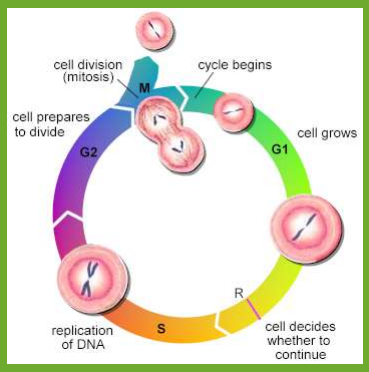
The Four "R" s of Radiotherapy

Redistribution



Radiosensitivity varies with phase of cell cycle

- **M is most sensitive**
- **Late S is least sensitive**
- **M> G1, G2 > Early S > LS**

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The Four "R" s of Radiotherapy

Repopulation

- **Repopulation of tumor cells may occur during RT , thereby, reducing its efficacy**
- **Accelerated Repopulation is well studied esp. in SqCC of the head and neck (@ around 3 weeks). Perhaps re-oxygenation may play a role in this phenomenon**

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The Four "R" s of Radiotherapy

Re-oxygenation

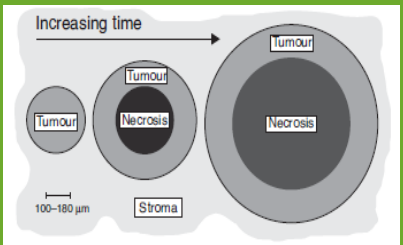
DIFFUSION-LIMITED HYPOXIA

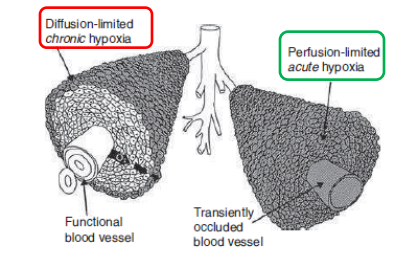
OXYGEN CAN DIFFUSE TO A LIMITED DISTANCE FROM BLOOD VESSELS

PERFUSION LIMITED HYPOXIA

TUMOR VESSELS ARE STRUCTURALLY AND FUNCTIONALLY ABBERANT

Thomlinson and Gray (1955)





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Fractionation

- Fractionation takes advantage of differences in repair between normal tissues and tumors, tumors hopefully being less able to repair damage
- Fractionation also is influenced by re-assortment
- Fractionation also takes advantage of inherent radio-sensitivity differential between normal tissues and tumor

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Radiation Response and Proliferative Rate

Law of Bergonie and Tribondeau (1906)

Based on radiation experiments on the ram testicle :

- ***Radio-sensitivity** is greatest in rapidly proliferating cells and in cells with a long proliferative future and it is least in differentiated cells"*
- ***Exception : lymphocytes***
- ***Applies only to clonogenic cells.***

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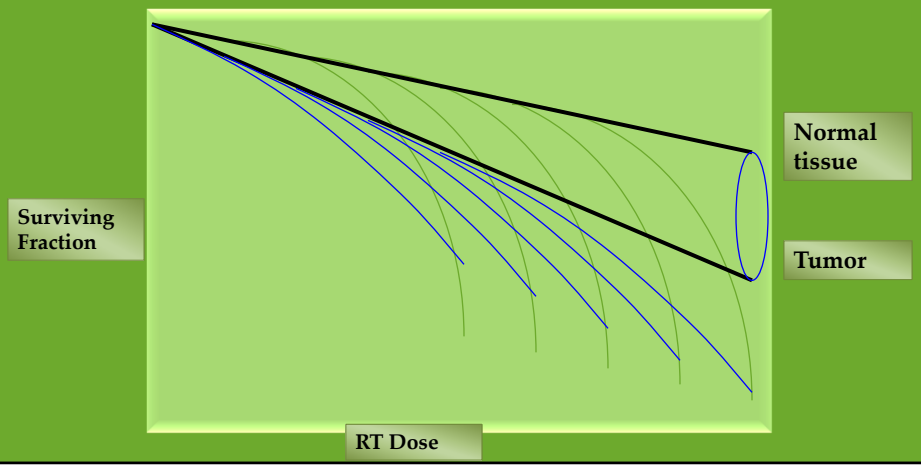
Multi-fraction Effects: Cell Type

- **Why Fractionation is useful.**
- **Different cell survival curve slopes , same fraction size**



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Part III
A Prelude to Clinical Radiation Oncology

- RT delivery systems
- Rationale and role of RT in treating tumors
- Adverse effects of radiation (what nurses need to know about)

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Delivery of Radiotherapy
Tools of the Trade

- **External Beam Radiotherapy (tele-therapy)**
  - Linear Accelerator
  - Tomo-therapy
  - Radioactive source machines (^{60}Co, ^{137}Cs)
  - Particle therapy
    - Protons
    - Carbon ions
  - Stereotactic Radiation
    - Cyber-knife
    - Gamma-knife

- **Brachytherapy (Low Dose Rate or High Dose Rate)**
  - Intra-cavitary
  - Interstitial
  - Surface

- **Internally Deposited Radionuclides**
  - Intra-arterial
    E.g., Intra-hepatic ^{90}Y-resin
  - Intra-venous
    E.g., ^{111}In or ^{90}Y labeled Rituximab
    E.g., ^{89}Strontium
  - Oral
    E.g., ^{131}Iodine

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External Beam Radiotherapy

(EBRT)

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Linear Accelerator (Linac)

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Tomotherapy

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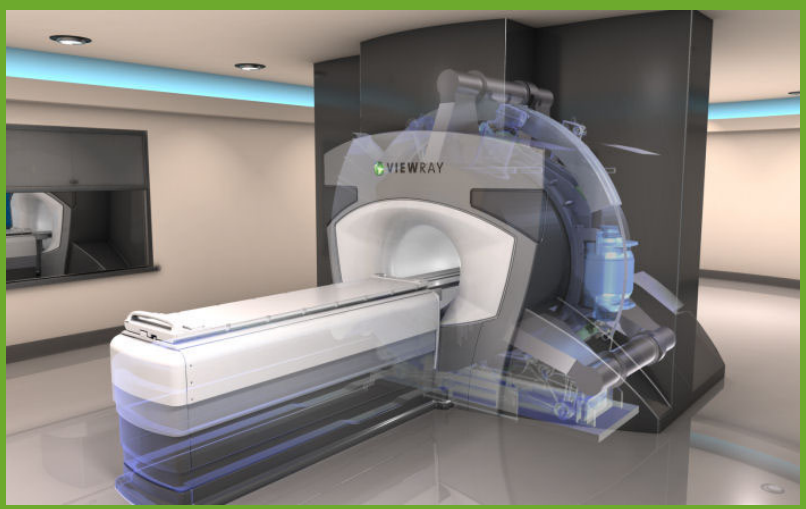
Radioactive source based machines



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Protons

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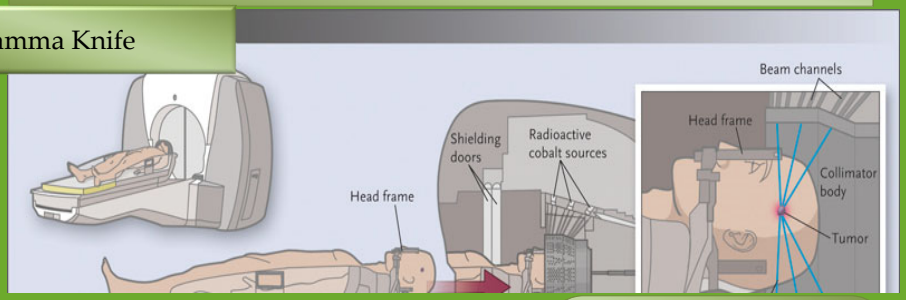
High Precision (Stereotactic) Radiation

Gamma Knife



Cyber Knife

- **SRS (stereotactic radiosurgery) single fraction**
- **FSRT (fractionated stereotactic radiotherapy)**

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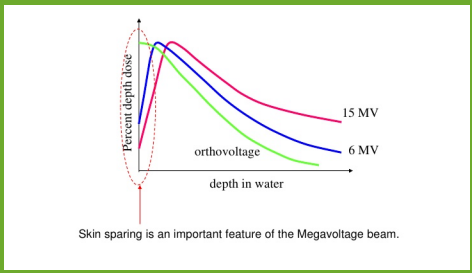
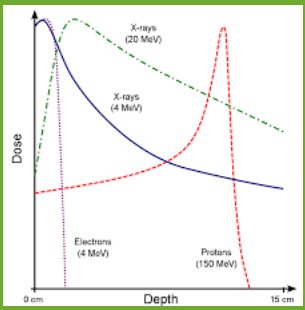
External Beam Radiotherapy (EBRT)

Beam profile at depth

Megavoltage, Orthovoltage and Particles





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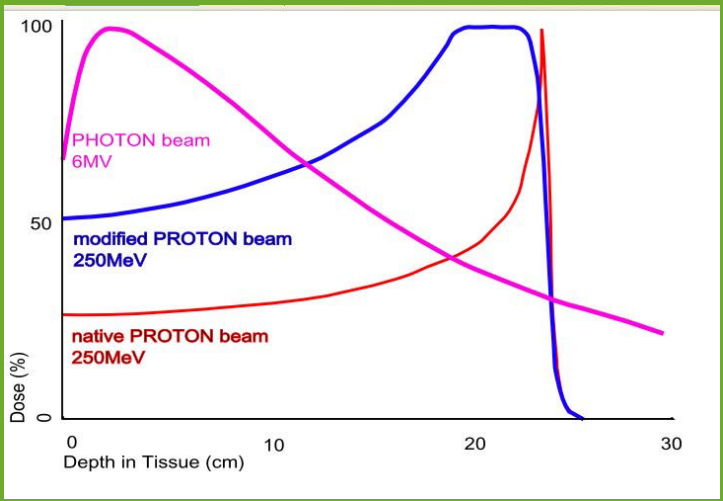
Some useful beam characteristics

Bragg Peak for Charged Particles



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Brachytherapy

Surface, Interstitial or Intra-cavitary

Permanent or Temporary

LDR (low dose rate) or HDR (High dose rate)

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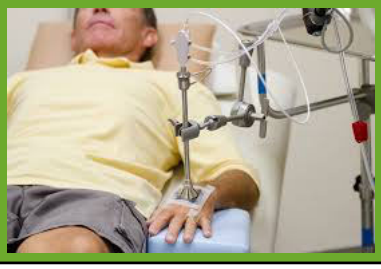
Brachytherapy

Surface Applicators for skin cancers
HDR



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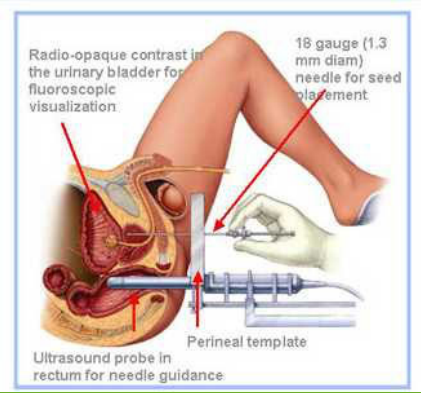
Interstitial Brachytherapy
Prostate Cancer
Low Dose Rate Permanent Seed Implant



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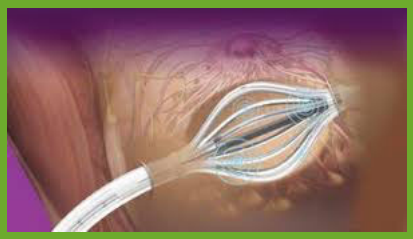
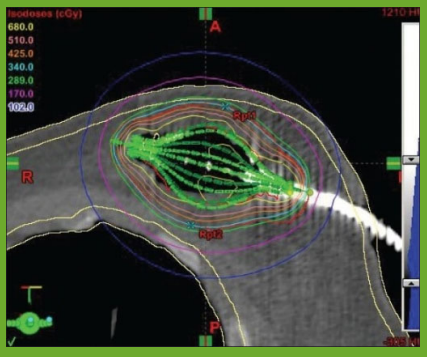
Interstitial Brachytherapy
Breast Cancer
High Dose Rate Implant





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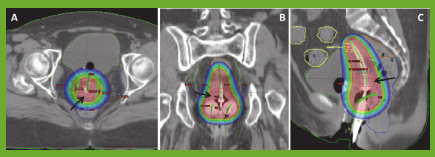
Intra-cavitary Brachytherapy
Gynecological Cancers
High Dose Rate (Minutes)

Figure 1: Patient with applicator and packing procedure



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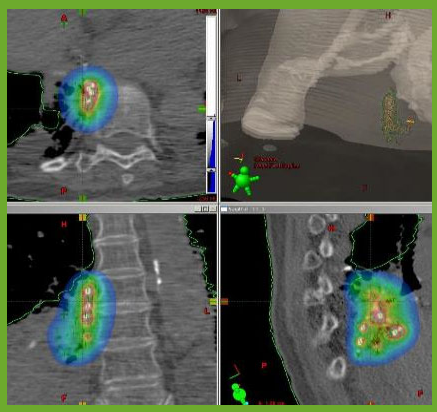
Brachytherapy
Intra-cavitary

Intra-bronchial HDR



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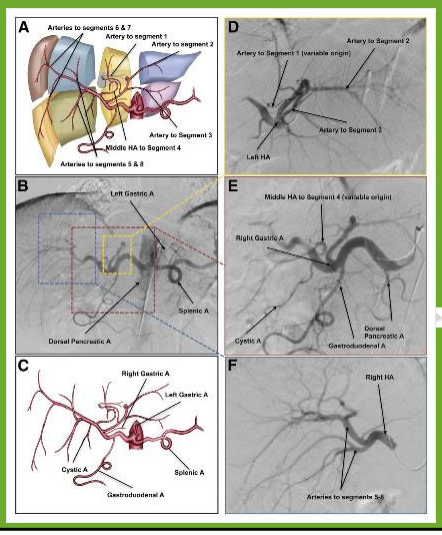
Internally Deposited Radiotherapy

Selective Intra-arterial ^{90}Y-resin Injection



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Principles of Work Flow in Radiotherapy

Consultation

Planning /Simulation

- Immobilization
- Image acquisition in treatment position and target localization
- Plan generation in software

Treatment delivery

Verification of accuracy of treatment delivery

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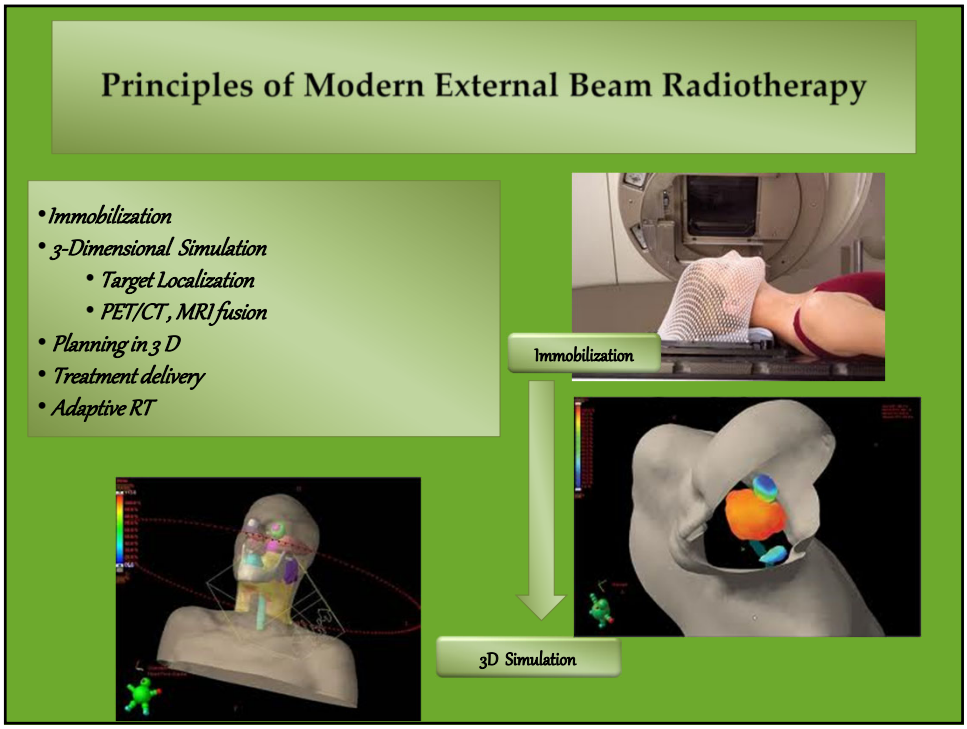
Principles of Modern External Beam Radiotherapy
•Immobilization
• 3-Dimensional Simulation
• Target Localization
• PET/CT, MRI fusion
• Planning in 3 D
• Treatment delivery
• Adaptive RT
Immobilization
3D Simulation

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