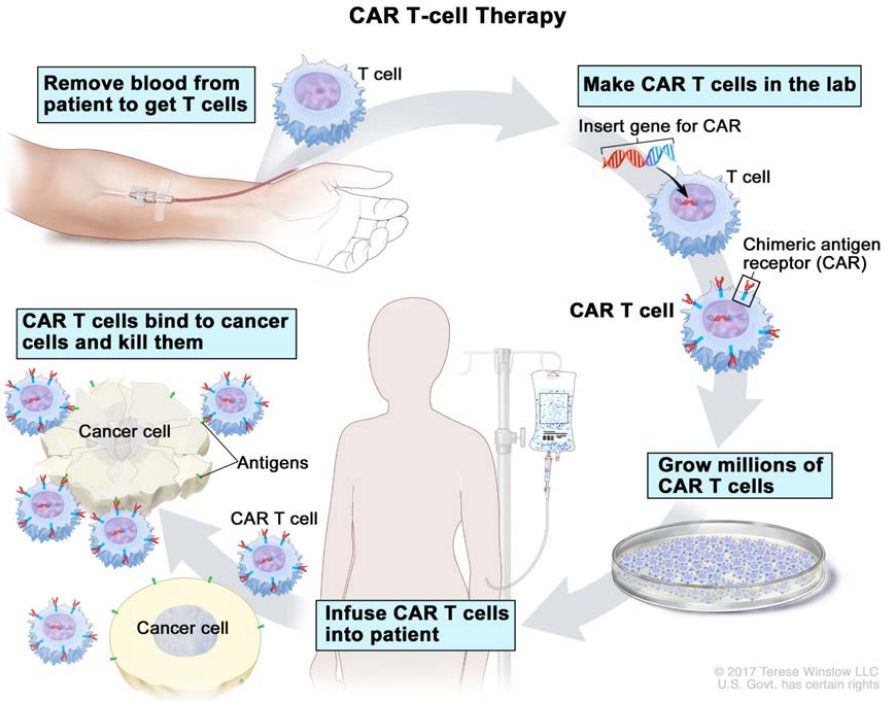
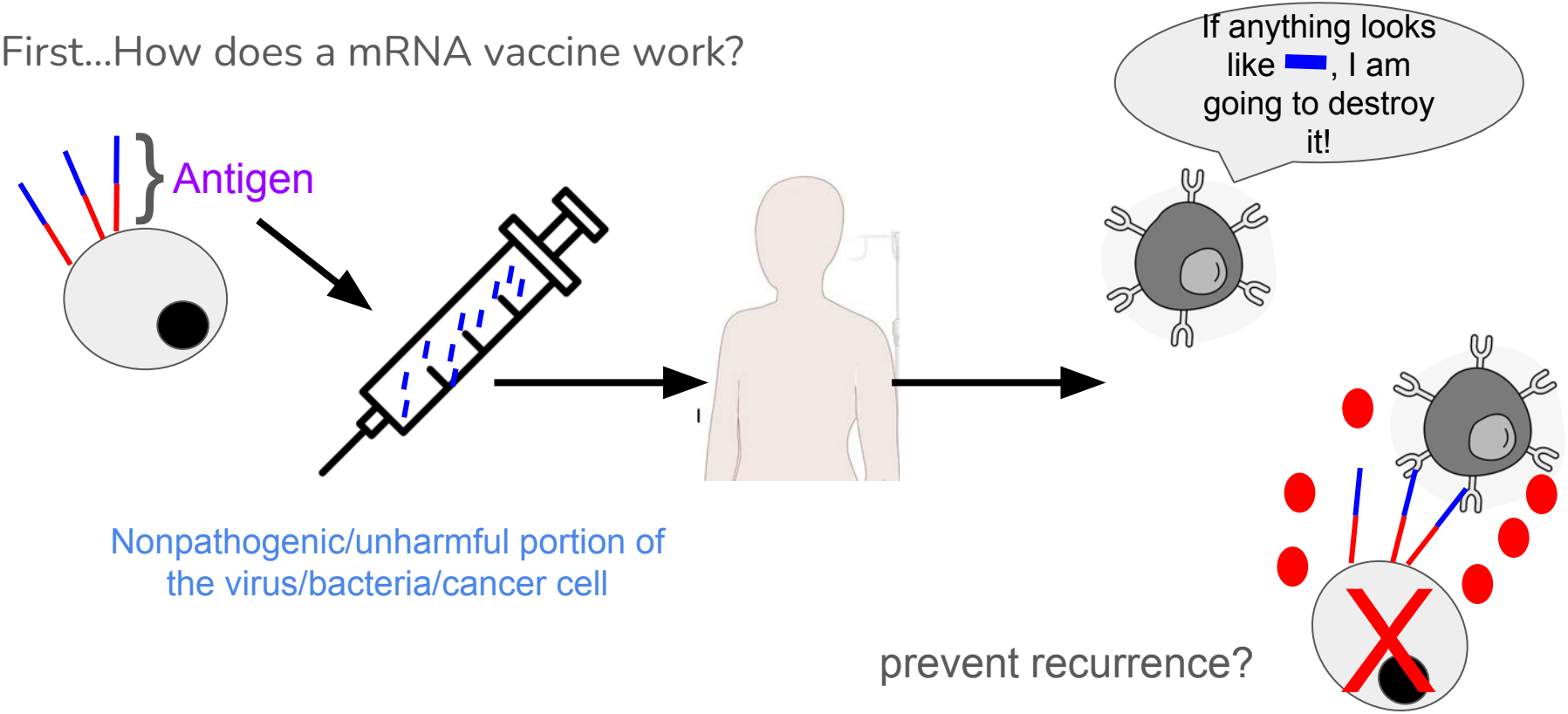


Photo Creds: NCI

Cancer vaccines train the immune system to target cancer

First...How does a mRNA vaccine work?



Immunotherapy can be personalized

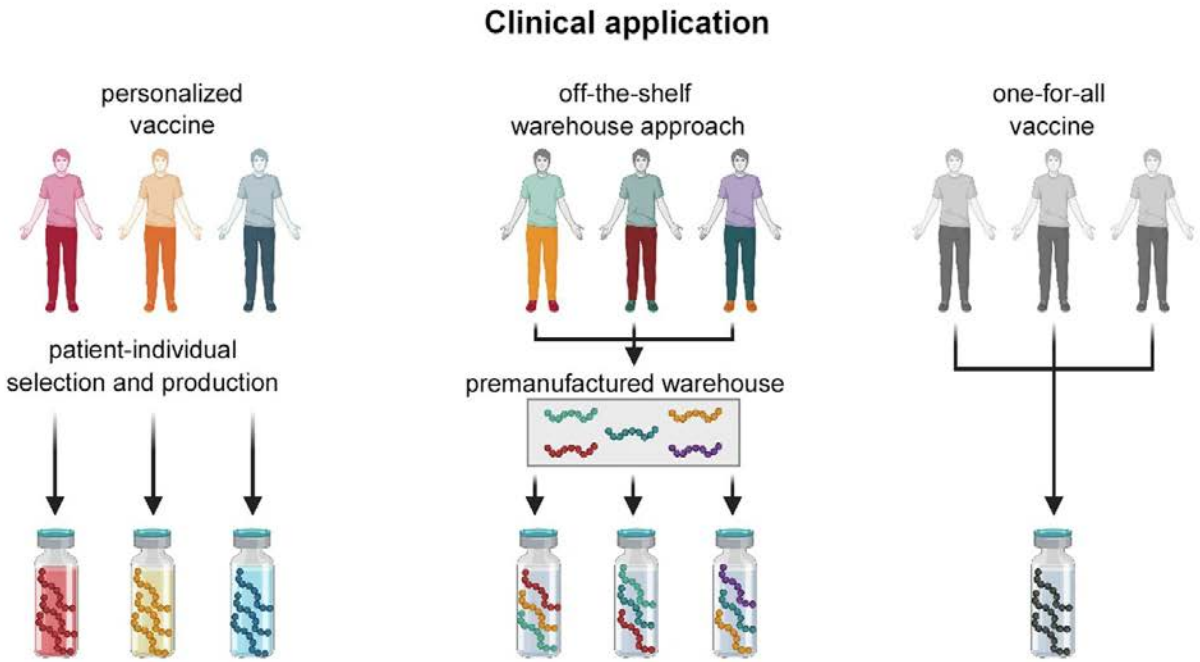


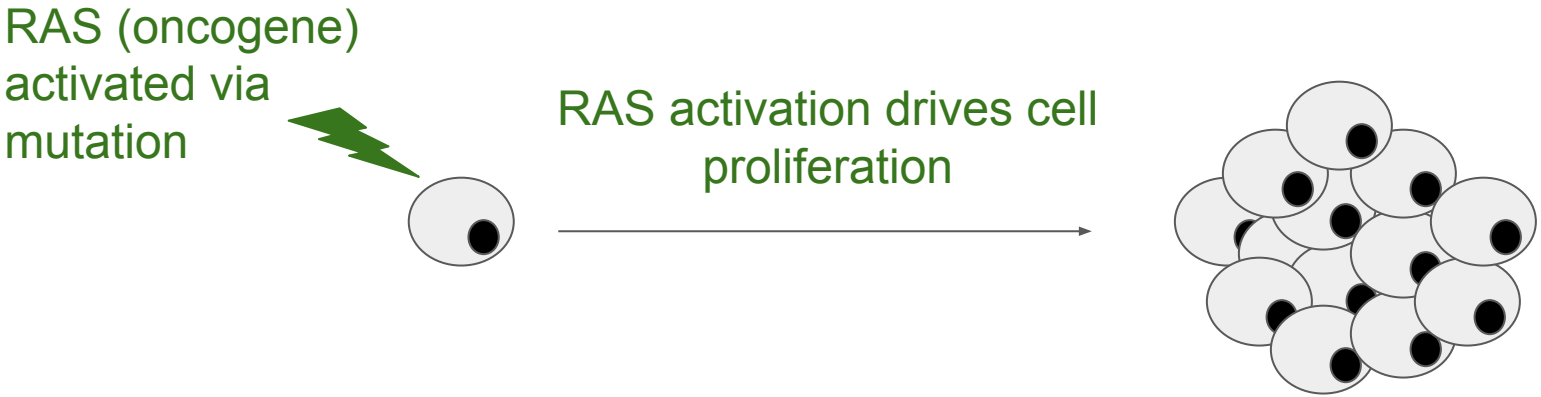
Photo Creds: Schaeffeler et al, Nature 2025

<u>FDA Approved for:</u>
Prostate Cancer, Melanoma

<u>Clinical Trials:</u>
Melanoma, Breast Cancer, Glioblastoma, AML, cervical cancer, Lung cancer

Targeted Therapies

RAS is a commonly mutated oncogene



- RAS is frequently mutated in cancer
- RAS expression drives cancer progression
- Considered to be an undruggable target for many years
- New RAS inhibitors: Daraxonrasib (RMC-6236), Sotorasib (Lumakras) & Adagrasib

Daraxonrasib doubles pancreatic cancer survival

Former Nebraska Senator, Ben Sasse
Photo Cred: NY Times

Pancreatic cancer has a 13% 5-year survival rate

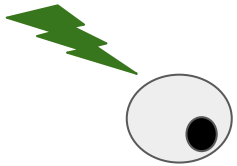
Daraxonrasib increased median survival from **6.7 to 13.2** months for stage IV pancreatic cancer!

Developed by Revolution Medicines

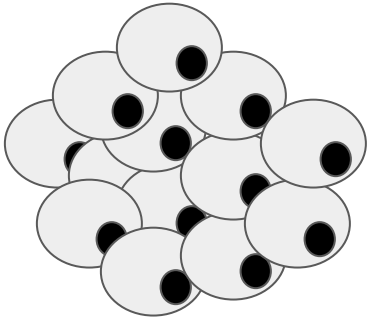
Researchers have been working on RAS for years: Shokat Lab (UC San Francisco), the Fesik Lab (Vanderbilt), and companies like Amgen and Mirati Therapeutics have played key roles in developing RAS inhibitors

Menin is a commonly mutated oncogene in AML

menin (oncogene) activated via mutation

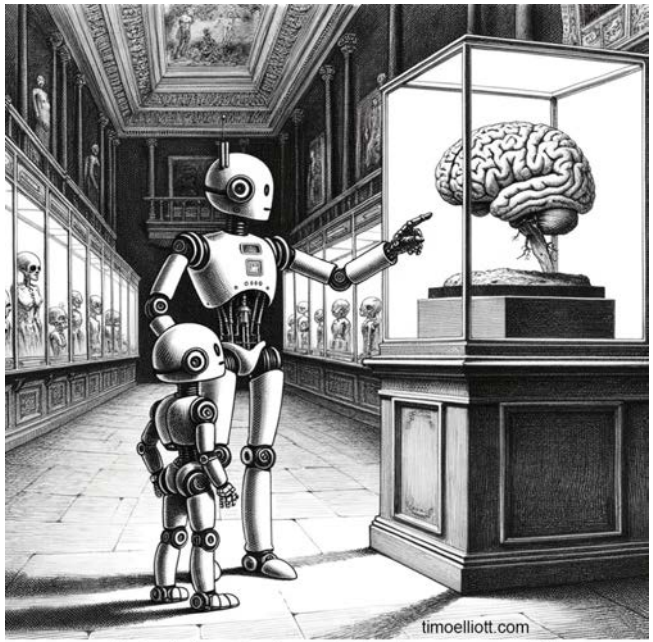


Menin drives expression of other oncogenes leading to cell proliferation



- Menin expression drives cancer progression
- Menin inhibitors: FDA approved revumenib, FDA approved in Oct 2025
  - Developed at the University of Michigan and Dana-Farber in collaboration with Kura Oncology and Syndax Pharmaceuticals

Is there anything good about AI? Actually yes..



"And that is the original processor!"

Artificial Intelligence is improving cancer detection and treatment

What is AI?

- Artificial intelligence (AI) is a machine's ability to perform functions that are usually thought of as intelligent human behaviors
- Computers derive this ability from algorithms
- AI algorithms can detect patterns in large amounts of data and identify relationships among pieces of data

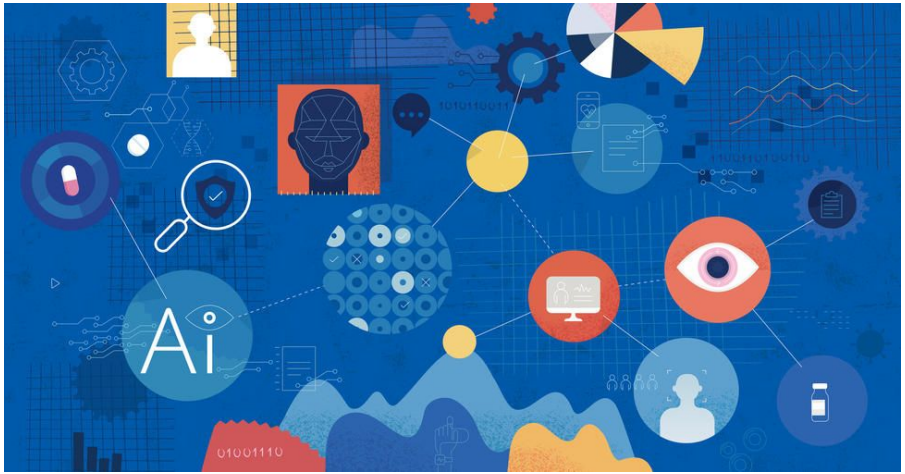


Photo Creds: NCI

Artificial Intelligence is improving cancer detection

- to better detect prostate cancer in biopsies
- to detect breast cancer in mammograms AND to determine invasive breast cancer
- To detect cervical lesions
- Computer aided detection during colonoscopies

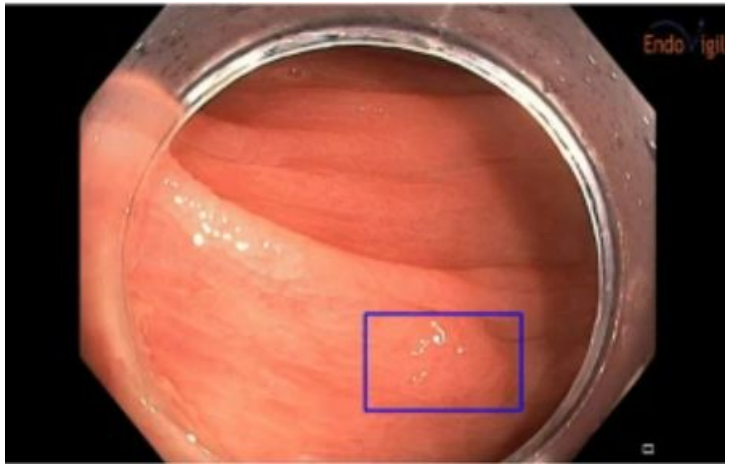


Photo Cred: Cancer.gov

Artificial Intelligence is improving cancer treatment

- Predict survival outcomes for patients
- Predict drug response
- Helping oncologists to survey the literature and identify the latest in cancer treatment options

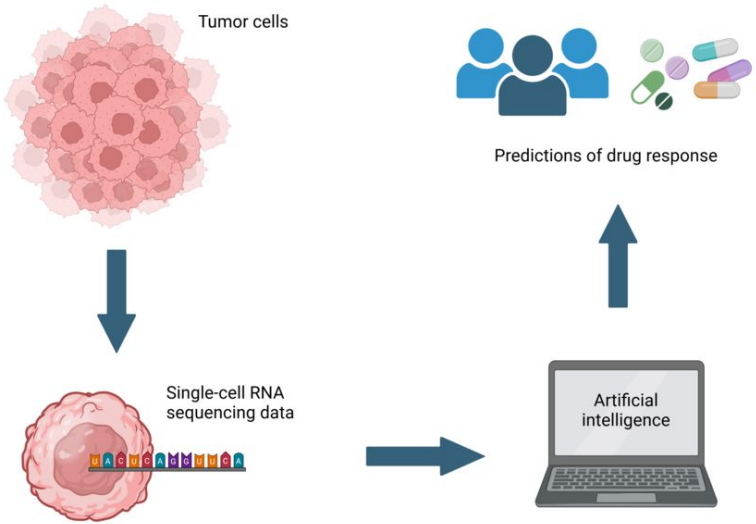


Photo Cred: Cancer.gov

Conclusions

1. Cancer is a highly proliferative state
2. Cancer therapies take advantage of the needs of proliferative cells
3. Newer cancer treatments are leveraging...
    - new & improved imaging techniques
    - the potential of the immune system
    - a more targeted approach
    - the power of AI

Thank you!