
INTRODUCTION TO BRACHYTHERAPY

RT4220 – Lecture #15

Kedree Proffitt

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

Intracavitory: Applicator in a natural cavity

- Gynecological

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

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

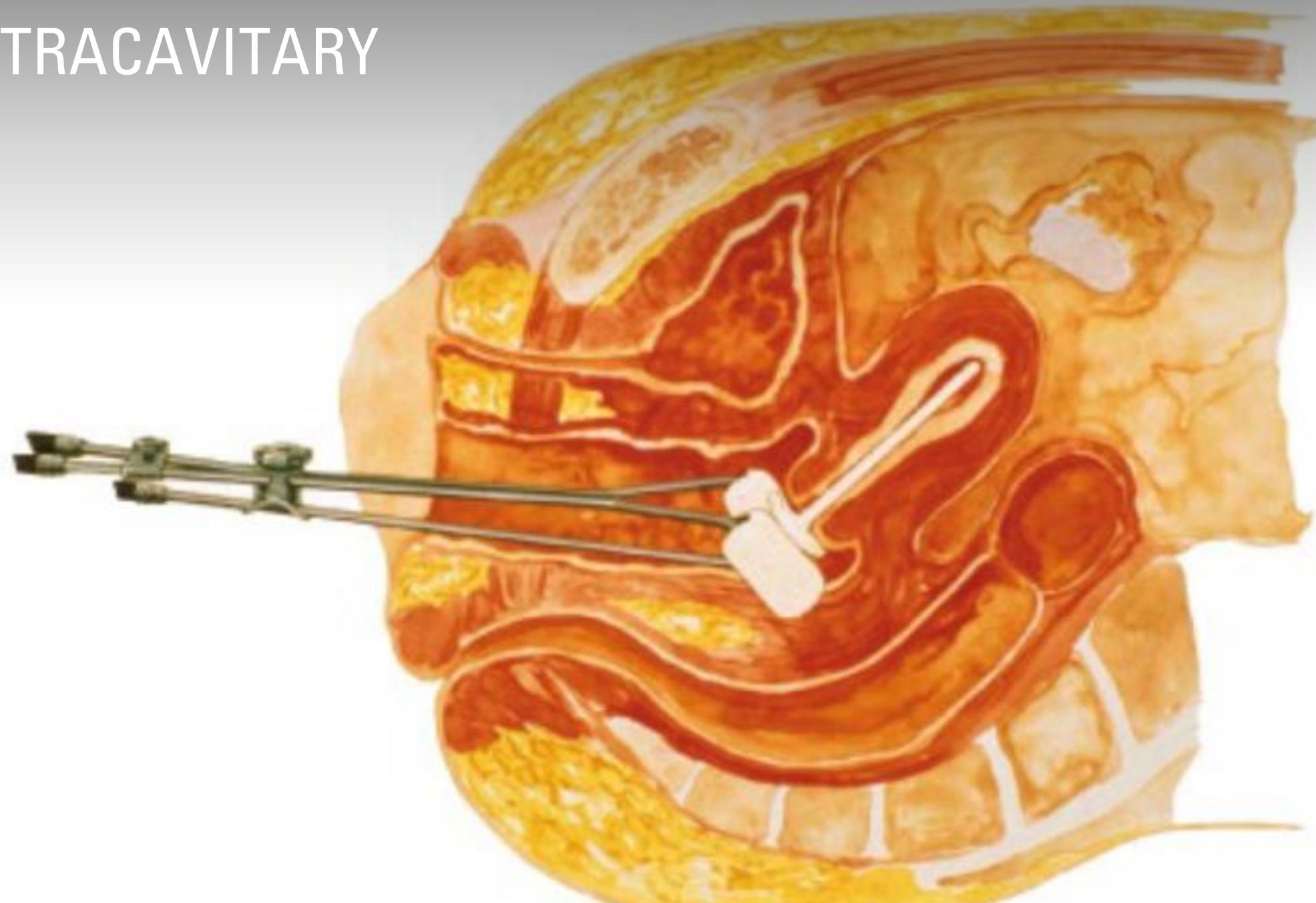
Surface: Applicator applied externally

- Skin

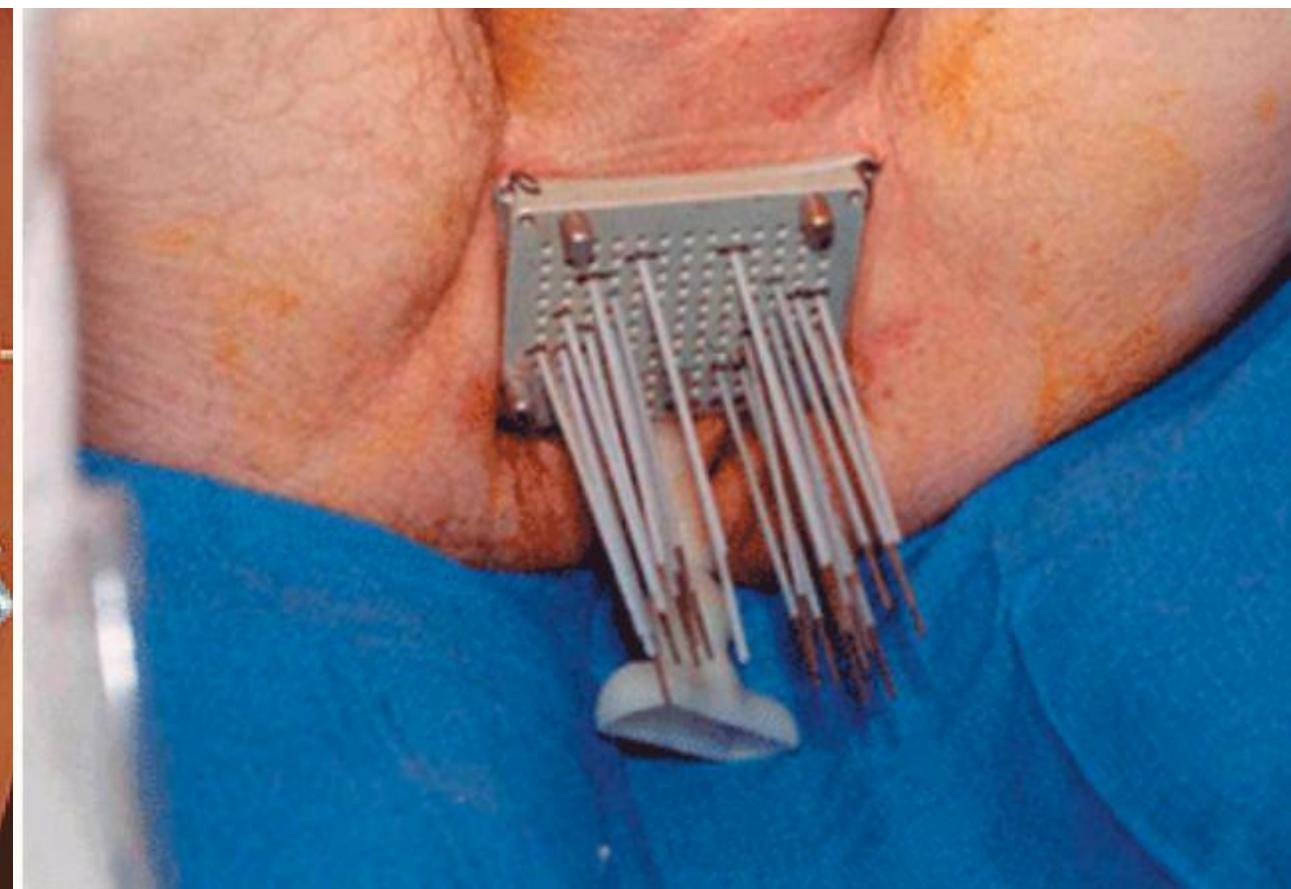
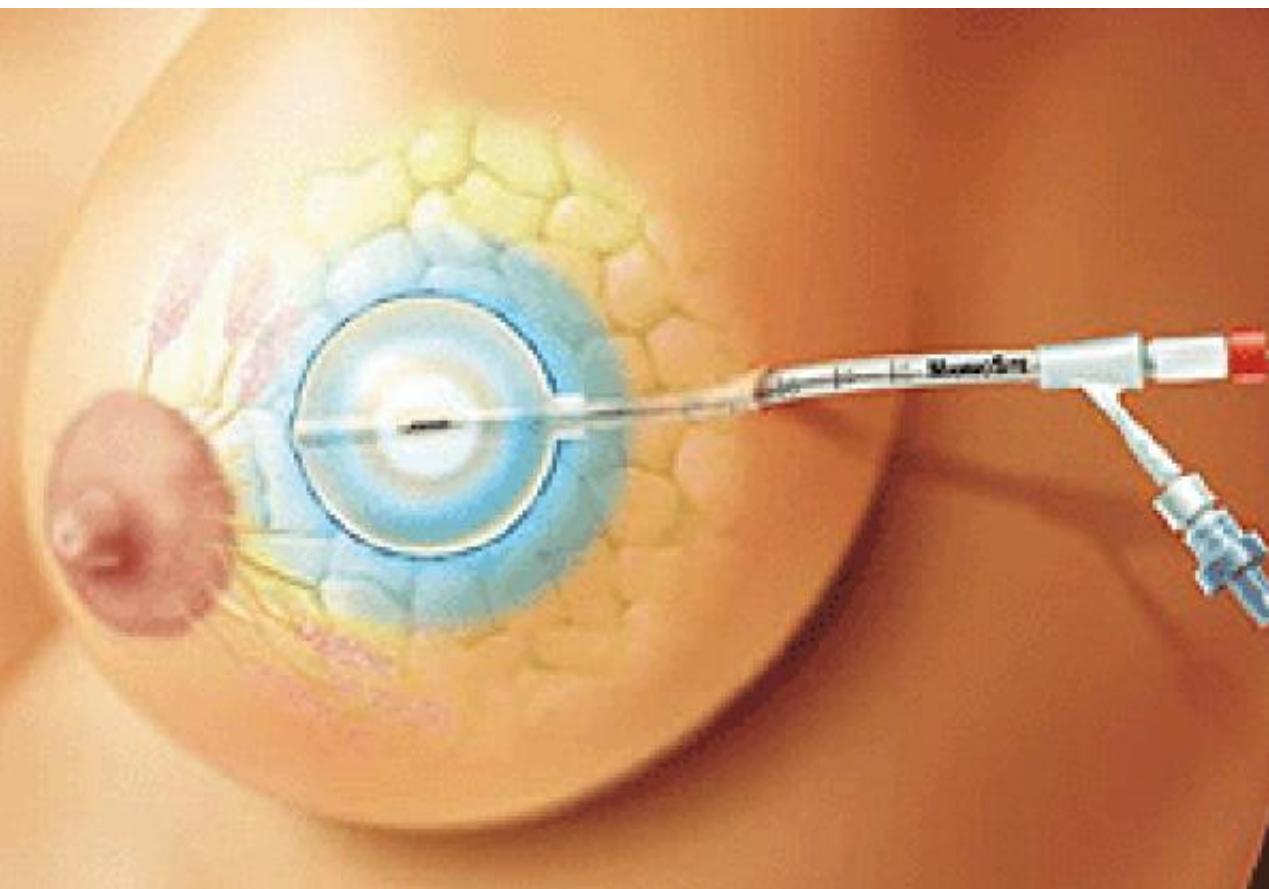
Intraluminal: Tubes placed in tubular organs

- Bronchus, biliary tree, esophagus, arteries

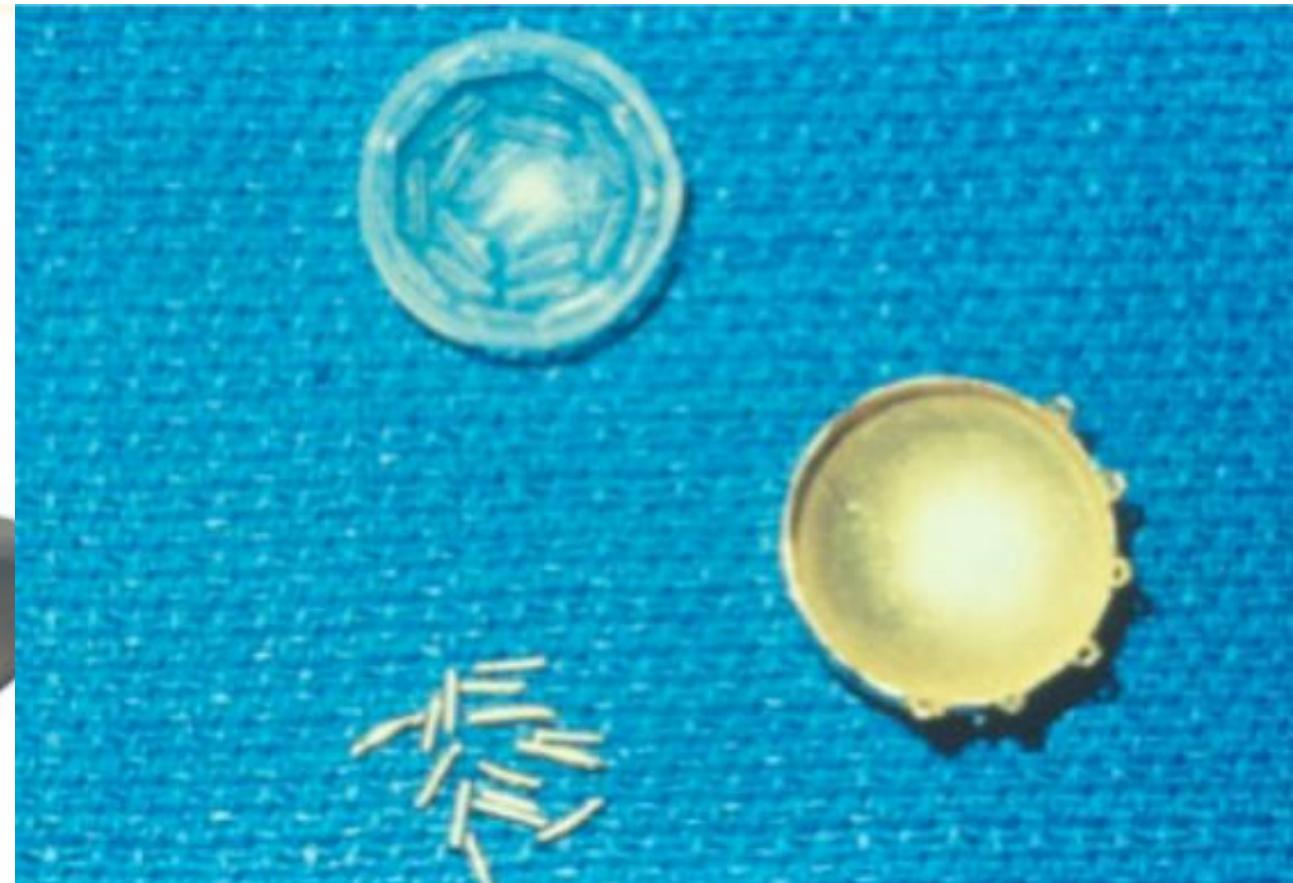
INTRACAVITARY



INTERSTITIAL



SURFACE



INTRALUMINAL

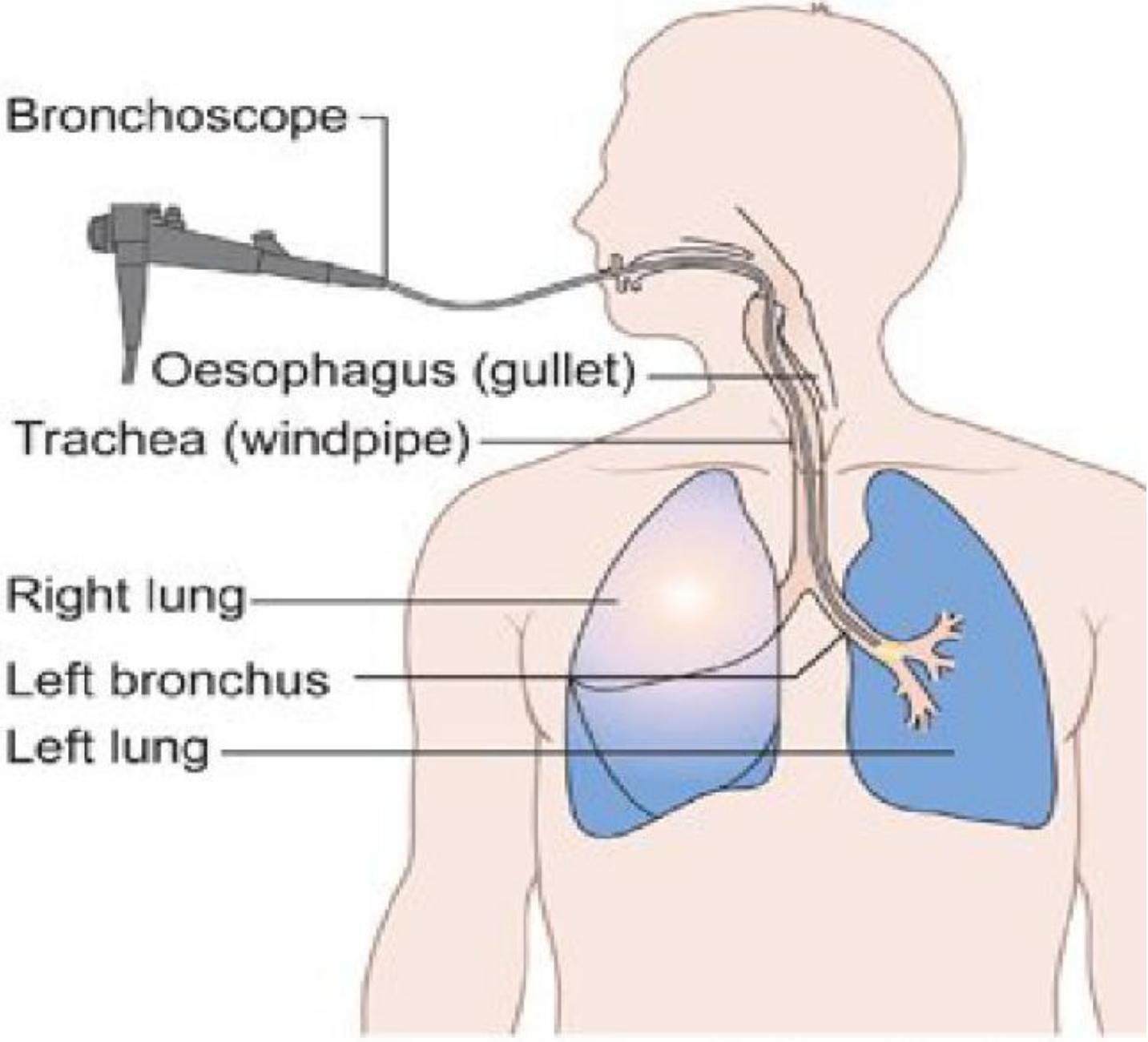


Diagram showing a bronchoscopy
Copyright © CancerHelp UK

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

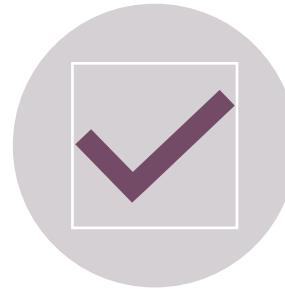
Periodic Table of the Elements

Atomic Number →	1	H	Symbol	
Name →	Hydrogen	1.008	Atomic Weight	
6	VIB	7	VIIB	
24	Cr	25	Mn	
Chromium 51.9961	Manganese 54.938044	26	Fe	
Iron 55.845	27	Co	9	VIIIB
Cobalt 58.933194	28	Ni	10	VIIIB
Nickel 58.6934	29	Cu	11	IB
Copper 63.546	30	Zn	12	IIB
Zinc 65.38	31	Ga	32	Ge
Gallium 69.723	As	Arsenic 74.9321595	33	P
Germanium 72.630	34	In	51	Sb
Indium 114.818	Sn	Tin 118.710	52	Bi
Tin 118.710	53	Pb	Bismuth 208.98040	
Antimony 121.760	54	Fl	115	Mc
Molybdenum 95.95	55	Tl	116	Nh
Technetium (98)	56	Pb	117	Fm
Ruthenium 101.07	57	Ho	118	Tm
Rhodium 102.90550	58	Er	119	Er
Palladium 106.42	59	Dy	120	Tm
Silver 107.8682	60	Tb	121	Th
Cadmium 114.414	61	Ho	122	Er
Indium 114.818	62	Er	123	Th
Tin 118.710	63	Eu	124	Th
Antimony 121.760	64	Gd	125	Th
Molybdenum 95.95	65	Tb	126	Th
Technetium (98)	66	Dy	127	Th
Ruthenium 101.07	67	Ho	128	Th
Rhodium 102.90550	68	Er	129	Th
Palladium 106.42	69	Dy	130	Th
Silver 107.8682	70	Tb	131	Th
Cadmium 114.414	71	Ho	132	Th
Indium 114.818	72	Er	133	Th
Tin 118.710	73	Eu	134	Th
Antimony 121.760	74	Gd	135	Th
Molybdenum 95.95	75	Tb	136	Th
Technetium (98)	76	Dy	137	Th
Ruthenium 101.07	77	Ho	138	Th
Rhodium 102.90550	78	Er	139	Th
Palladium 106.42	79	Eu	140	Th
Silver 107.8682	80	Gd	141	Th
Cadmium 114.414	81	Tb	142	Th
Indium 114.818	82	Dy	143	Th
Tin 118.710	83	Ho	144	Th
Antimony 121.760	84	Er	145	Th
Molybdenum 95.95	85	Eu	146	Th
Technetium (98)	86	Gd	147	Th
Ruthenium 101.07	87	Tb	148	Th
Rhodium 102.90550	88	Dy	149	Th
Palladium 106.42	89	Ho	150	Th
Silver 107.8682	90	Er	151	Th
Cadmium 114.414	91	Eu	152	Th
Indium 114.818	92	Gd	153	Th
Tin 118.710	93	Tb	154	Th
Antimony 121.760	94	Dy	155	Th
Molybdenum 95.95	95	Ho	156	Th
Technetium (98)	96	Er	157	Th
Ruthenium 101.07	97	Eu	158	Th
Rhodium 102.90550	98	Gd	159	Th
Palladium 106.42	99	Tb	160	Th
Silver 107.8682	100	Dy	161	Th
Cadmium 114.414	101	Ho	162	Th
Indium 114.818	102	Er	163	Th
Tin 118.710	103	Eu	164	Th
Antimony 121.760	104	Gd	165	Th
Molybdenum 95.95	105	Tb	166	Th
Technetium (98)	106	Dy	167	Th
Ruthenium 101.07	107	Ho	168	Th
Rhodium 102.90550	108	Er	169	Th
Palladium 106.42	109	Eu	170	Th
Silver 107.8682	110	Gd	171	Th
Cadmium 114.414	111	Tb	172	Th
Indium 114.818	112	Dy	173	Th
Tin 118.710	113	Ho	174	Th
Antimony 121.760	114	Er	175	Th
Molybdenum 95.95	115	Eu	176	Th
Technetium (98)	116	Gd	177	Th
Ruthenium 101.07	117	Tb	178	Th
Rhodium 102.90550	118	Dy	179	Th
Palladium 106.42	119	Ho	180	Th
Silver 107.8682	120	Er	181	Th
Cadmium 114.414	121	Eu	182	Th
Indium 114.818	122	Gd	183	Th
Tin 118.710	123	Tb	184	Th
Antimony 121.760	124	Dy	185	Th
Molybdenum 95.95	125	Ho	186	Th
Technetium (98)	126	Er	187	Th
Ruthenium 101.07	127	Eu	188	Th
Rhodium 102.90550	128	Gd	189	Th
Palladium 106.42	129	Tb	190	Th
Silver 107.8682	130	Dy	191	Th
Cadmium 114.414	131	Ho	192	Th
Indium 114.818	132	Er	193	Th
Tin 118.710	133	Eu	194	Th
Antimony 121.760	134	Gd	195	Th
Molybdenum 95.95	135	Tb	196	Th
Technetium (98)	136	Dy	197	Th
Ruthenium 101.07	137	Ho	198	Th
Rhodium 102.90550	138	Er	199	Th
Palladium 106.42	139	Eu	200	Th
Silver 107.8682	140	Gd	201	Th
Cadmium 114.414	141	Tb	202	Th
Indium 114.818	142	Dy	203	Th
Tin 118.710	143	Ho	204	Th
Antimony 121.760	144	Er	205	Th
Molybdenum 95.95	145	Eu	206	Th
Technetium (98)	146	Gd	207	Th
Ruthenium 101.07	147	Tb	208	Th
Rhodium 102.90550	148	Dy	209	Th
Palladium 106.42	149	Ho	210	Th
Silver 107.8682	150	Er	211	Th
Cadmium 114.414	151	Eu	212	Th
Indium 114.818	152	Gd	213	Th
Tin 118.710	153	Tb	214	Th
Antimony 121.760	154	Dy	215	Th
Molybdenum 95.95	155	Ho	216	Th
Technetium (98)	156	Er	217	Th
Ruthenium 101.07	157	Eu	218	Th
Rhodium 102.90550	158	Gd	219	Th
Palladium 106.42	159	Tb	220	Th
Silver 107.8682	160	Dy	221	Th
Cadmium 114.414	161	Ho	222	Th
Indium 114.818	162	Er	223	Th
Tin 118.710	163	Eu	224	Th
Antimony 121.760	164	Gd	225	Th
Molybdenum 95.95	165	Tb	226	Th
Technetium (98)	166	Dy	227	Th
Ruthenium 101.07	167	Ho	228	Th
Rhodium 102.90550	168	Er	229	Th
Palladium 106.42	169	Eu	230	Th
Silver 107.8682	170	Gd	231	Th
Cadmium 114.414	171	Tb	232	Th
Indium 114.818	172	Dy	233	Th
Tin 118.710	173	Ho	234	Th
Antimony 121.760	174	Er	235	Th
Molybdenum 95.95	175	Eu	236	Th
Technetium (98)	176	Gd	237	Th
Ruthenium 101.07	177	Tb	238	Th
Rhodium 102.90550	178	Dy	239	Th
Palladium 106.42	179	Ho	240	Th
Silver 107.8682	180	Er	241	Th
Cadmium 114.414	181	Eu	242	Th
Indium 114.818	182	Gd	243	Th
Tin 118.710	183	Tb	244	Th
Antimony 121.760	184	Dy	245	Th
Molybdenum 95.95	185	Ho	246	Th
Technetium (98)	186	Er	247	Th
Ruthenium 101.07	187	Eu	248	Th
Rhodium 102.90550	188	Gd	249	Th
Palladium 106.42	189	Tb	250	Th
Silver 107.8682	190	Dy	251	Th
Cadmium 114.414	191	Ho	252	Th
Indium 114.818	192	Er	253	Th
Tin 118.710	193	Eu	254	Th
Antimony 121.760	194	Gd	255	Th
Molybdenum 95.95	195	Tb	256	Th
Technetium (98)	196	Dy	257	Th
Ruthenium 101.07	197	Ho	258	Th
Rhodium 102.90550	198	Er	259	Th
Palladium 106.42	199	Eu	260	Th
Silver 107.8682	200	Gd	261	Th
Cadmium 114.414	201	Tb	262	Th
Indium 114.818	202	Dy	263	Th
Tin 118.710	203	Ho	264	Th
Antimony 121.760	204	Er	265	Th
Molybdenum 95.95	205	Eu	266	Th
Technetium (98)	206	Gd	267	Th
Ruthenium 101.07	207	Tb	268	Th
Rhodium 102.90550	208	Dy	269	Th
Palladium 106.42	209	Ho	270	Th
Silver 107.8682	210	Er	271	Th
Cadmium 114.414	211	Eu	272	Th
Indium 114.818	212	Gd	273	Th
Tin 118.710	213	Tb	274	Th
Antimony 121.760	214	Dy	275	Th
Molybdenum 95.95	215	Ho	276	Th
Technetium (98)	216	Er	277	Th
Ruthenium 101.07	217	Eu	278	Th
Rhodium 102.90550	218	Gd	279	Th
Palladium 106.42	219	Tb	280	Th
Silver 107.8682	220	Dy	281	Th
Cadmium 114.414	221	Ho	282	Th
Indium 114.818	222	Er	283	Th
Tin 118.710	223	Eu	284	Th
Antimony 121.760	224	Gd	285	Th
Molybdenum 95.95	225	Tb	286	Th
Technetium (98)	226	Dy	287	Th
Ruthenium 101.07	227	Ho	288	Th
Rhodium 102.90550	228	Er	289	Th
Palladium 106.42	229	Eu	290	Th
Silver 107.8682	230	Gd	291	Th
Cadmium 114.414	231	Tb	292	Th
Indium 114.818	232	Dy	293	Th
Tin 118.710	233	Ho	294	Th
Antimony 121.760	234	Er	295	Th
Molybdenum 95.95	235	Eu	296	Th
Technetium (98)	236	Gd	297	Th
Ruthenium 101.07	237	Tb	298	Th
Rhodium 102.90550	238	Dy	299	Th
Palladium 106.42	239	Ho	300	Th
Silver 107.8682	240	Er	301	Th
Cadmium 114.414	241	Eu	302	Th
Indium 114.818	242	Gd	303	Th
Tin 118.710	243	Tb	304	Th
Antimony 121.760	244	Dy	305	Th
Molybdenum 95.95	245	Ho	306	Th
Technetium (98)	246	Er	307	Th
Ruthenium 101.07	247	Eu	308	Th
Rhodium 102.90550	248	Gd	309	Th
Palladium 106.42	249	Tb	310	Th
Silver 107.8682	250	Dy	311	Th
Cadmium 114.414	251	Ho	312	Th
Indium 114.818	252	Er	313	Th
Tin 118.710	253	Eu	314	Th
Antimony 121.760	254	Gd	315	Th
Molybdenum 95.95	255	Tb	316	Th
Technetium (98)	256	Dy	317	Th
Ruthenium 101.07	257	Ho	318	Th
Rhodium 102.90550	258	Er	319	Th
Palladium 106.42	259	Eu	320	Th
Silver 107.8682	260	Gd	321	Th
Cadmium 114.414	261	Tb	322	Th
Indium 114.818	262	Dy	323	Th
Tin 118.710	263	Ho	324	Th
Antimony 121.760	264	Er	325	Th
Molybdenum 95.95	265	Eu	326	Th
Technetium (98)	266	Gd	327	Th
Ruthenium 101.07	267	Tb	328	Th
Rhodium 102.9				

EXPOSURE RATE CONSTANT (Γ)



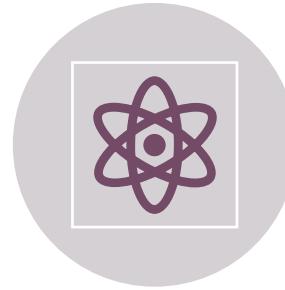
Relates contained activity to an output



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:**

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

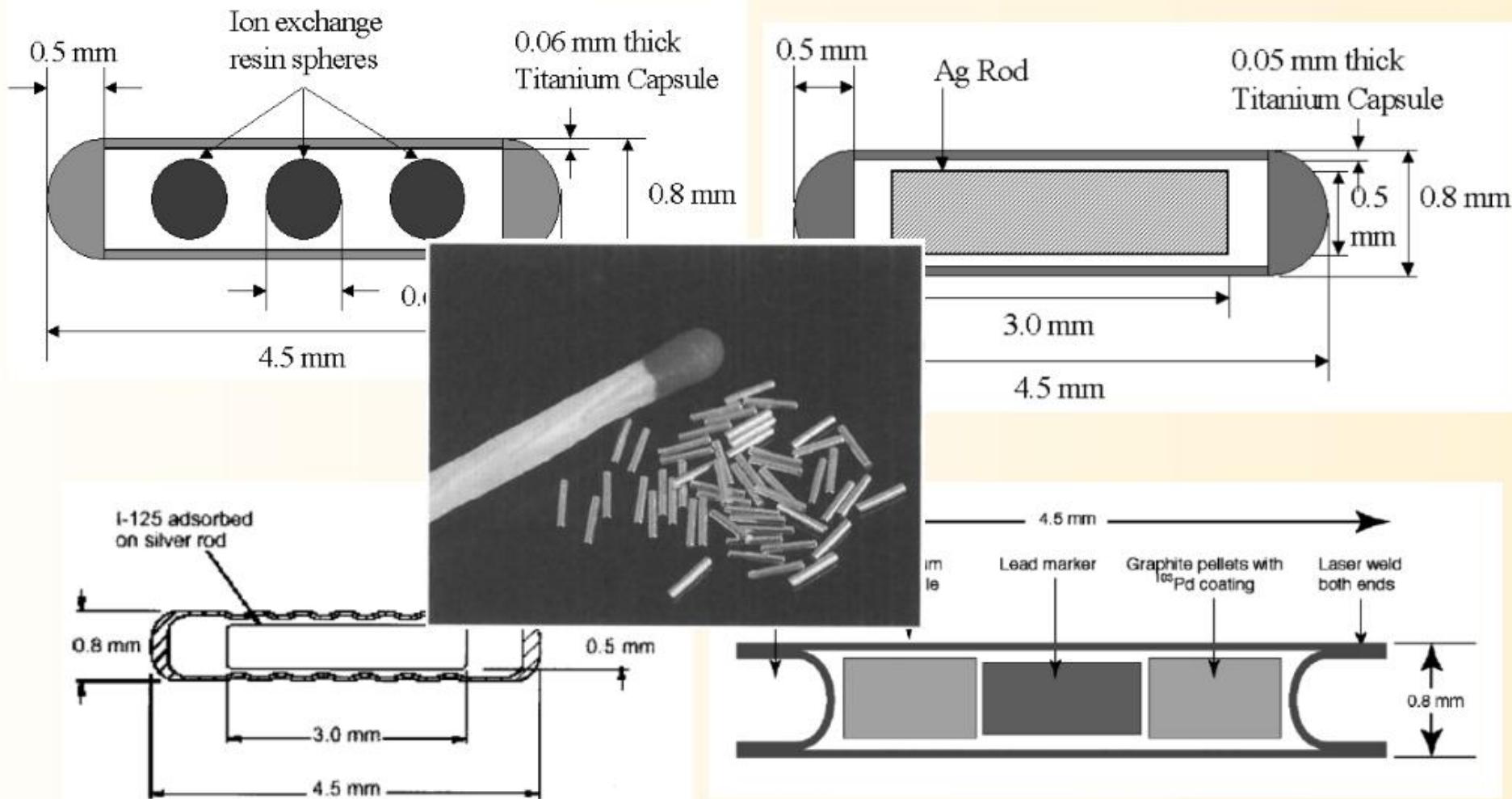
- **Half-life:** expected time where half of the original activity will decay

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

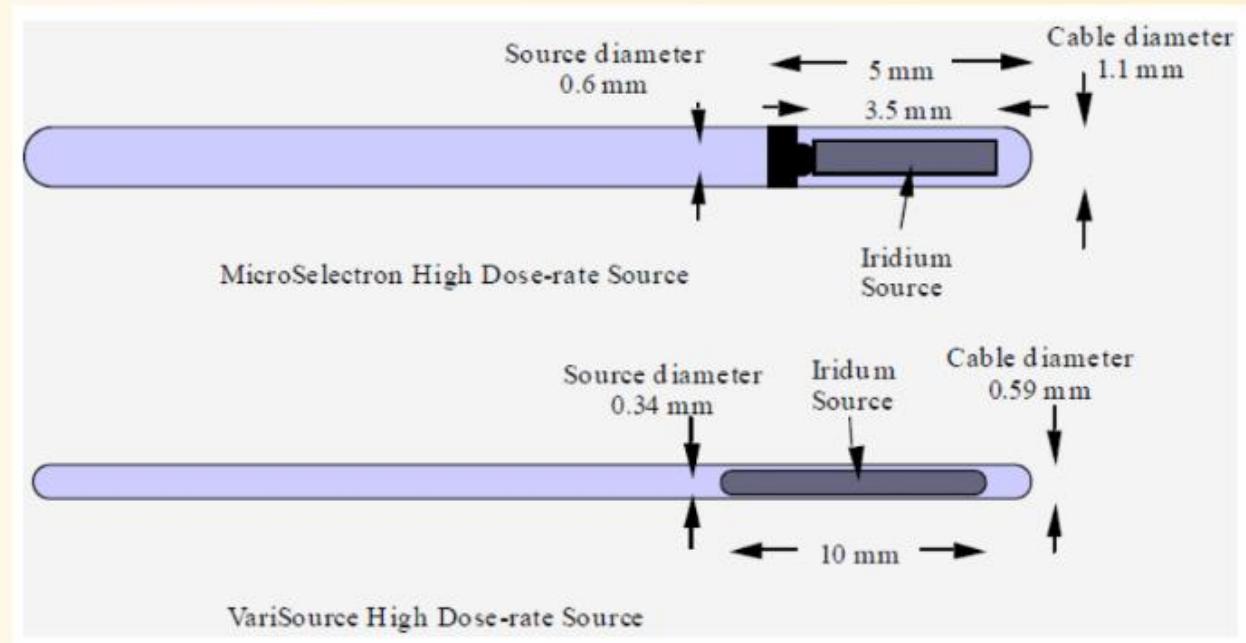
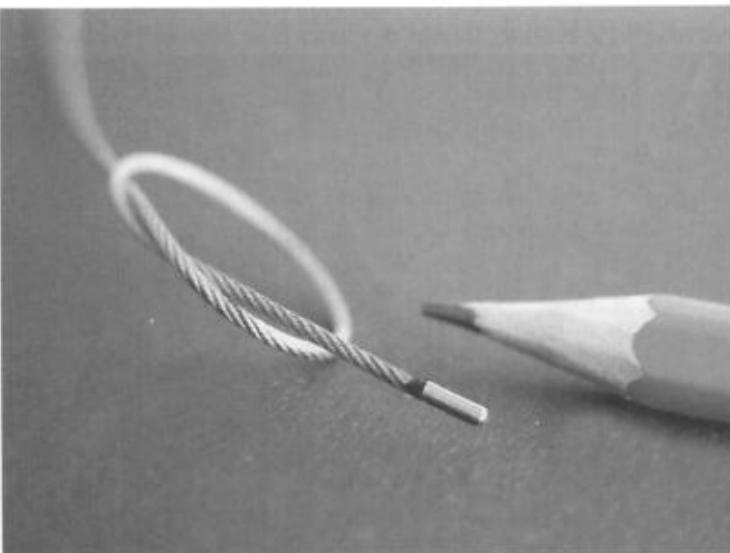
- **Mean-life:** the average lifetime of a given nucleus

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

Seed Designs

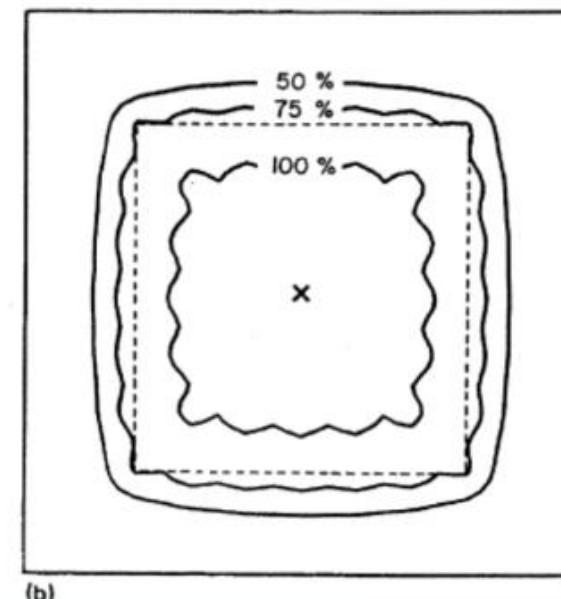
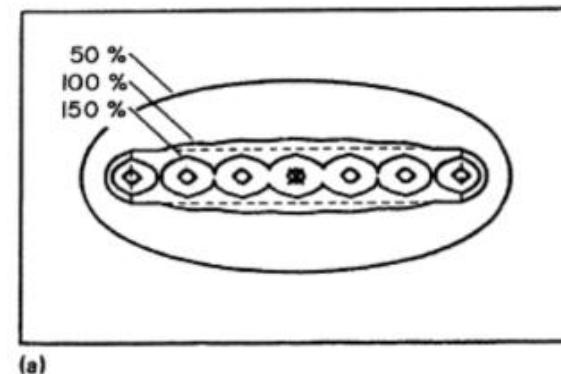


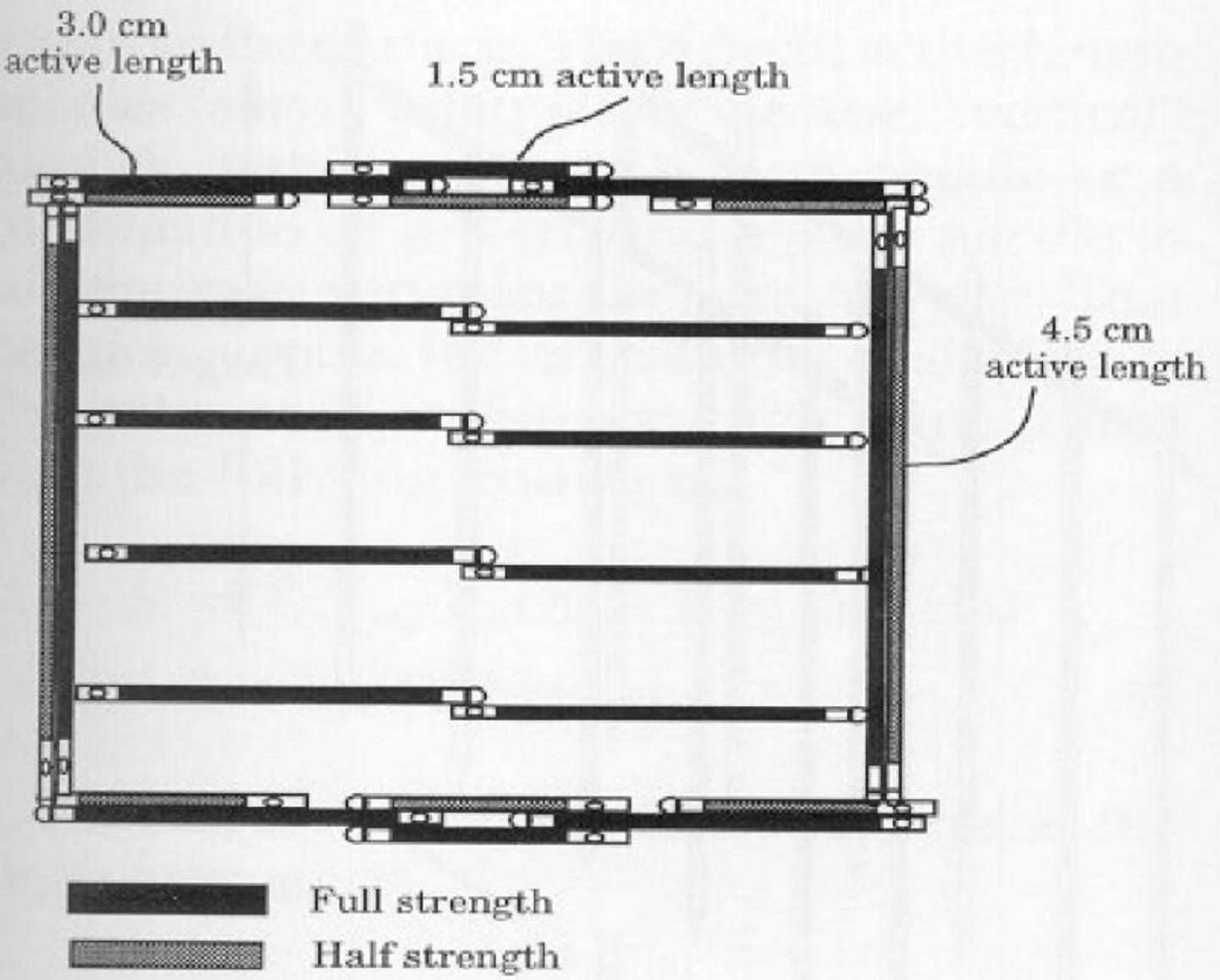
Cable-Mounted Designs



Quimby Planar Implants

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





Types of Needles

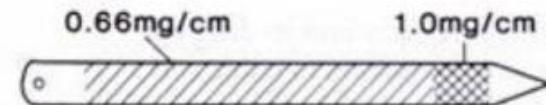
- Needles with activity all along except at ends
- Needles with normal activity along the length and higher activity at one end – “Indian club needles”
- Needles with normal activity along the length and higher activity at both ends – “Dumbell needles”

RADIUM NEEDLES

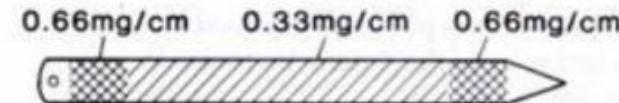
Uniform



“Indian Club”



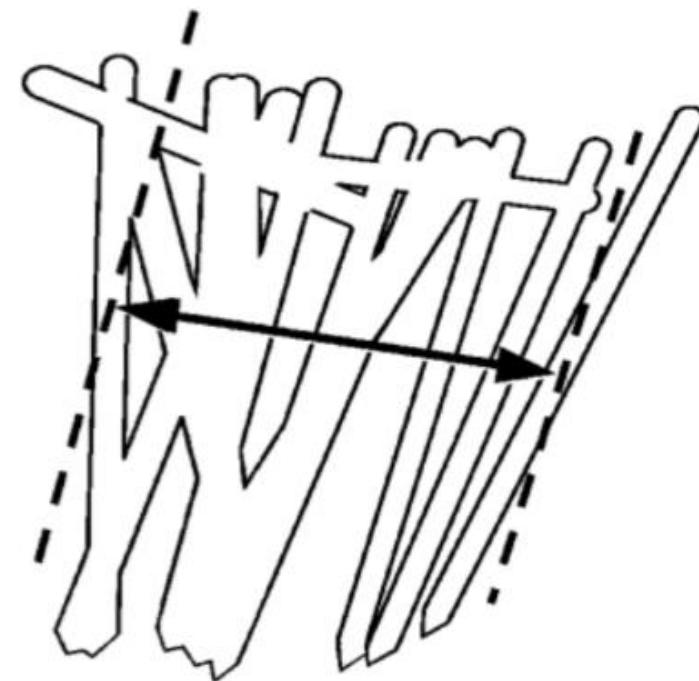
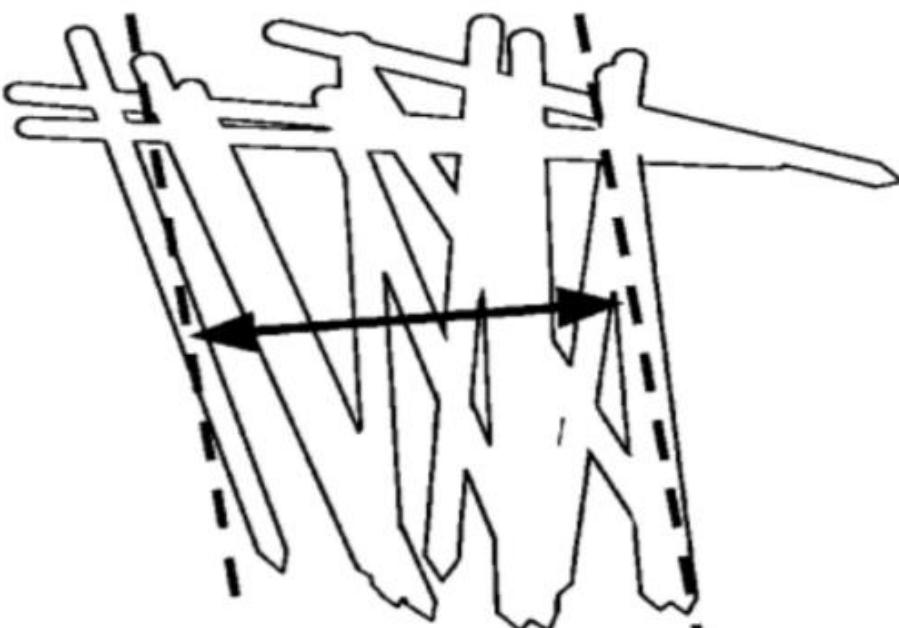
“Dumbbell”



Tube



Actual Implants



LOAD UP BRACHYTHERAPY QUALITY ASSURANCE!

By Dr. Adrian Nalichowski

