

2013 DECADAL STUDY

The Impact of Sex & Gender on Adaptation to Space



A Joint Study by the National Aeronautics and Space Administration and the National Space Biomedical Research Institute

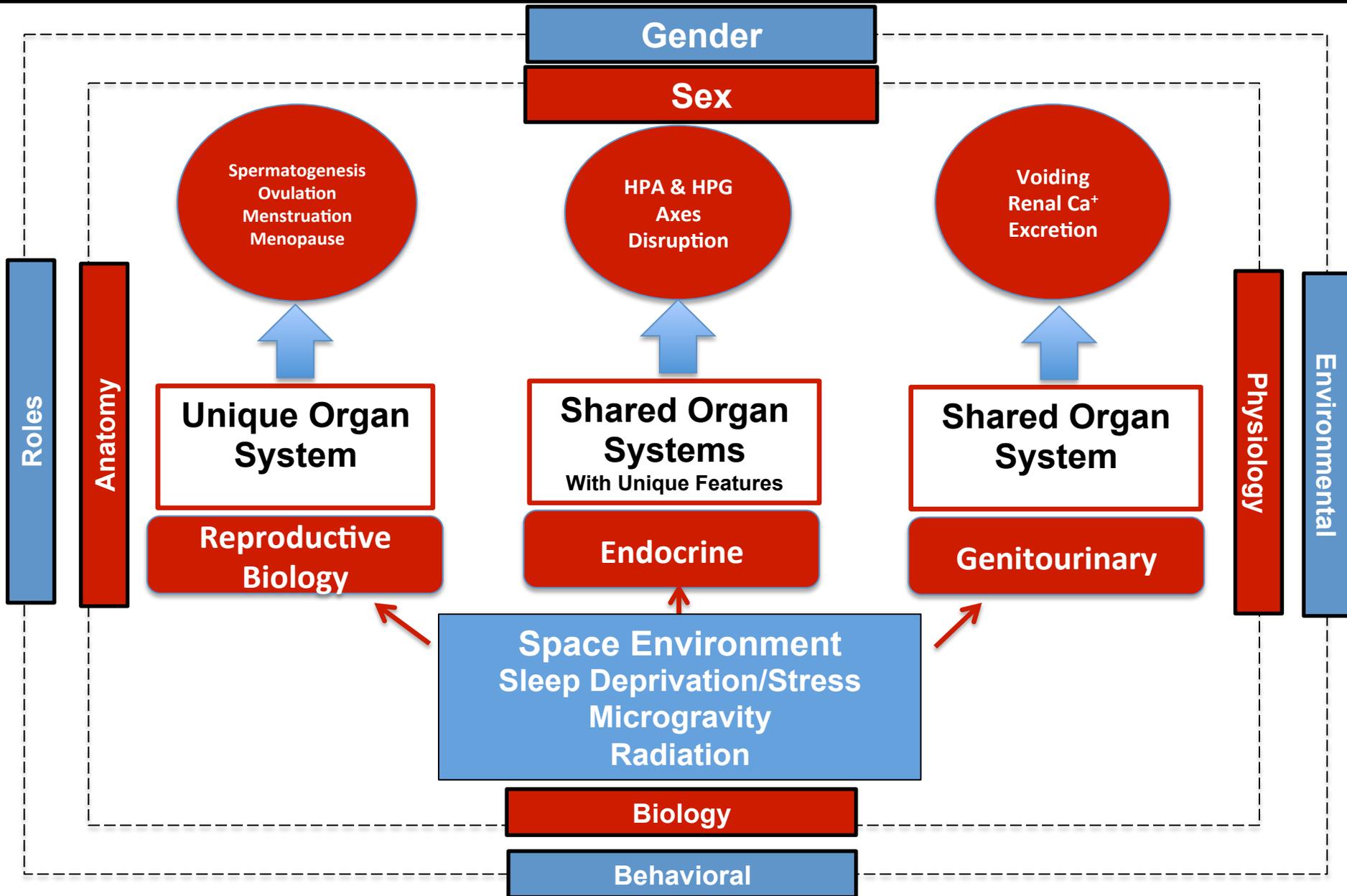
Reproduction Workgroup

Working Group Members and Affiliations



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Approach to Evaluation of Sex and Gender on Reproductive and Genitourinary Health



Reproductive System: Effects of Radiation



Gonads Top the Table of Radiation Tissue Sensitivity*

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.

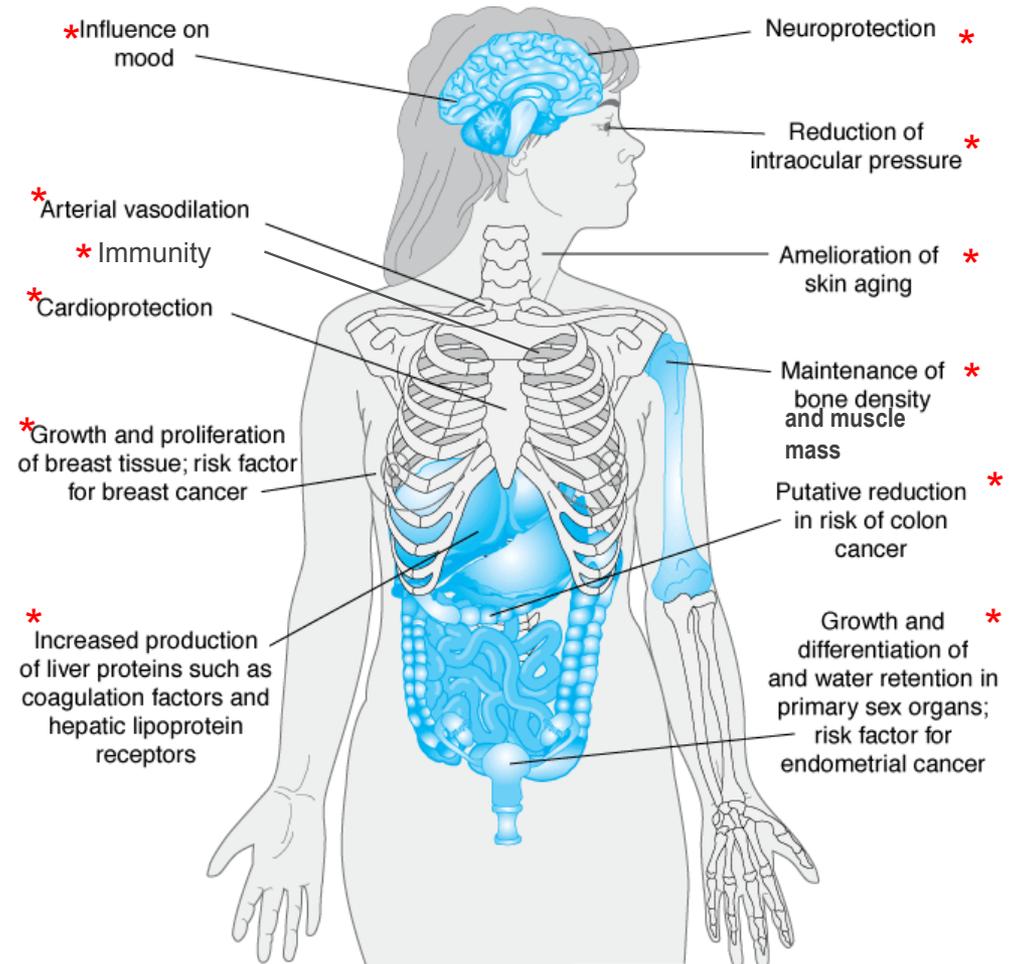
Current Knowledge of the Impact of Sex & Gender on Reproductive Biology of Astronauts



Estrogen Signaling Impacts Major Physiologic Systems Altered in Aging and Space Flight in Males and Females

Are there sex differences in altered estrogen signaling in the space-flight affected/aging systems?

- Ground-based studies have identified age-related alterations in estrogen receptor signaling in many major organ systems
- A body of animal research has indicated several of these same systems are also altered in space flight (which is known to accelerate some aging processes)

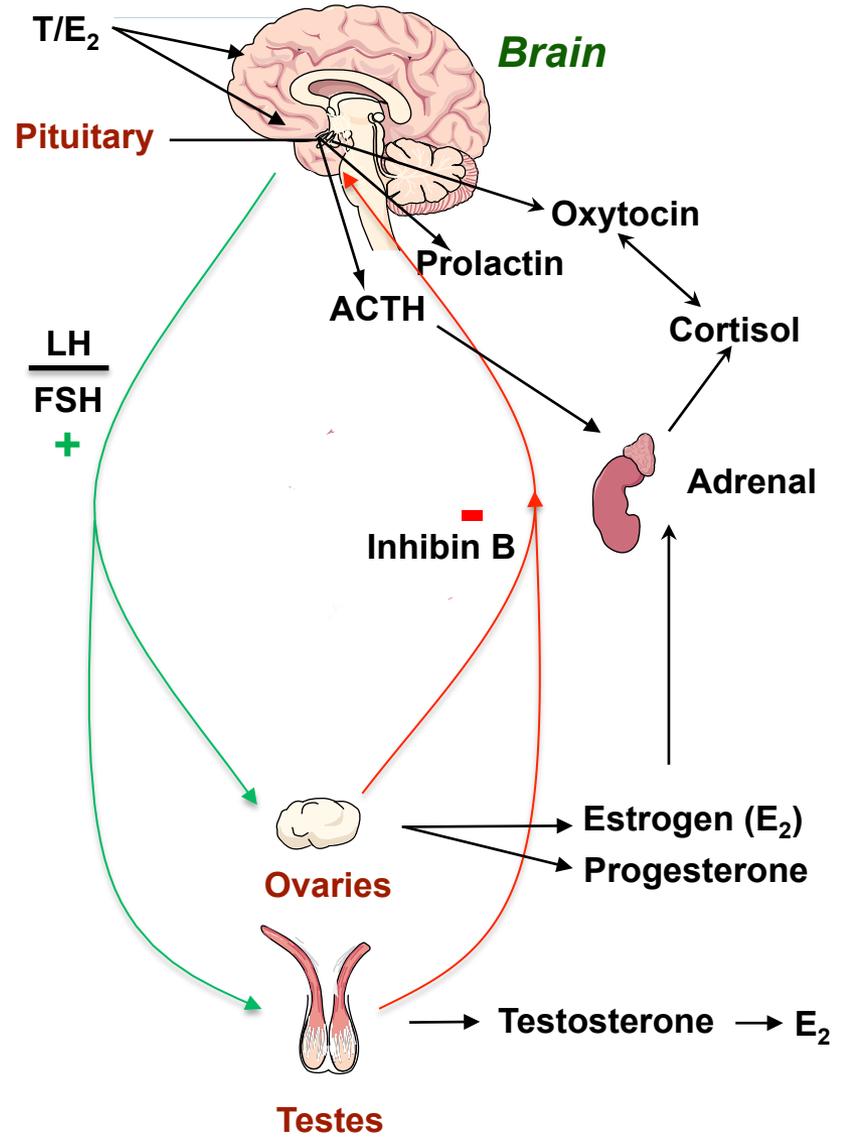


Source: Molina PE: *Endocrine Physiology, 3rd Edition*:
<http://www.accessmedicine.com>

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*Estrogen-regulated systems known to be affected by space flight & aging

Consideration of the Impact of Sex & Gender on Reproductive Biology of Astronauts



Stress:

- impacts gonadal hormone levels
- increases inflammatory markers
- activates the HPA axis
 - can lead to disrupt ovarian function
- increases risk and prognosis of CVD and events

Future Reproduction:

Prior flight vs post flight fertility (Spermatogenesis, IVF, spontaneous abortions, term pregnancy, pregnancy associated complications)

Unique Organ System

Reproductive/Endocrine



- **Terrestrial**

- HPG Axis

- Dysregulation alters sleep quality
- Age and Sex-related differences in reproductive hormones exert known effects

- HPA Axis

- Stressor exposure increases pituitary and adrenal hormone release
- Stronger correlation of increased cortisol levels to male performance
- OC usage is associated with ↓ stress-induced cortisol release

- **Space Travel**

- ACTH and cortisol are have been shown to be ↑ following some missions
- Longer duration travel has significantly increased duration of exposure relative to normal reproductive cycle lengths

- **Future Exploration**

- Prospectively examine whether OC usage alter the space-flight and recovery profiles of HPA-axis tone
- Examine sex differences in cortisol levels and performance during and post-flight

Shared Organ System

Urogenital Systems



- **Terrestrial**
 - Urinary tract stones are more prevalent in Caucasian men
 - Urinary tract infections are more common in women
 - Emerging data regarding normal urinary microbiome
 - There is no data on sex differences in spontaneous urinary retention
 - Incidence on post-operative urinary retention is not different between men and women
- **Space Travel**
 - Incidence of urinary tract stones is equivalent between sexes
 - Incidence of urinary tract infections is greater in women
 - Urinary retention requiring catheterization has occurred only in women
 - Unless there is evidence of more anti-emetic use in women or more dehydration, this likely represents adaptation to new voiding behavior
- **Future Exploration**
 - Studies of urinary tract manipulation in low gravity environment
 - Better understanding of risk factors for UTI

Reproductive Health

Considering Sex and Gender



	Women	Men
Demographics of Astronauts		
Average Age during 1 st transit	42.4 yo	44.5 yo
% with at least 1 child	38%**	67%
# of Children	1.6	2.5
% Married	69%	76%
Societal Roles (Gender)		
	Women	Men
More likely to be primary caregiver	X	
Hiatus from career due to parental role	X	
Biological Factors (Sex)		
	Female	Male
Cessation of Reproductive Capacity	Menopause	
Thromboembolic Risk with OCPs	X	
Bone loss with certain types of contraception	X	

**p <0.01

Sex and Gender in Space Adaptation: Past - Present - Future



- **2013 Report on Sex, Space and Environmental Adaptation**
 - **Approach**
 - Organized the work around applicable unique and shared organ systems and the major space travel components likely to alter these systems
 - **Updated Content**
 - Outlines sex differences in genitourinary health
 - Includes both Sex-based and Gender-based issues such as the impact of sex and gender on healthy aging in conjunction with astronaut health
 - **Considerations to Enhance the Research Infrastructure**
 - Discussion of further development of ground-based analogs
 - Pre-, During, and Post-flight longitudinal de-identified data collection
 - Tandem space and ground-based studies
 - “Space originated’ cells, systems and organisms across generations
 - Emphasizes threading sex and gender throughout health research platforms

The background features a dark blue gradient with silhouettes of space-related elements. On the left, an astronaut in a full suit floats. In the center, a large satellite with multiple solar panels is depicted. At the bottom, a rover with a dome-shaped habitat is shown on a planet's surface.

Thank you