

INTRODUCTION TO BRACHYTHERAPY

RT4220 – Lecture #15

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WSU

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WHAT IS BRACHYTHERAPY?

- **“Treatment with radionuclides at short distance”**
 - From latin brachios, meaning short
 - This is in contrast to external beam therapy, or teletherapy
 - We can characterize the many modalities of brachytherapy as such:
 - Method of placing sources
 - Dose rate
 - Loading technique
-

WHY IS BRACHY USED?

01

High dose to
small volume

02

Less dose to
superficial
tissues

03

Shorter overall
treatment time
(days)

04

Radiobiological
advantages of
low dose rate (?)

WHERE BRACHY FAILS

Radiation
exposure to
staff, visitors

Invasive
procedure

Requires highly
skilled operator

Requires
hospital
admission

Not suitable for
large volumes

Precision of
placement
becomes critical

CATEGORIES; BY METHOD

Intracavitary: Applicator in a natural cavity

- Gynecological

Interstitial: Needles, catheters, or seeds placed directly in tissue

- Prostate, cervix, head and neck, breast, ...

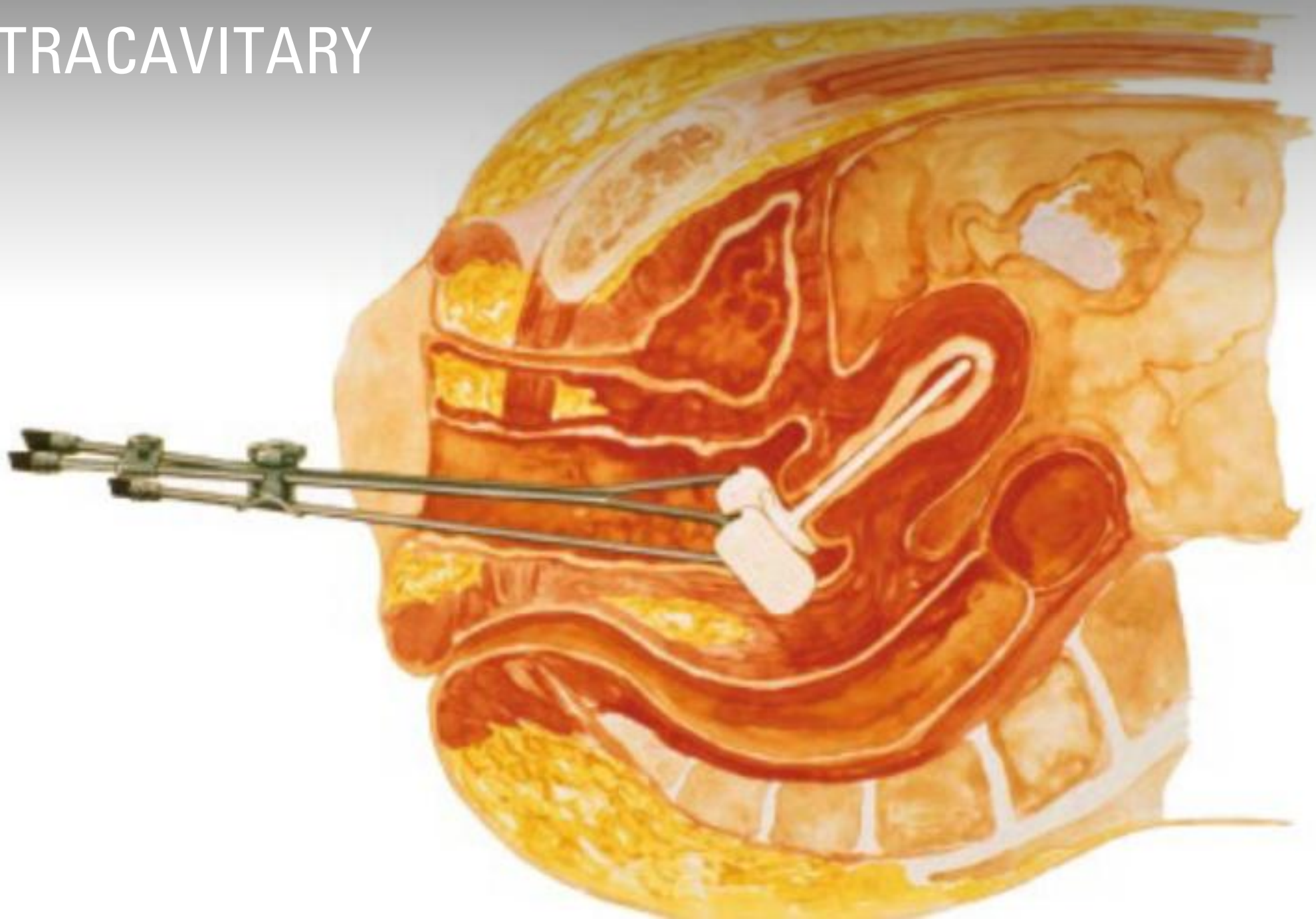
Surface: Applicator applied externally

- Skin

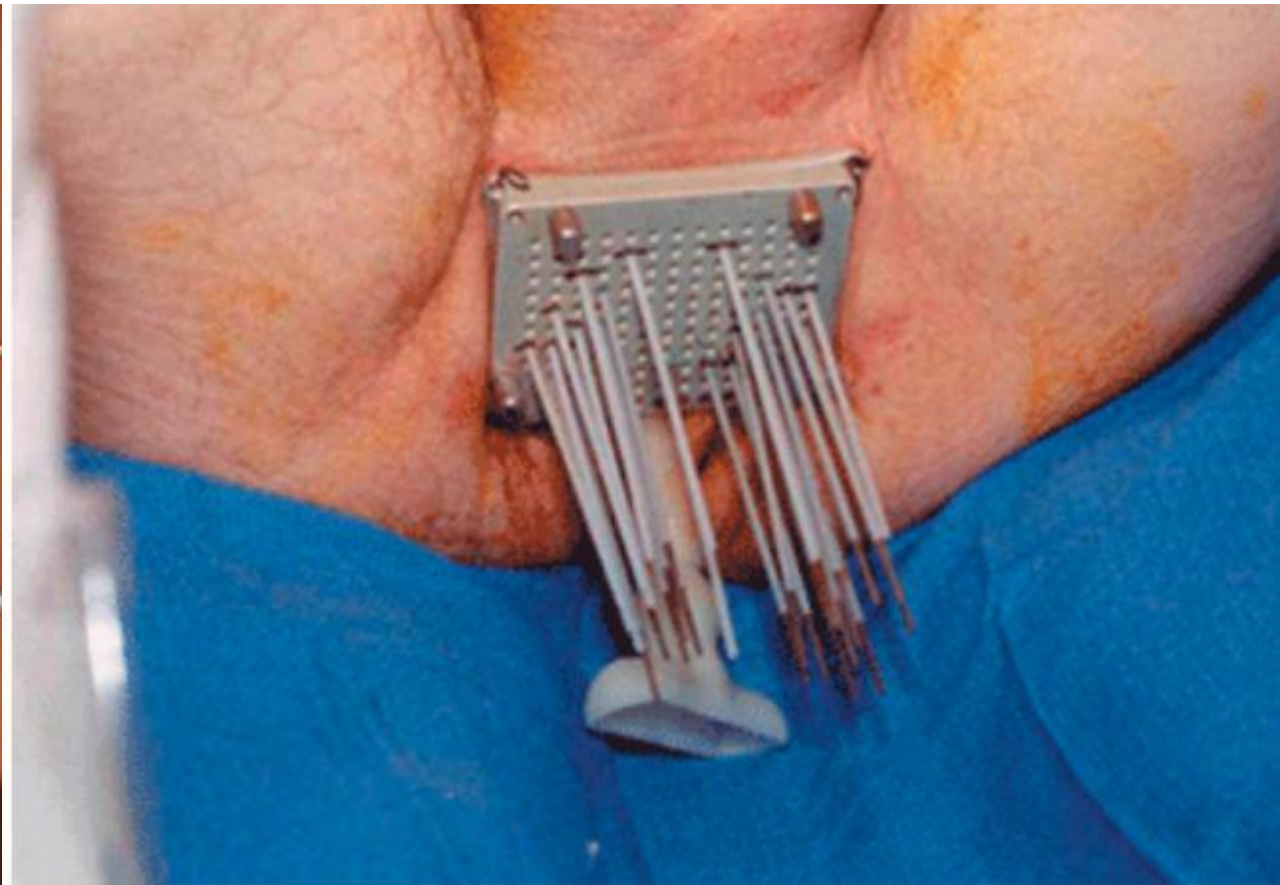
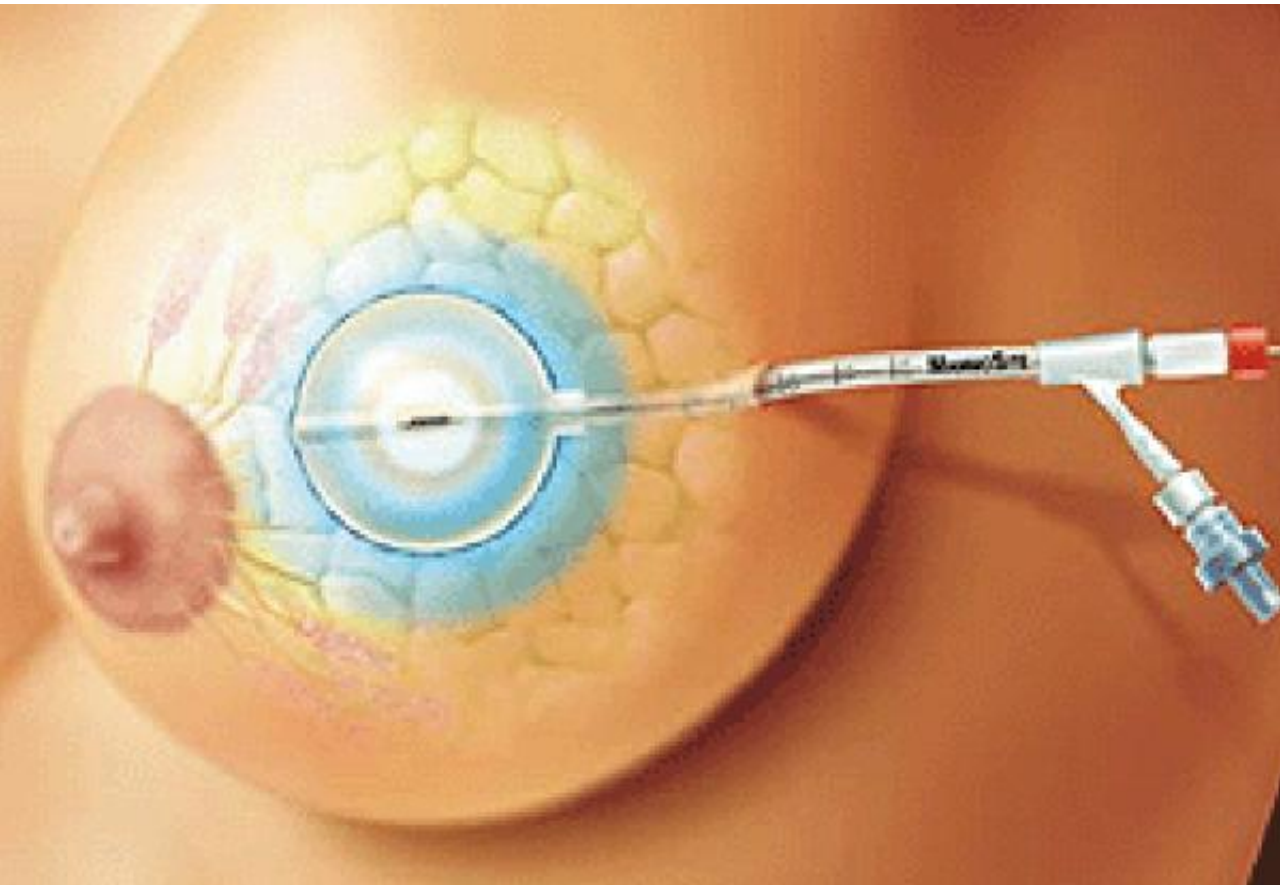
Intraluminal: Tubes placed in tubular organs

- Bronchus, biliary tree, esophagus, arteries

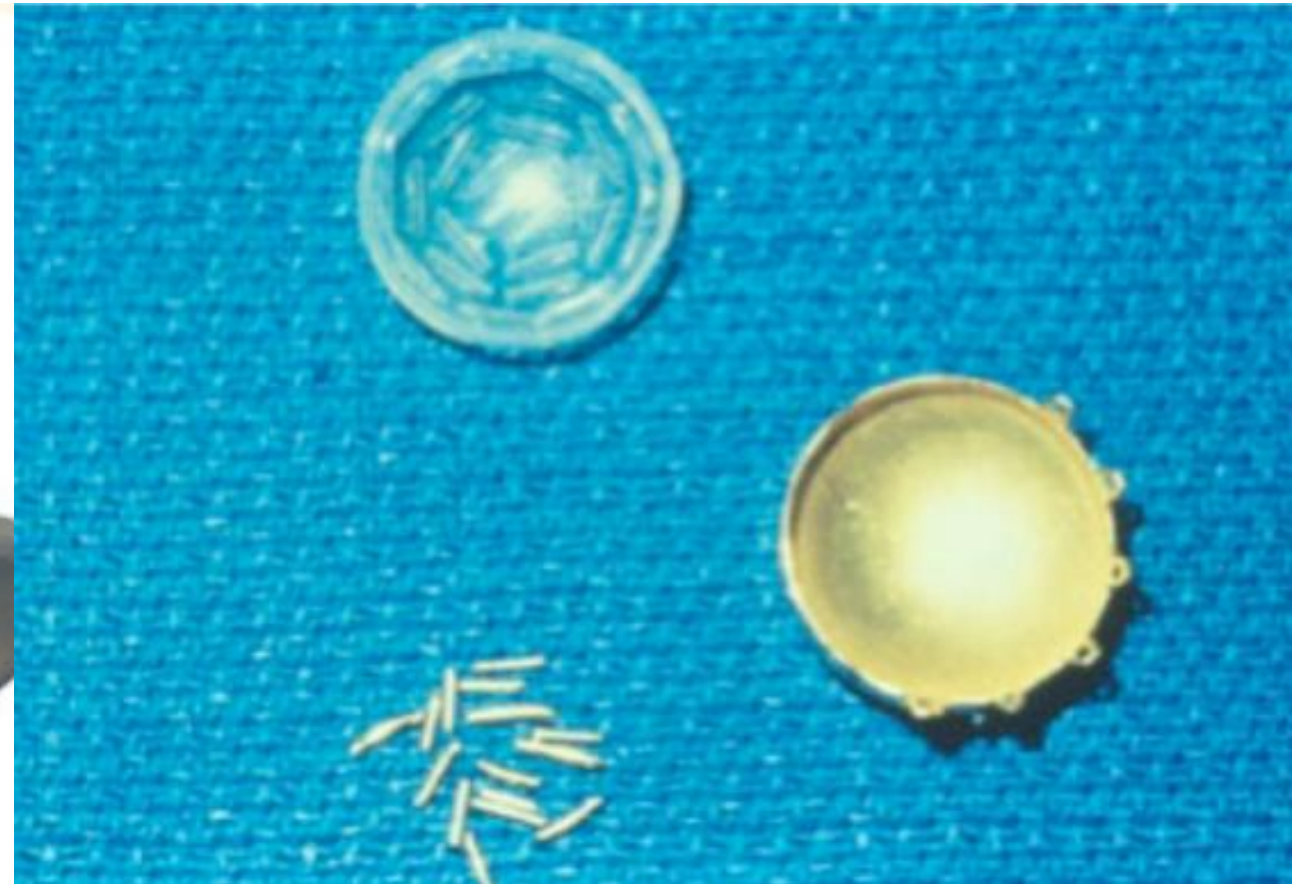
INTRACAVITARY



INTERSTITIAL



SURFACE



INTRALUMINAL

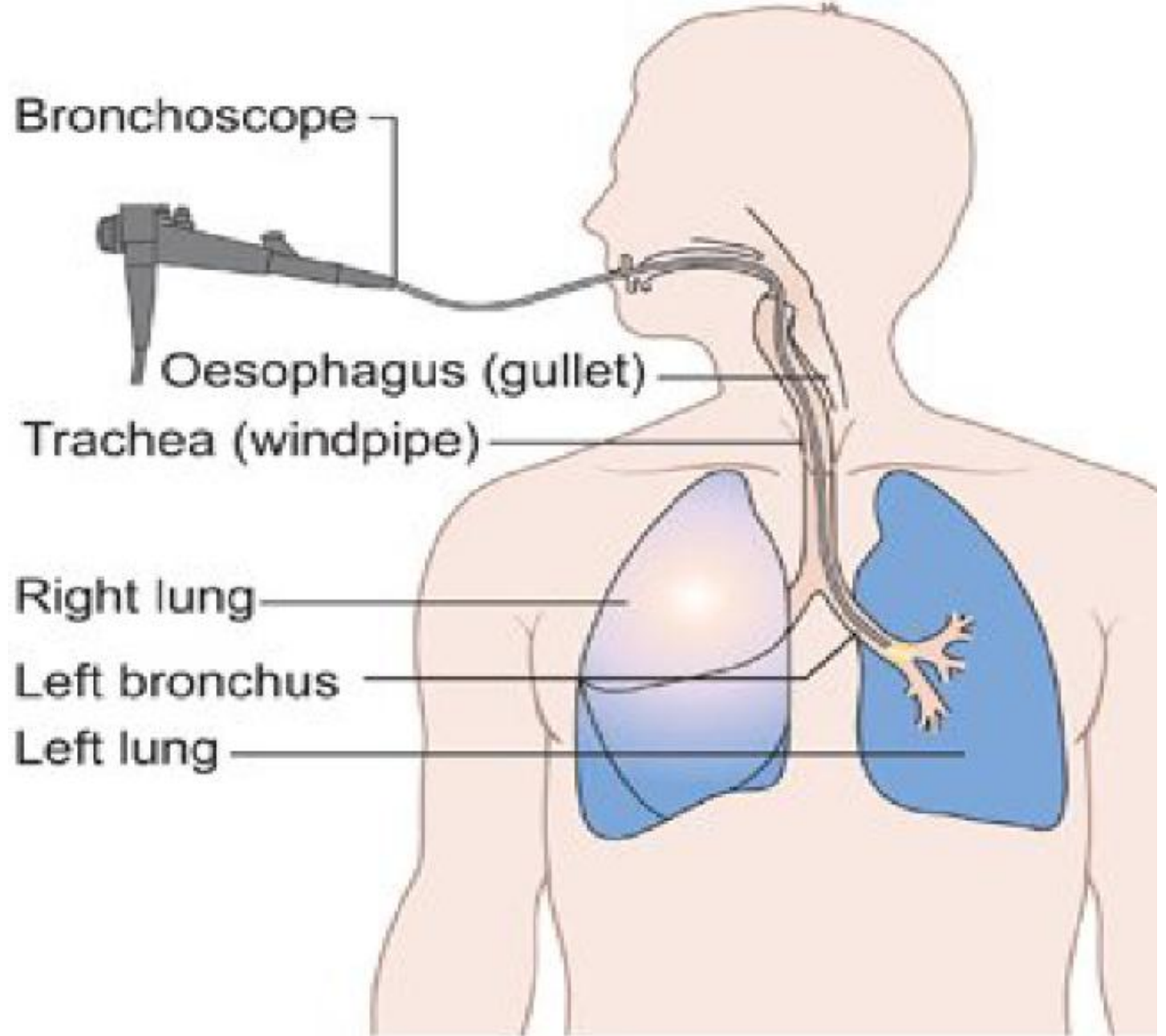


Diagram showing a bronchoscopy
Copyright © CancerHelp UK

CATEGORIES; BY DOSE RATE



Permanent: < 20 cGy/hr (natural decay)



Low Dose Rate (LDR): 30-80 cGy/hr (standard)



Medium Dose Rate: 100-1200 cGy/hr (has problems with radiobiology)



High Dose Rate (HDR): >1200 cGy/hr (fractionated)



Pulsed: many small HDR fractions, simulating LDR

CATEGORIES; BY LOADING METHOD

- **Manual:** “hot” loading in the OR
- **Manual Afterloading:**
unloaded applicator at surgery,
sources placed later for
continuous treatment
- **Remote Afterloading:** source
managed by machine, usually
fractionated or interruptible





TYPICAL ACTIVITIES USED



Radioactive Stent: uCi range



Permanent I-125: 0.4 mCi/seed, to 30 mCi



Temporary GYN: 25 mCi/source, to 200 mCi



Temporary Template: 3 mCi/seed, to 400 mCi



HDR: 10 Ci

TYPES OF SOURCES

Needles

Tubes

Wire

Seeds

Ribbons

Plaques

Pellets

**Cable-
mounted**

IMPORTANT FUNDAMENTAL CHARACTERISTICS

Half-life

Mean Energy

HVL, TVL

Exposure Rate Constant (Γ)

REVIEW OF FUNDAMENTALS

GET PHYSICSED! :o

MEAN ENERGY

- Photon emitting isotopes can be grouped into two categories:
 - **High Energy:** >100 keV, similar to Radium in tissue, thus they have similar character in tissue, vary only in shielding characteristics
 - **Low Energy:** <50 keV, isotopes like I-125 and Pd-103

Periodic Table of the Elements

[illegible]

EXPOSURE RATE CONSTANT (Γ)



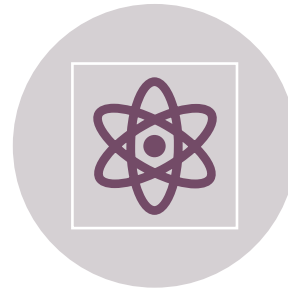
Relates contained activity to an output



May describe exposure or air kerma



Source of error in traditional systems



Not used today to calculate dose, but physics still learns it

RADIOACTIVE DECAY AND ACTIVITY

- **Activity:** the number of nuclear disintegrations per unit time

$$A(t) = -\frac{dN(t)}{dt}$$

- **Experimental Activity:** proportional to the number of parent nuclei

$$A(t) = \lambda N(t)$$

- **Activity at a Given Time:**

$$A(t) = A_0 e^{-\lambda t}$$

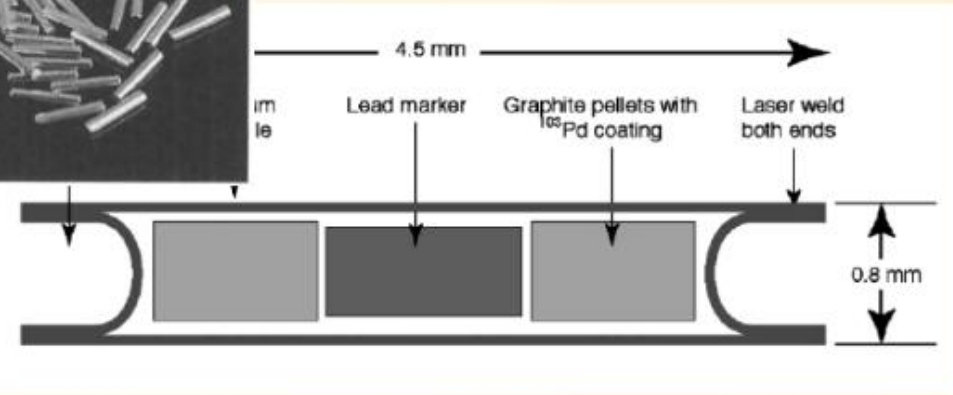
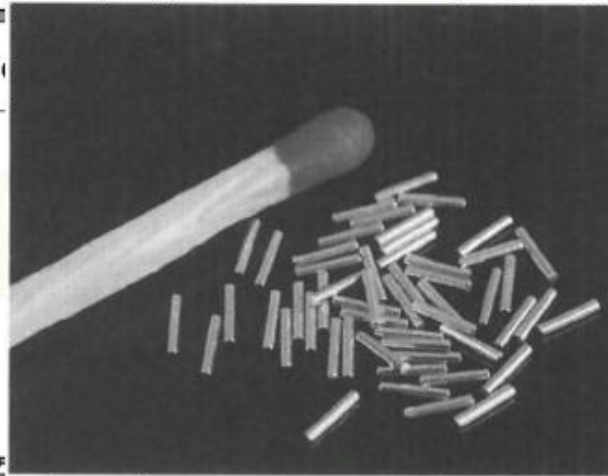
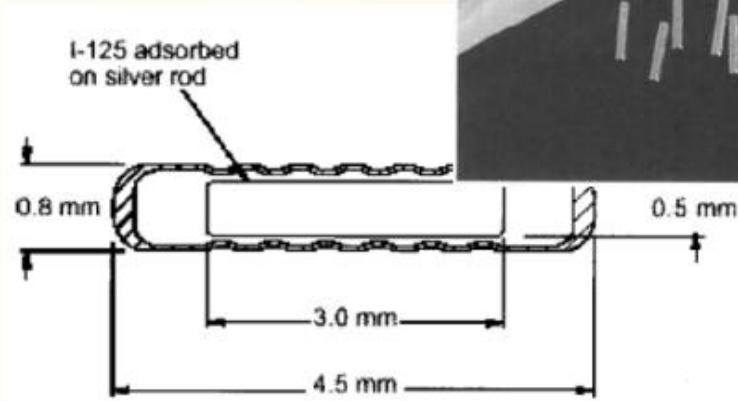
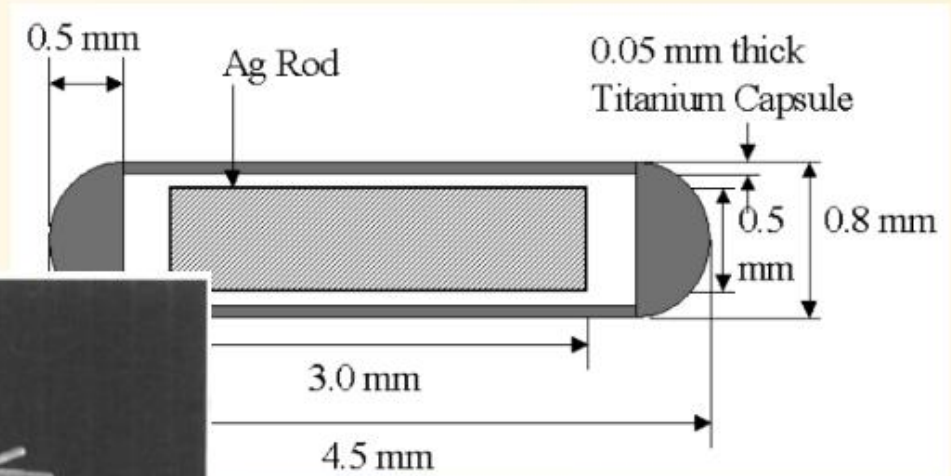
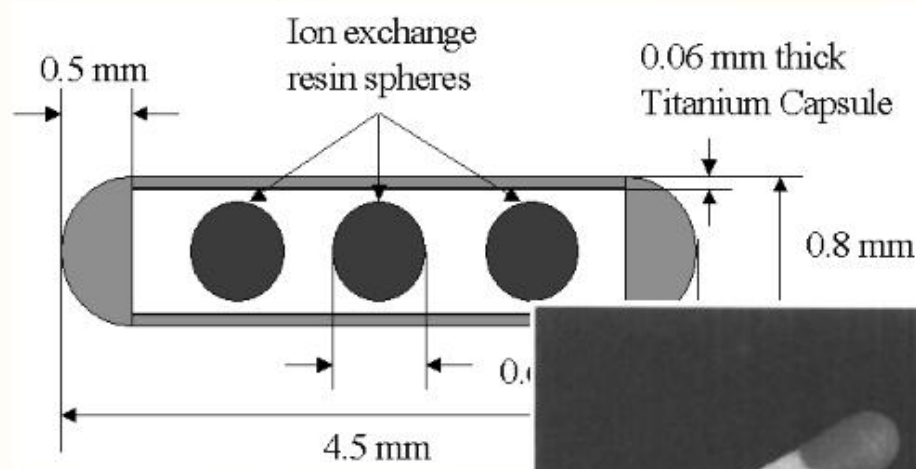
- **Half-life:** expected time where half of the original activity will decay

$$T_{1/2} = \frac{\ln 2}{\lambda}$$

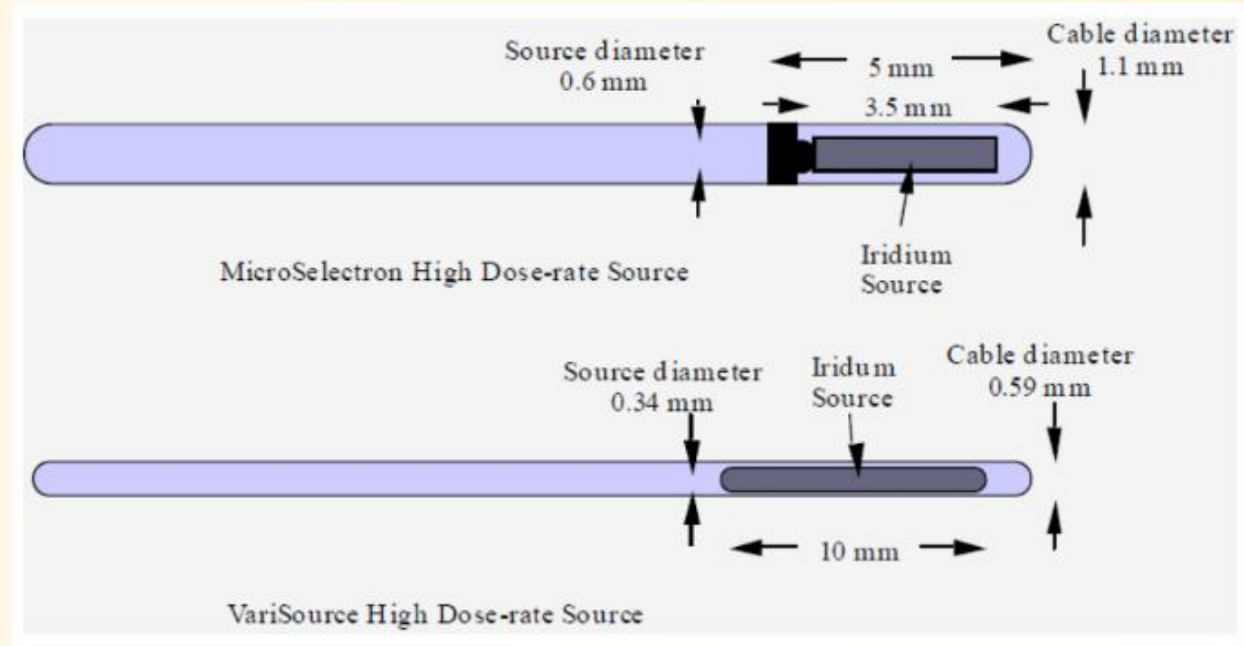
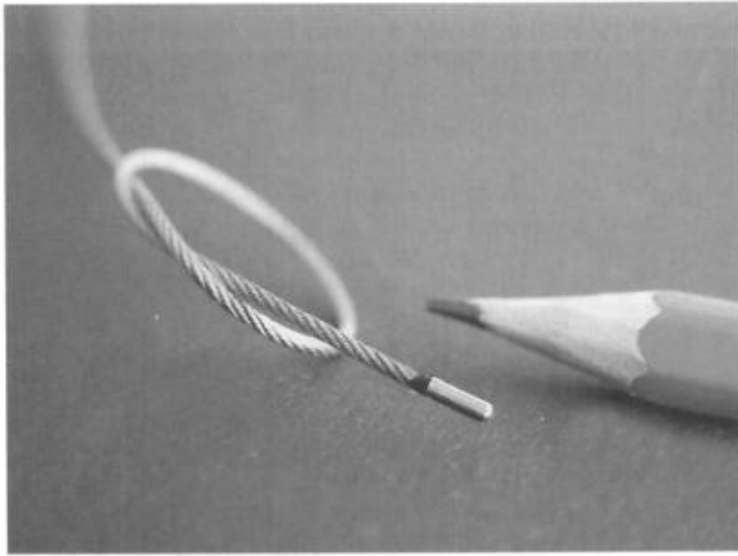
- **Mean-life:** the average lifetime of a given nucleus

$$\tau = \frac{1}{\lambda}$$

Seed Designs

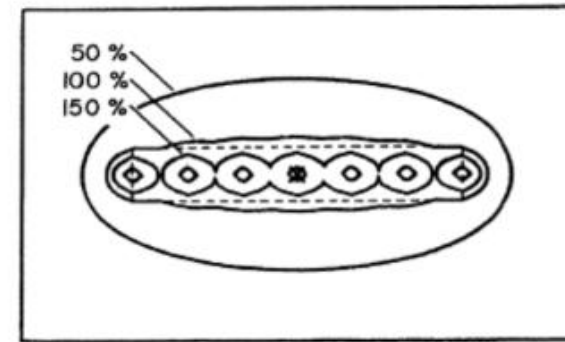


Cable-Mounted Designs

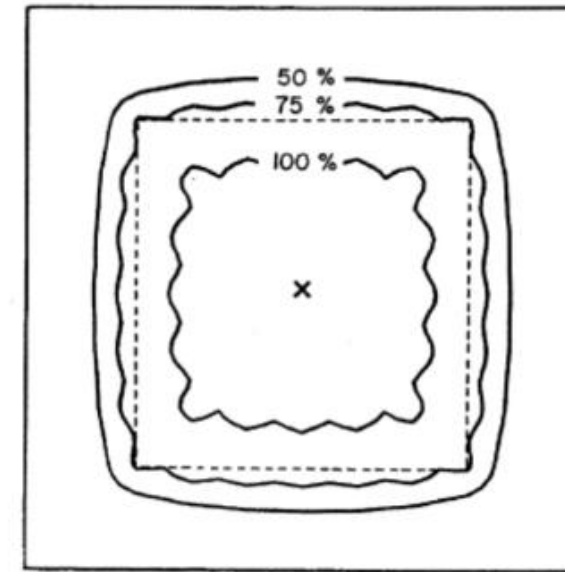


Quimby Planar Implants

- Dose to center of implant much higher than dose to boundaries
- Only a single plane of sources considered



(a)



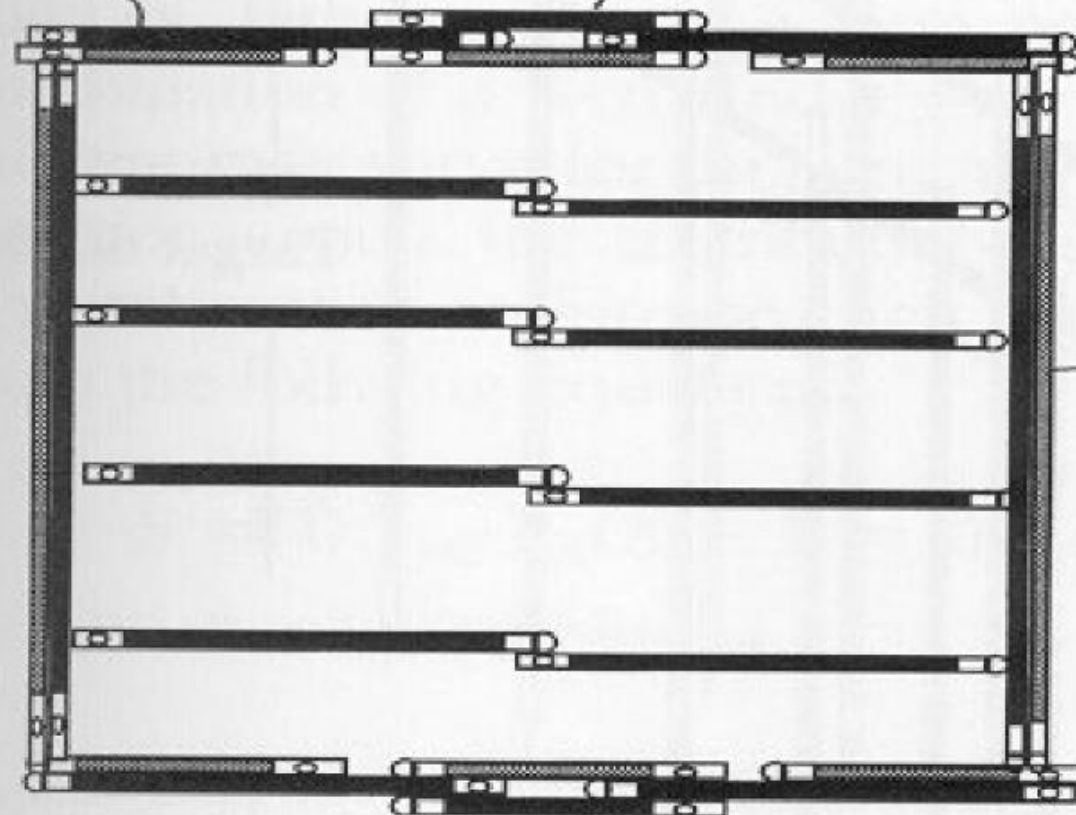
(b)



3.0 cm
active length

1.5 cm active length

4.5 cm
active length



Full strength



Half strength



Types of Needles

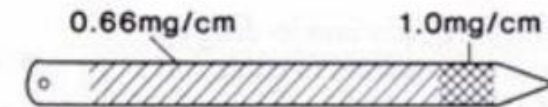
- Needles with activity all along except at ends
- Needles with normal activity along the length and higher activity at one end – “Indian club needles”
- Needles with normal activity along the length and higher activity at both ends – “Dumbbell needles”

RADIUM NEEDLES

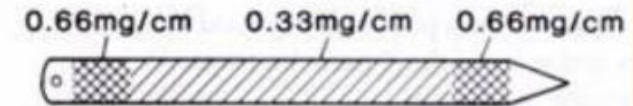
Uniform



“Indian Club”



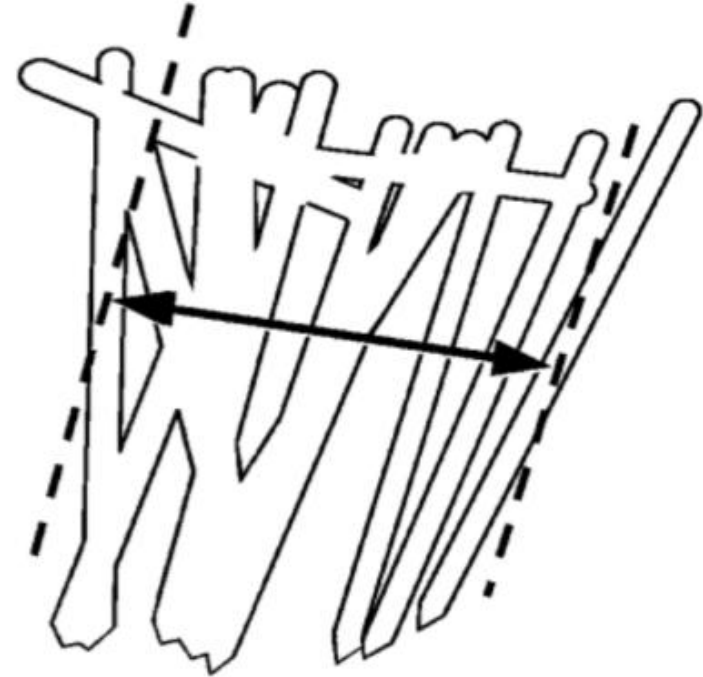
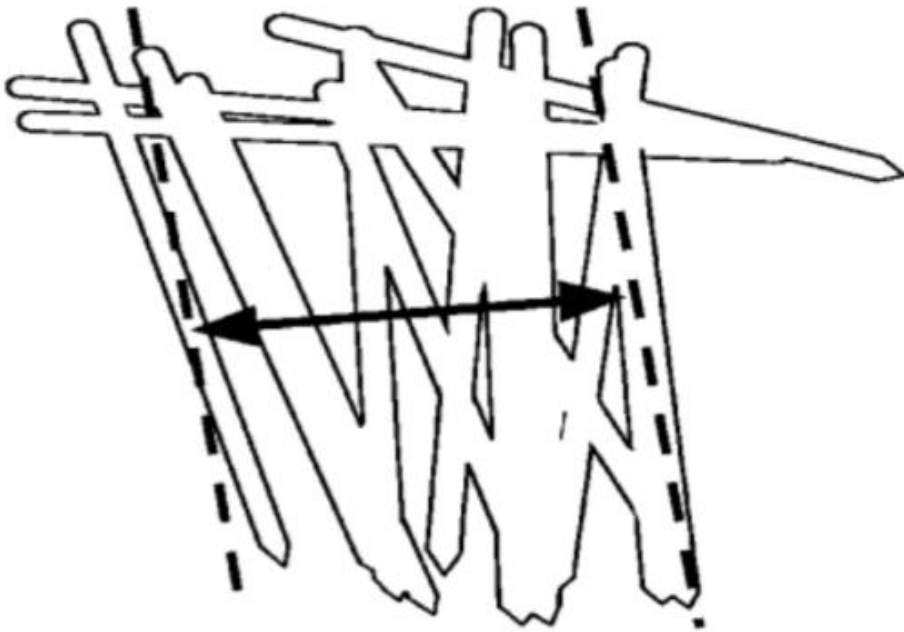
“Dumbbell”



Tube



Actual Implants



LOAD UP BRACHYTHERAPY QUALITY ASSURANCE!

By Dr. Adrian Nalichowski

