

# 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

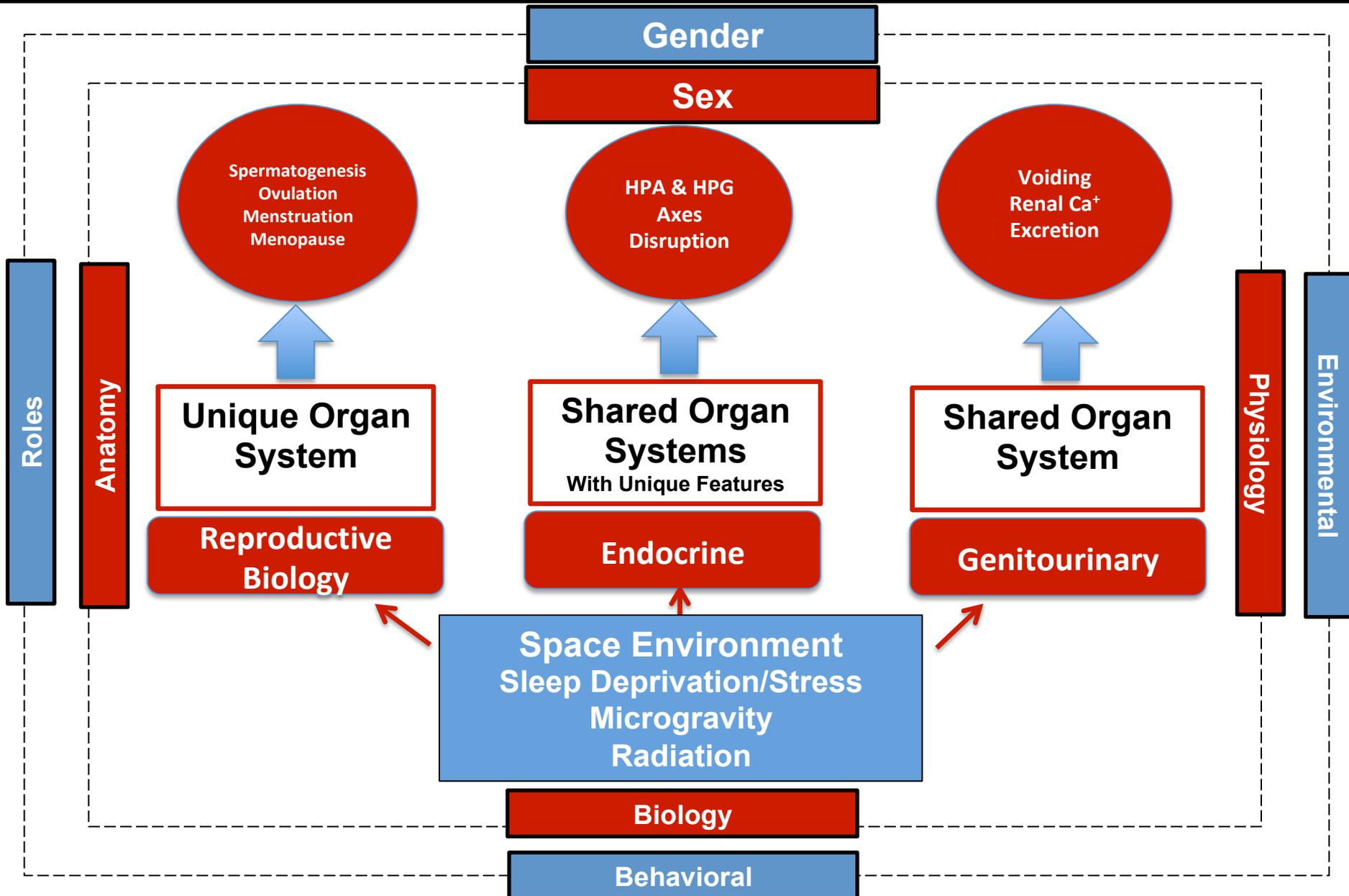
## Reproduction Workgroup

# 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)	
<b>Ovary</b>	<b>2-6</b>	<b>Testes</b>	<b>1-2</b>
Bone marrow	2-10	<b>Ovary</b>	<b>6-10</b>
<b>Testes</b>	<b>2-10</b>	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.

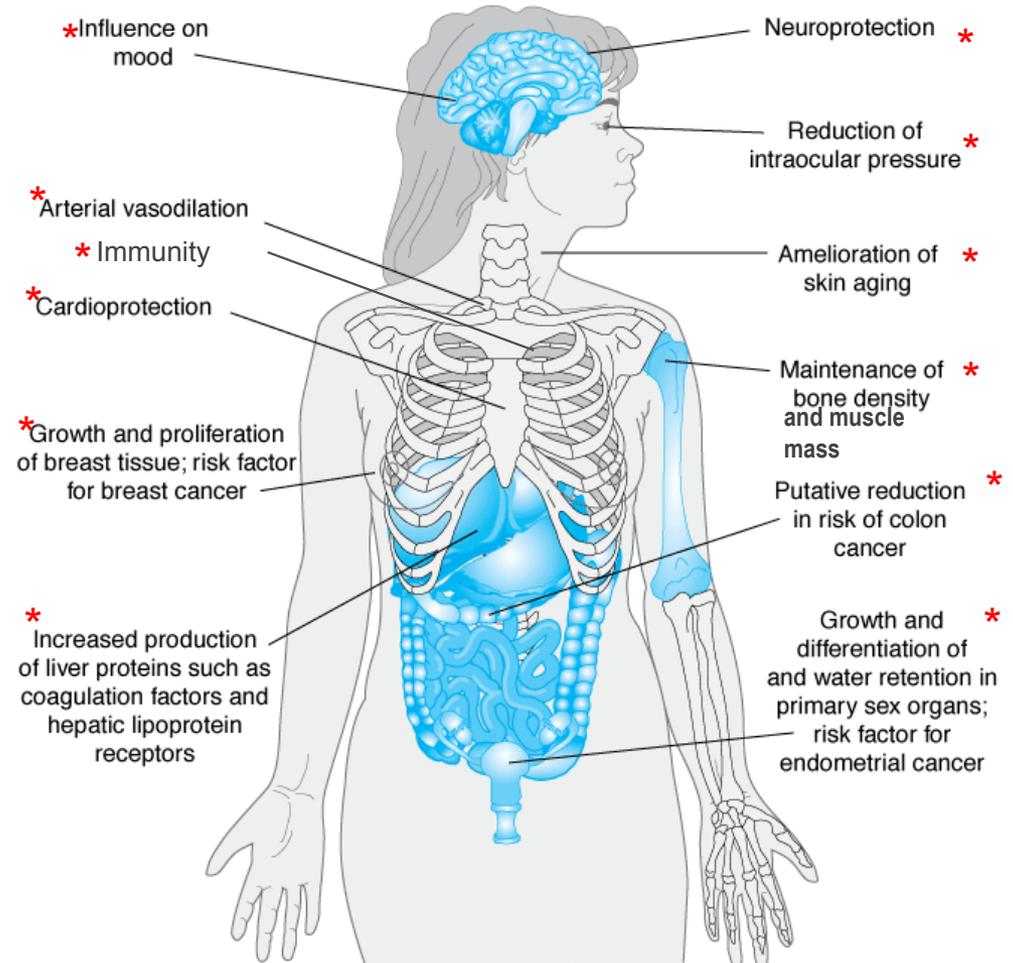
# Current Knowledge of the Impact of Sex & Gender on Reproductive Biology of Astronauts



## 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?

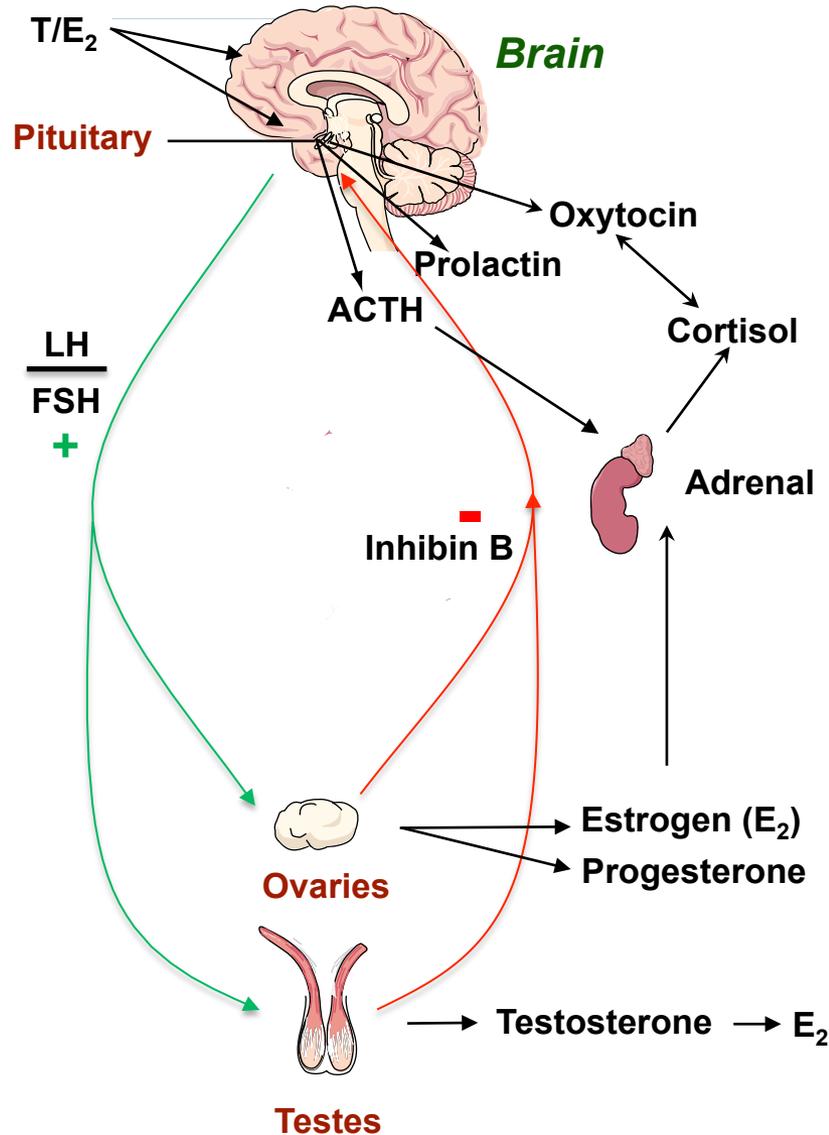
- Ground-based studies have identified age-related alterations in estrogen receptor signaling in many major organ systems
- A body of animal research has indicated several of these same systems are also altered in space flight (which is known to accelerate some aging processes)



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
<b>Demographics of Astronauts</b>		
Average Age during 1 <sup>st</sup> transit	42.4 yo	44.5 yo
% with at least 1 child	38%**	67%
# of Children	1.6	2.5
% Married	69%	76%
<b>Societal Roles (Gender)</b>		
	Women	Men
More likely to be primary caregiver	X	
Hiatus from career due to parental role	X	
<b>Biological Factors (Sex)</b>		
	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. On the left, a silhouette of an astronaut in a full space suit is shown floating. In the center and right, a large satellite with multiple solar panel arrays is depicted. At the bottom, a silhouette of a rover with a dome and a dish antenna is on a planet's surface.

**Thank you**