Protecting and Predicting Astronaut Health and Performance

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Baylor College of Medicine

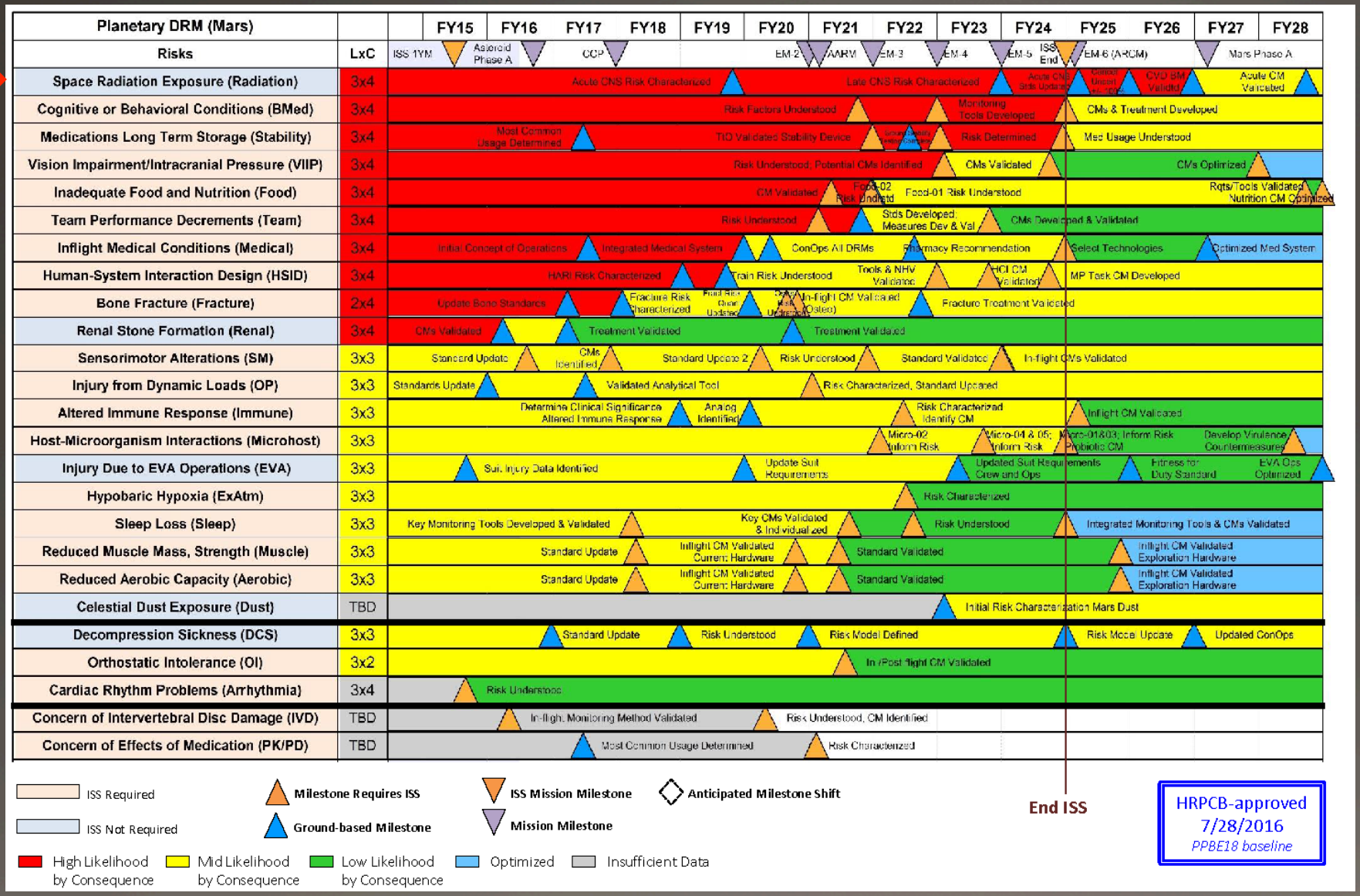
NSBRI Mission:

To lead biomedical research to support long-term human exploration of space And improve life on Earth

Via a Cooperative Agreement with NASA
(NCC 9-58)
We Fund R&D through Grants

Approach: Support Technologies and Countermeasures for Space while also making an impact on Earth

NASA Human Research Program Integrated Path to Risk Reduction, Rev D



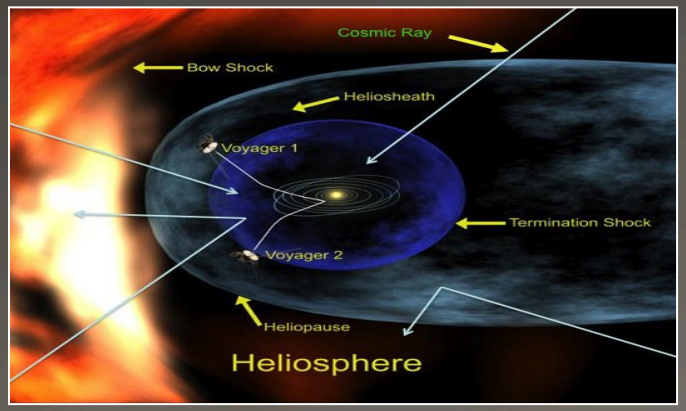
Space Radiation Environment

Galactic cosmic rays (GCR) - penetrating protons and heavy nuclei

Occurs continuously, omni-directional, varying in flux with solar cycle - lower GCR levels occur during solar maximum

Shielding is NOT effective due to secondary radiation produced in shielding and tissue

Countermeasure: Biological approaches with a great degree of uncertainties



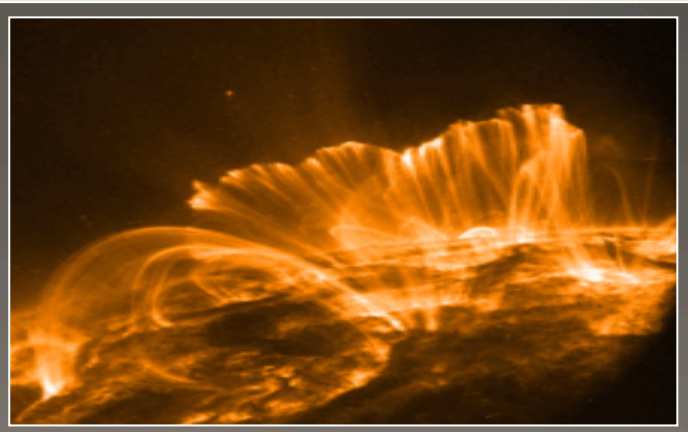
Omni-directional GCR

Solar Particle Events (SPE) - low to medium energy protons

Infrequent events occurring most often during solar cycle maximum (~11-year cycles) – peak activity during solar maximum

Shielding (5-20 g/cm^2 Al and polyethylene) IS effective, optimization to reduce weight

Countermeasures: Shielding, monitoring, accurate event determination, dosimetry and timely reporting to alert crew to seek shelter are essential for crew safety



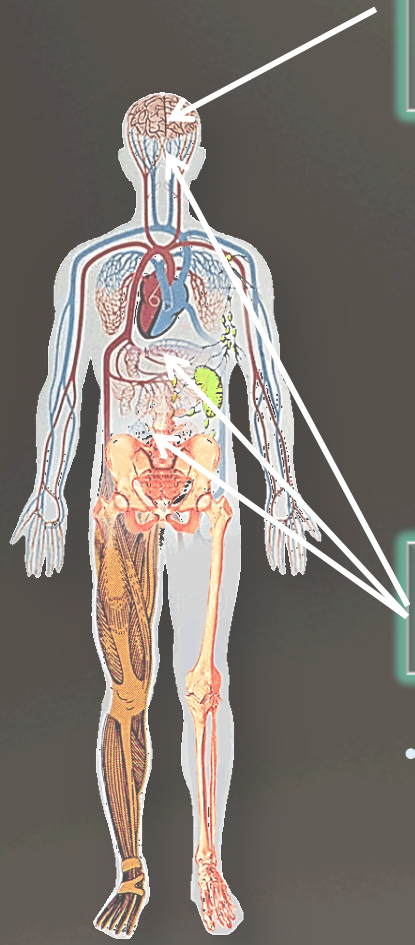
Solar Flares - SPEs

NASA'Risks of Space Radiation Exposure

Carcinogenesis

Focus of NASA Radiation Risk Model
- Solid Cancers – tumors
- Leukemia
- Issues emerging from research studies of GCR solid cancer risks:
  - Possible earlier appearance and aggressive tumors not seen with controls, gamma-rays or proton tumors

LATE



Central Nervous System (CNS) risks to the Brain

Central nervous system (CNS) damage leading to behavioral or cognitive effects and late disorders (Alzheimer's)

LATE

Chronic & Degenerative Tissue Risks

- *Circulatory Disease* concerns include CVD, IHD, and coronary revascularization and myocardial infarction
- Digestive diseases

LATE

Acute Radiation Syndromes

- Prodromal effects (nausea, vomiting, anorexia, and fatigue), skin injury, and depletion of the blood-forming organs

Predict
Prevent
Diagnose
Treat

Predict

Risk Assessment

* Environment
* Mission Architecture
  - Time
  - Activities (planned and unplanned)
  - Resources (and lack of)
* Individual Susceptibilities

Risk Posture Differs with Mission Architecture

Risk of Radiation Carcinogenesis

Short Title: Cancer
Element: Space Radiation (SR)
Evidence: Report
Risk Master Logic Diagram: Logic Diagram Not Available
Point of Contact: Janice Huff

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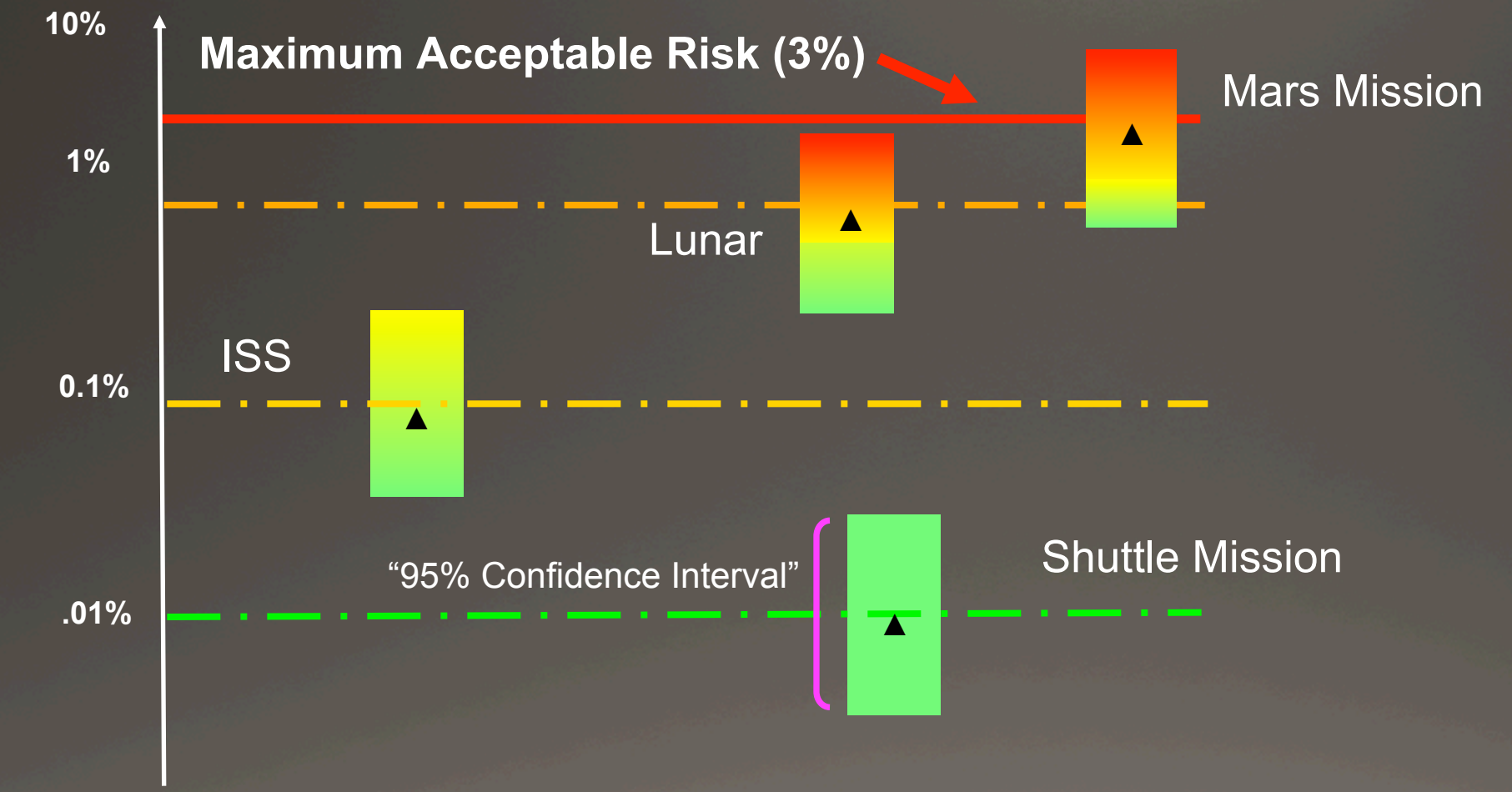
Risk Ratings and Dispositions per Design Reference Mission (DRM) Category

DRM Categories	Mission Duration	Operations		Long-Term Health	
		LxC	Risk Disposition *	LxC	Risk Disposition *
Low Earth Orbit	6 months	1x1	Accepted	3x2	Accepted Within PELs
	1 year	1x1	Accepted	3x2	Accepted Within PELs
Deep Space Sortie	1 month	1x1	Accepted	3x1	Accepted Within PELs
Lunar Visit/ Habitation	6 months	1x1	Accepted	3x3	Requires Mitigation
Deep Space Journey/Habitation	1 year	1x1	Accepted	3x4	Requires Mitigation
Planetary	3 years	1x1	Accepted	3x4	Requires Mitigation

Note: LxC is the likelihood and consequence rating. This risk is mapped to the official (consolidated) HSRB risk "Risk of Adverse Health Outcomes and Performance Decrements resulting

“ACCEPTABLE" RISK THRESHOLDS



Slide courtesy of J. Chancellor

Sex Differences: Maximum "Safe" Days in Deep Space

- Solar Min Maximum Days in Deep Space (heavy shielding) to 95% Confidence to be below NASA Limits for cancer risk: (parenthesis is deep solar min of 2009)

a_E, y	NASA 2005	NASA 2012 U.S. Avg. Population	NASA 2012 Never-smokers
		Males	
35	158	209 (205)	271 (256)
45	207	232 (227)	308 (291)
55	302	274 (256)	351 (335)
		Females	
35	129	106 (95)	187 (180)
45	173	139 (125)	227 (212)
55	259	161 (159)	277 (246)

- Solar Max Maximum Days in Deep Space (heavy shielding) to 95% Confidence to be below NASA Limits for cancer risk alone (parenthesis is for case of ideal storm shelter which negates any SPE cancer risk):

a_E, y	NASA 2012 U.S. Avg. Population	NASA 2012 Never-smokers
	Males	
35	306 (357)	395 (458)
45	344 (397)	456 (526)
55	367 (460)	500 (615)
	Females	
35	144 (187)	276 (325)
45	187 (232)	319 (394)
55	227 (282)	383 (472)

~ 30 % "Sex" difference in terms of days that can be spent in deep space!

Tissue Sensitivities to Radiation

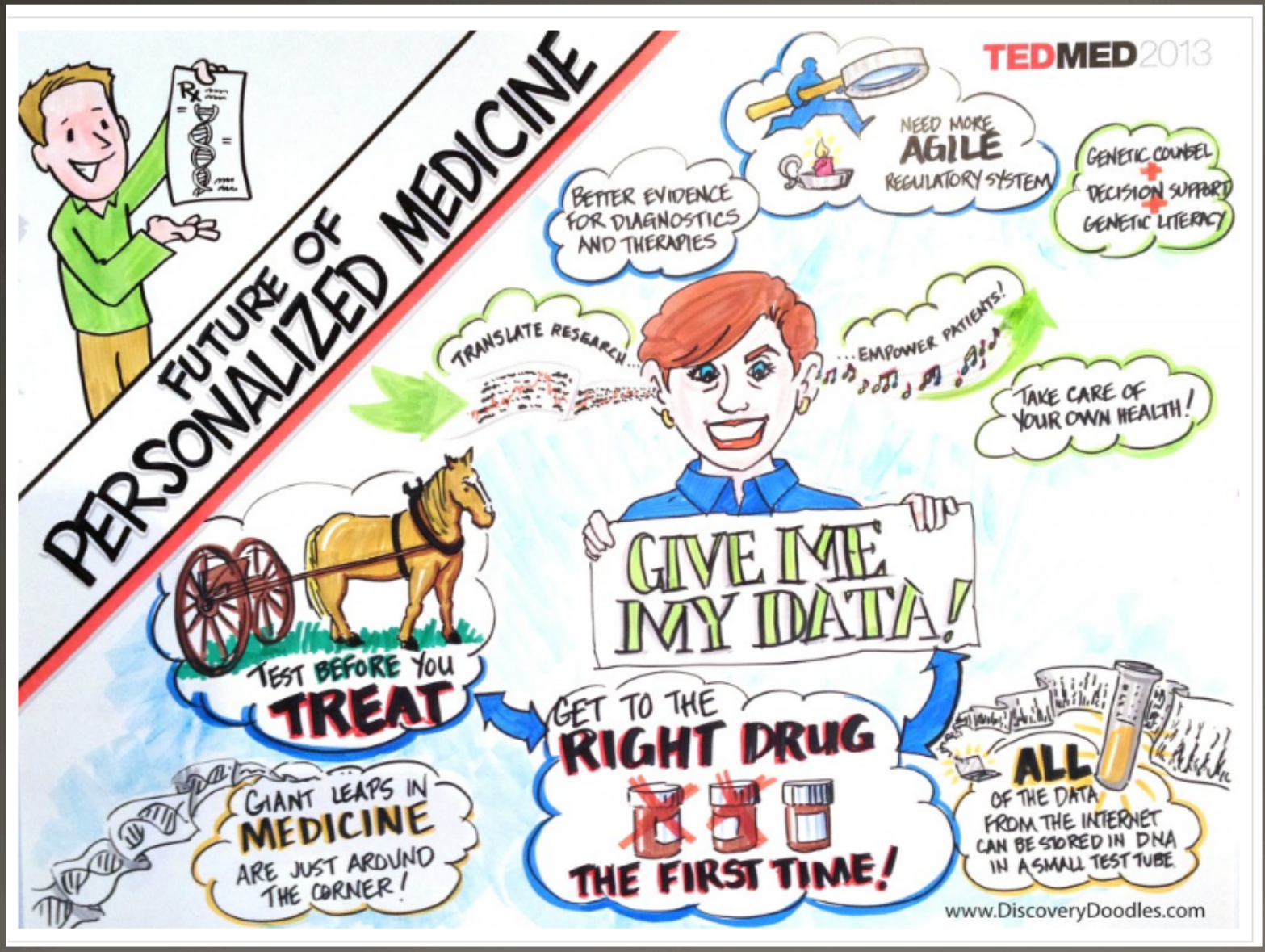
Single Dose (Gy)		Fractionated Dose (Gy)	
Ovary	**2–6**	**Testes**	**1–2**
Bone marrow	2–10	**Ovary**	**6–10**
Testes	**2–10**	Eye (lens)	6–12
Eye (lens)	2–10	Kidney	20–30
Mucosa	5–20	Thyroid	20–40
Gastrointestinal	5–10	Lung	23–28
Lung	7–10	Skin	30–40
Colorectal	10–20	Liver	35–40
Kidney	10–20	Bone marrow	40–50
Vasculoconnective tissue	10–20	Heart	43–50
Liver	15–20	Gastrointestinal	50–55
Skin	15–20	Vasculoconnective tissue	50–60
Peripheral nerve	15–20	Spinal cord	50–60
Spinal cord	15–20	Brain	55–70
Brain	15–25	Peripheral nerve	65–77
Heart	18–20	Mucosa	65–77
Bone and cartilage	>30	Bone and cartilage	>70
Muscle	>70	Muscle	>70

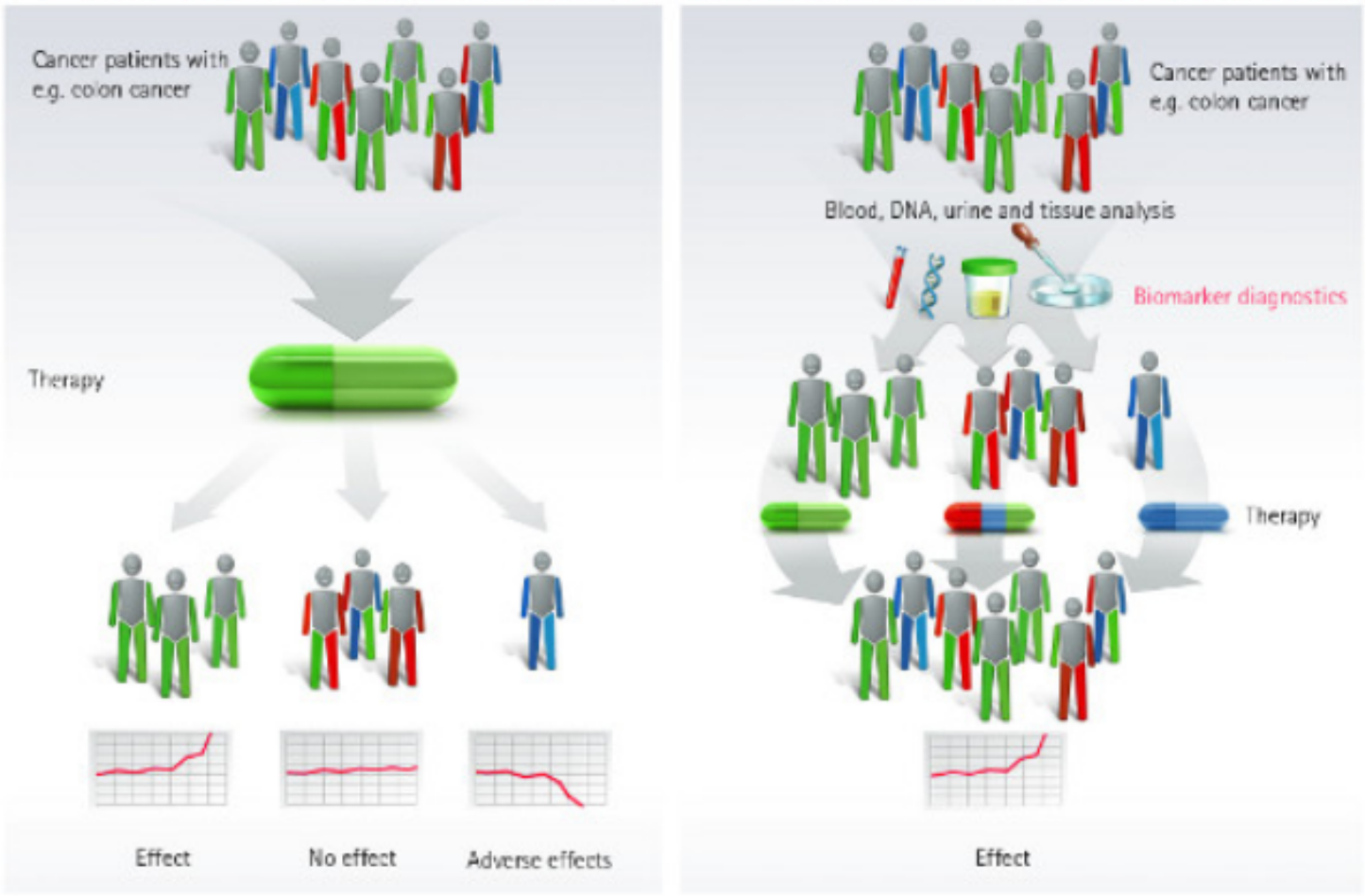
*From Rubin P. Law and order of radiation sensitivity: absolute versus relative. In: Vaeth JM, Meyer JL, eds. Frontiers of radiation therapy and oncology. Basel: Karger; 1989:7–40.

Individual Susceptibilities

- Minimally considered in NASA's risk assessments
- NASA "dipped a toe" into Omics and personalized medicine (Twins Study)
- Critical for radiation risk in particular

The Dawn of Personalized Medicine





Different people respond differently to the same therapy: while one treatment brings about the desired success in one group of patients with e.g. colon cancer, it does not change the condition of other groups at all, or even leads to adverse effects (left). The reason: the genetic makeup and metabolic profile of each individual patient influences the effect of a drug. Personalized medicine takes these individual patterns of cellular and metabolic products into account in the diagnostic phase: biomarker diagnostics separates patients into groups with similar characteristics, and provides information on the best individual treatment. This should enable all patients to benefit from their own, "personal" therapy.

Prognostics & Health Management

Predict

- Radiation Dosimetry
- Space Weather Prediction Models
- Genetic Analysis of Susceptibility

Prevent

- Shielding when possible
- Radiation prophylactics
- Pre-screen for resilience (or at least no known susceptibility – some genetic markers are known to be linked to higher risk of cancer

Diagnose

- BioDosimetry ("Canary in Mine") – Biomarkers

Treat – Peronalized Medicine

OPPORTUNITIES

Biodosimetry
Biomarkers
Susceptibility markers

Information Fusion
- Environmental sensors
- Real-Time biological sensors

New NASA Translational Research Institute at Baylor College of Medicine With MIT and CalTech as partners

JSC Features

Archives | Humans of JSC

NASA establishes institute to explore new ways to protect astronauts

July 20, 2016

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NASA is joining with Baylor College of Medicine in Houston to operate a new institute charged with researching and developing innovative approaches to reduce risks to humans on long-duration exploration missions, including NASA's Journey to Mars.

Work under the Translational Research Institute Cooperative Agreement, overseen by NASA's Human Research Program, begins Oct. 1.

Translational research is an interdisciplinary model of research that focuses on translating fundamental research concepts into practice, with appreciable health outcomes. The NASA Translational Research Institute (NTRI) will implement a "bench-to-spaceflight" model, moving results or methods from laboratory experiments or clinical trials to point-of-care astronaut health and performance applications. The goal of the research is to produce promising new approaches, treatments, countermeasures or technologies that have practical application to spaceflight.

"It's fitting or … humanit… …man … will help reduce risks for our astro… …ap—our… …recto… …ices Research and Applications…

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