Endocrine Disrupting Activity Associated With Oil and Natural Gas Extraction

Susan C Nagel, PhD
Associate Professor
Obstetrics, Gynecology, and Women's Health
University of Missouri

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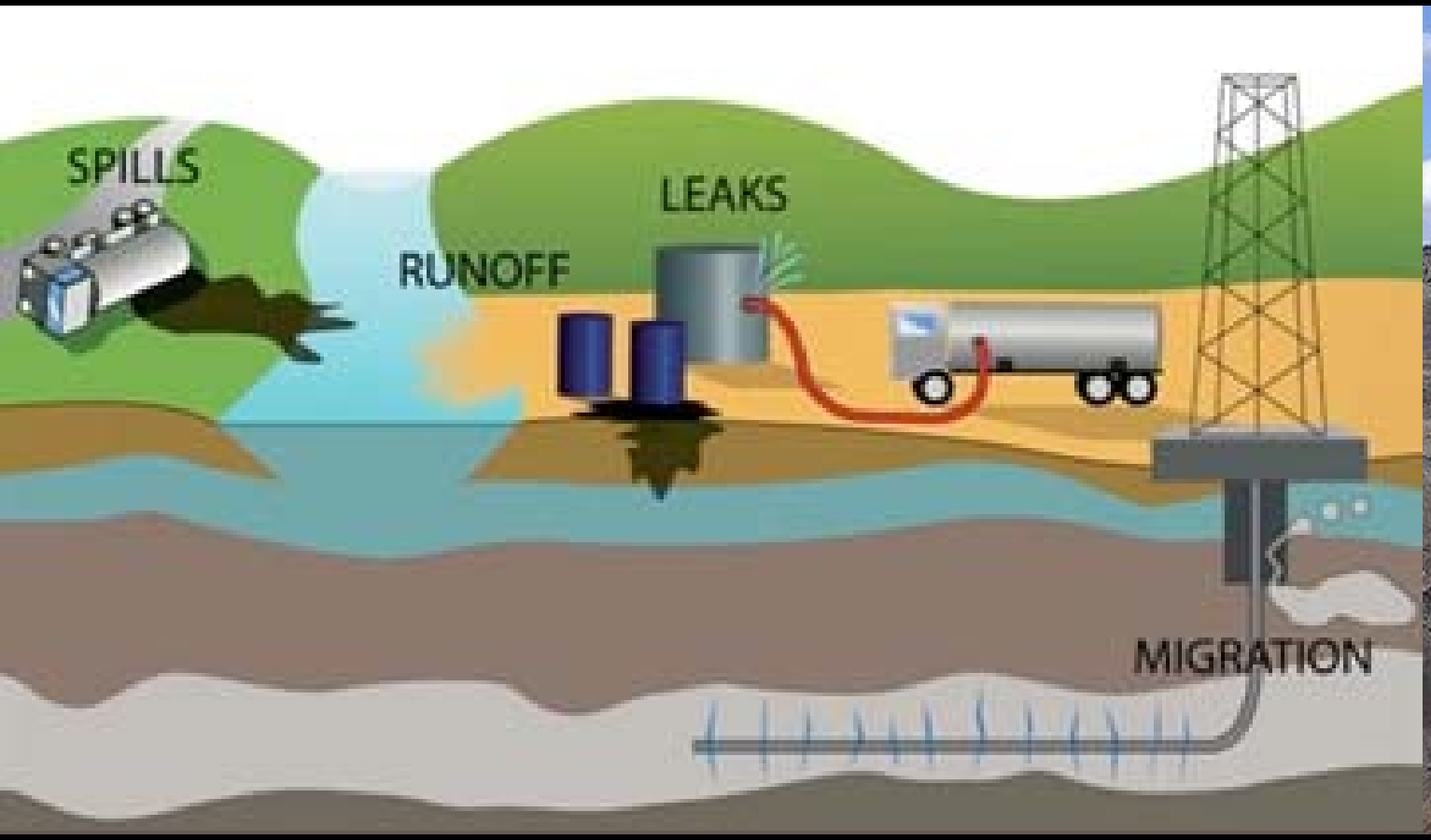
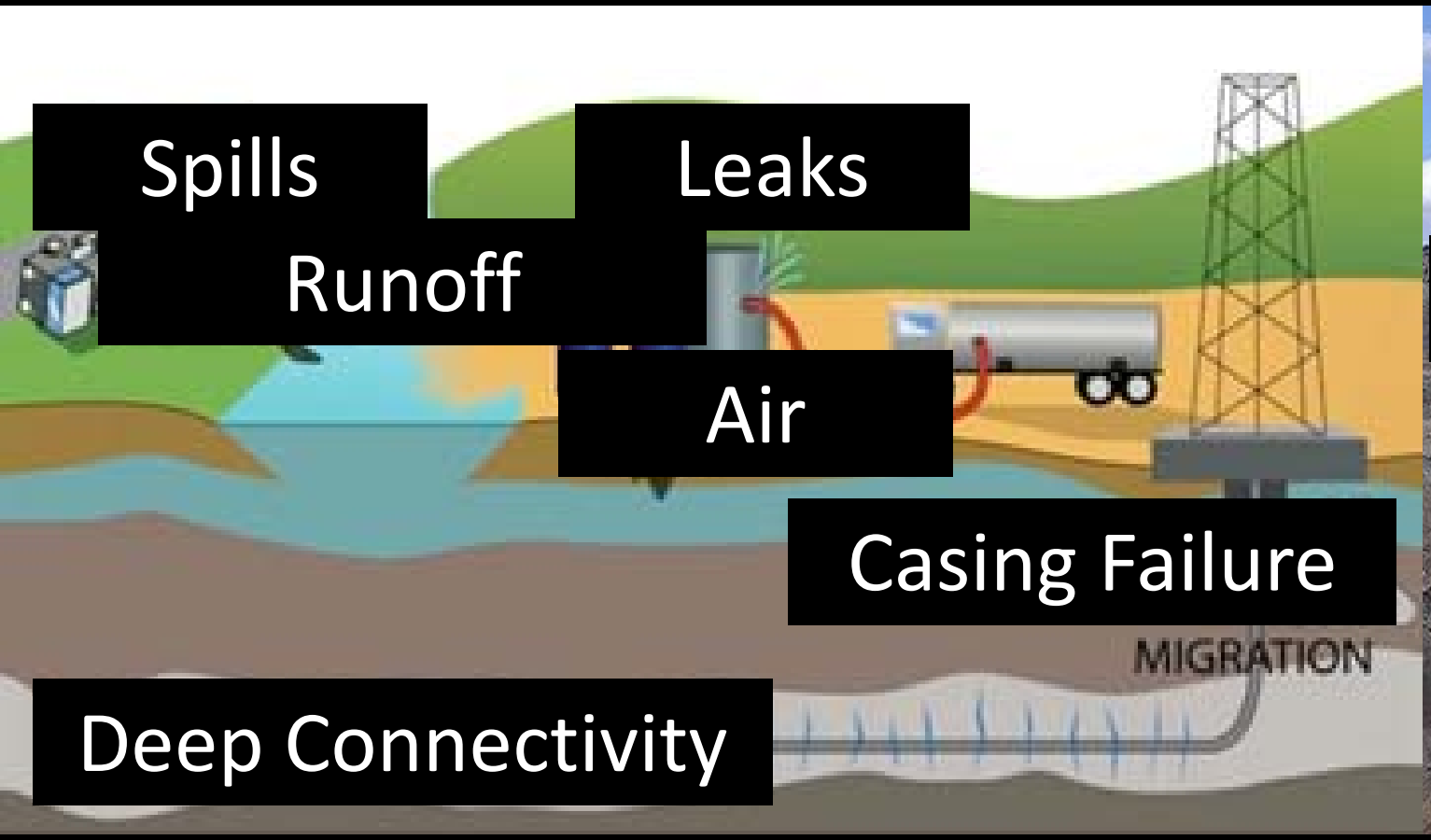
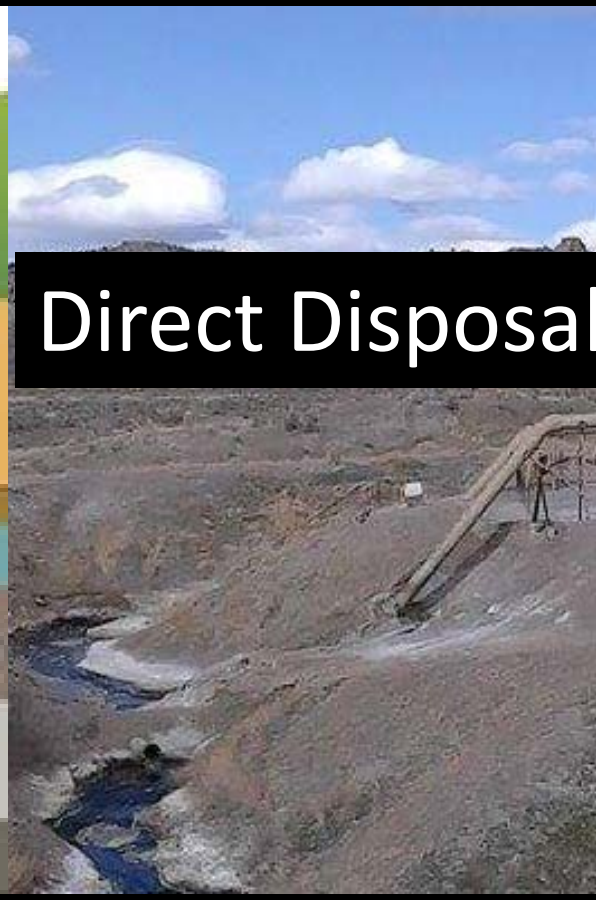
Routes of contamination of surface and ground water with oil and gas wastewater



Routes of contamination of surface and ground water with oil and gas wastewater



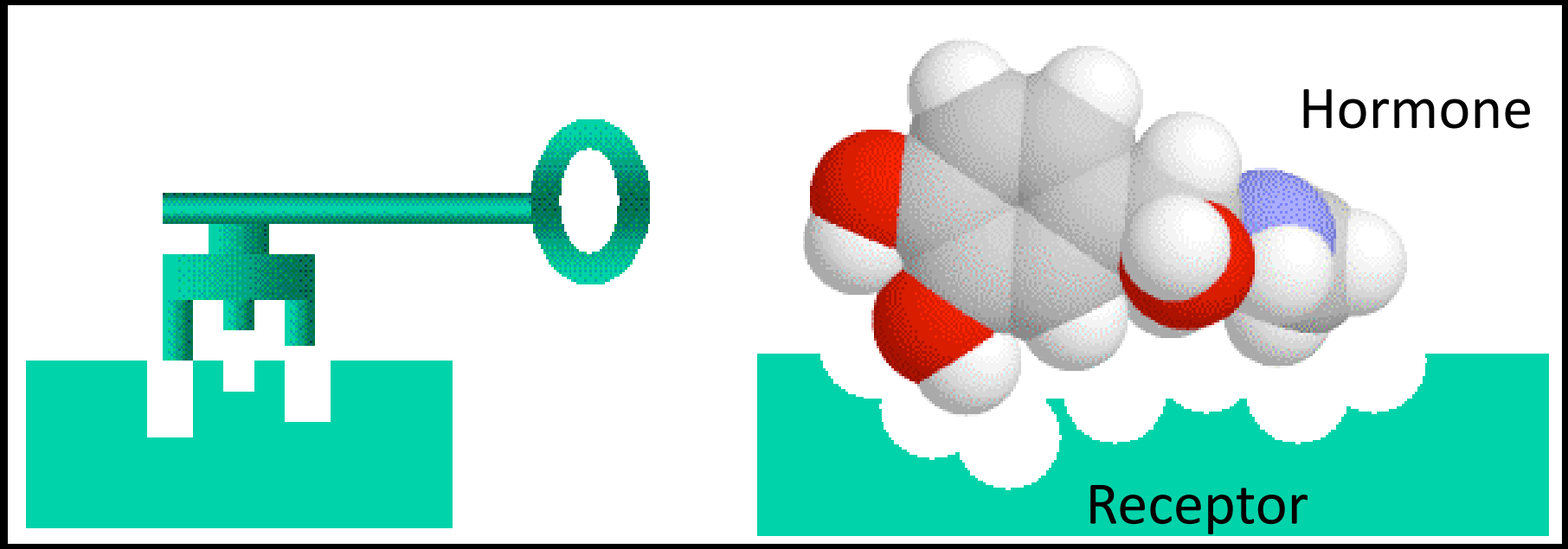


Riha and Rahm (2010)

1. Can chemicals used in unconventional oil and gas (UOG) operations disrupt normal endocrine signals?
2. Is there evidence of an association between oil and gas activities and human reproduction?
3. Does perinatal exposure to a mixture of oil and gas chemicals alter adult health?

Hormones are chemical messages essential for normal health and development

Hormone work by binding to specific receptors



Endocrine Disrupting Chemicals (EDC)

"A chemical, or mixture of chemicals, that interferes with any aspect of hormone action."





The Endocrine Society Statement on endocrine disrupting chemicals. Endocrinology 2012

Can chemicals used in unconventional oil and gas (UOG) disrupt normal hormone signals?

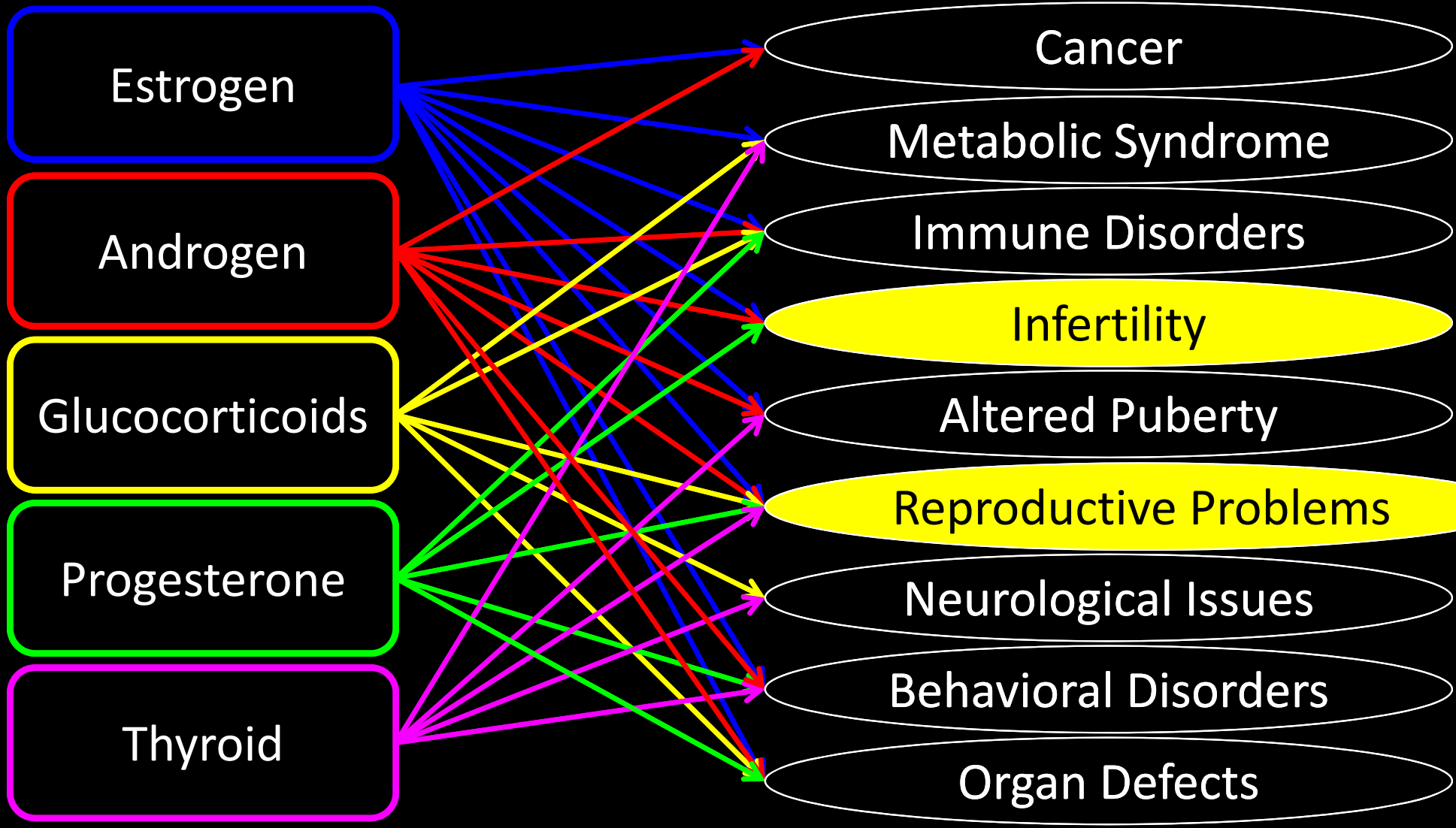
1,2,4-trimethylbenzene
2-(2-methoxyethoxy) ethanol
2-ethylhexanol
Acrylamide
Benzene
Bisphenol A
Bronopol
Cumene
Diethanolamine
Dimethyl formamide
Ethoxylated nonylphenol
Ethoxylated octylphenol
Ethylbenzene
Ethylene glycol
Ethylene glycol butyl ether
Methyl-4-isothiazolin
Naphthalene
Phenol
Propylene glycol
Sodium tetraborate decahydrate
Styrene
Toluene
Triethylene glycol
Xylenes

EDC Activity of 23 UOG Chemicals

Receptor	Activation	Inhibition
Estrogen	0	21
Androgen	0	21
Progesterone	1	12
Glucocorticoid	0	10
Thyroid	2	7

Kassotis et al 2014 and 2015, Endocrinology

Disruption of Hormones Is Associated with Human Disease



1. Can chemicals used in unconventional oil and gas (UOG) operations disrupt normal endocrine signals?
2. Is there evidence of an association between oil and gas activities and human reproduction?
3. Does perinatal exposure to a mixture of oil and gas chemicals alter adult health?

Systematic review of the association between oil and natural gas extraction processes and human reproduction

Victoria D. Balise, B.S.,[a,b] Chun-Xia Meng, M.D., Ph.D.,[a] Jennifer N. Cornelius-Green, M.S.,[a] Christopher D. Kassotis, Ph.D.,[c] Rana Kennedy, B.S.,[a,b] and Susan C. Nagel, Ph.D.[a,b]

[a] Department of Obstetrics, Gynecology and Women's Health, and [b] Division of Biological Sciences, University of Missouri, Columbia, Missouri; and [c] Nicholas School of the Environment, Duke University, Durham, North Carolina

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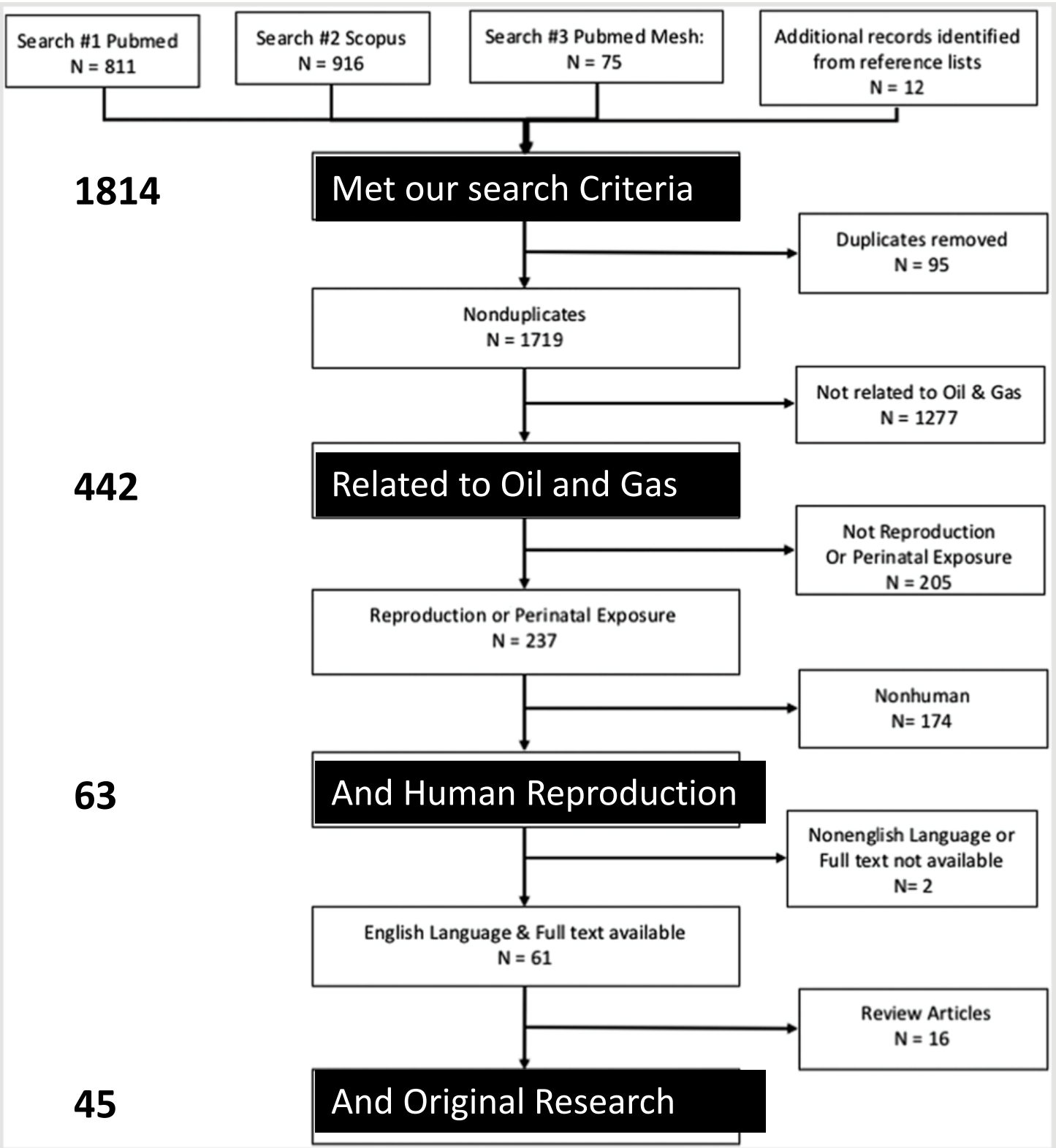


Balise, et al, 2016

Studies were assessed for quality of evidence and risk of bias and then the evidence was integrated

Effect High Number of Studies X 3

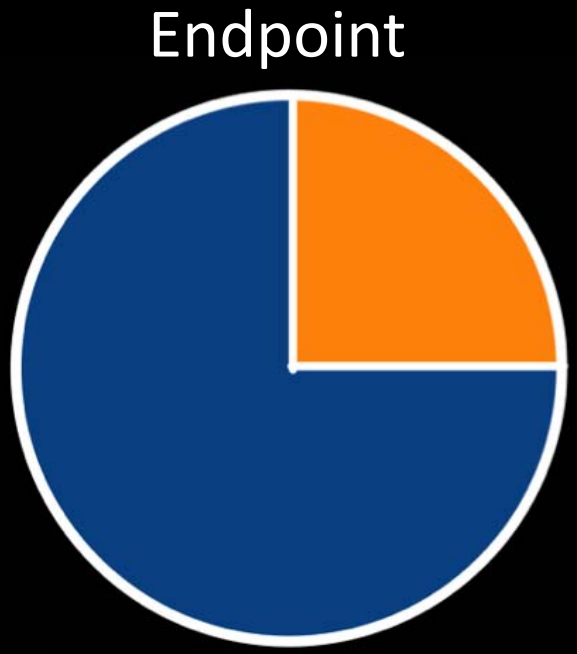
Effect Moderate Number of Studies X 2

Effect Low Number of Studies X 1

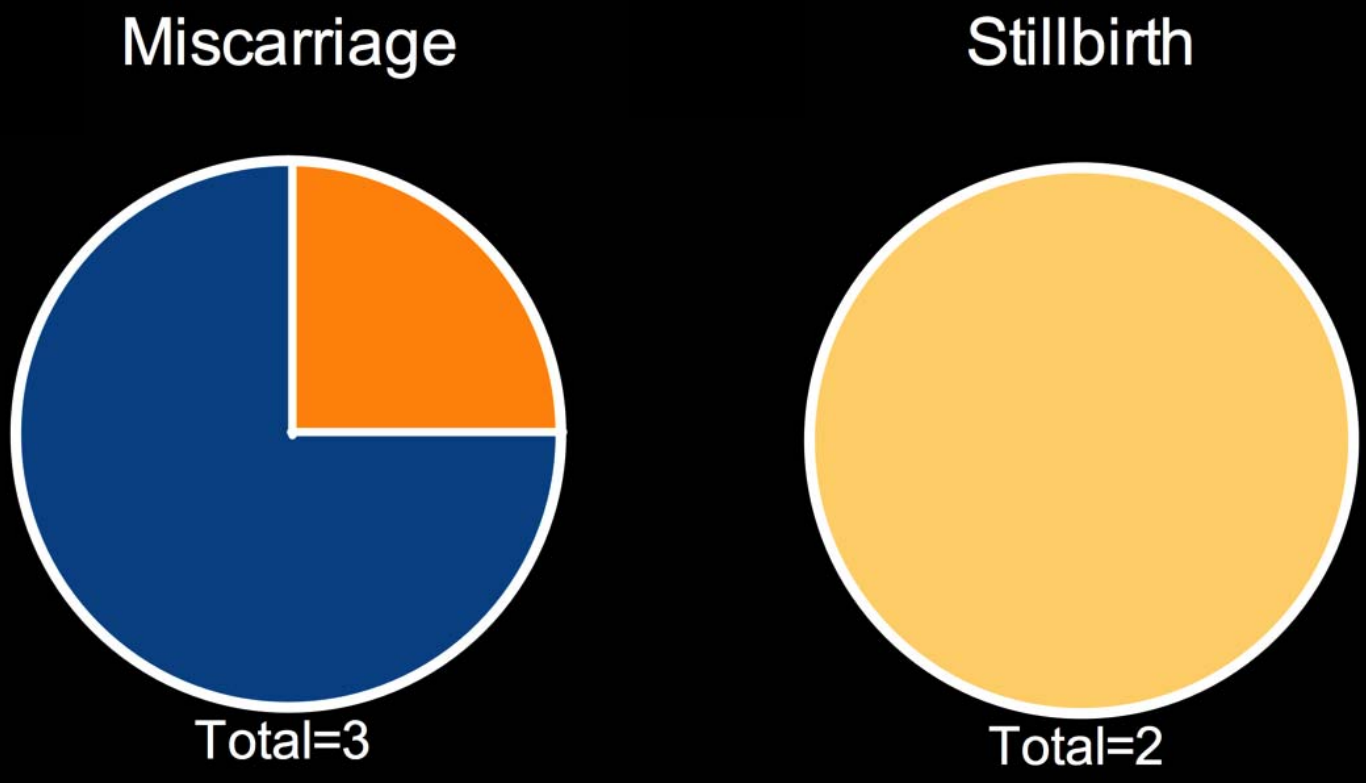
No Effect High Number of Studies X 3

No Effect Moderate Number of Studies X 2

No Effect Low Number of Studies X 1



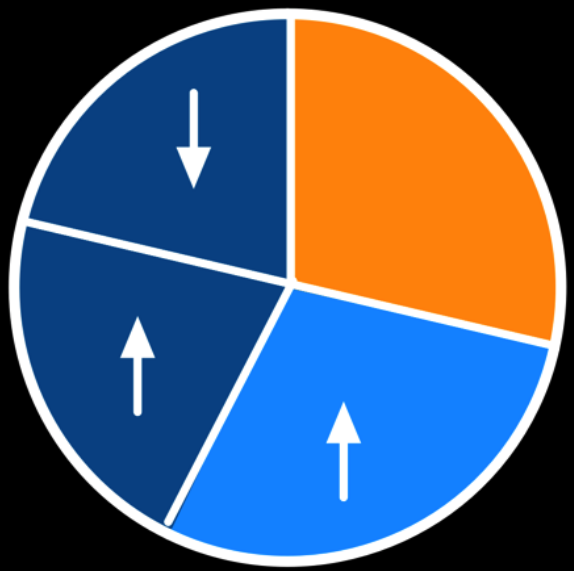
Birth Outcomes Associated with Oil and Gas Activities



Polina, et al. 2016. Fertility and Sterility

Birth Outcomes Associated with Oil and Gas Activities

Preterm Birth



Total=8*

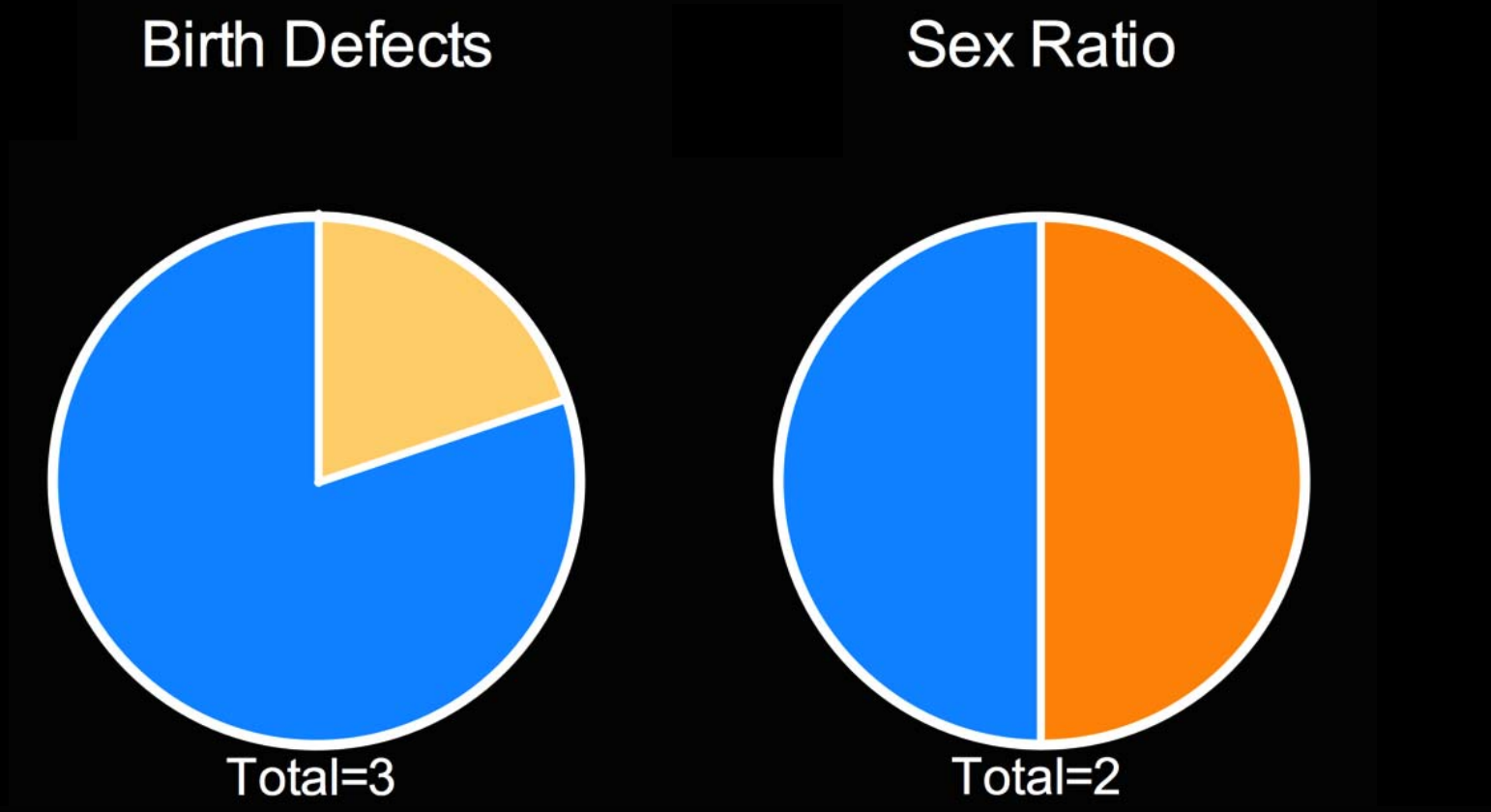
Low Birth Weight

Total=6

- Effect High
- Effect Moderate
- Effect Low
- No Effect Moderate
- No Effect Low

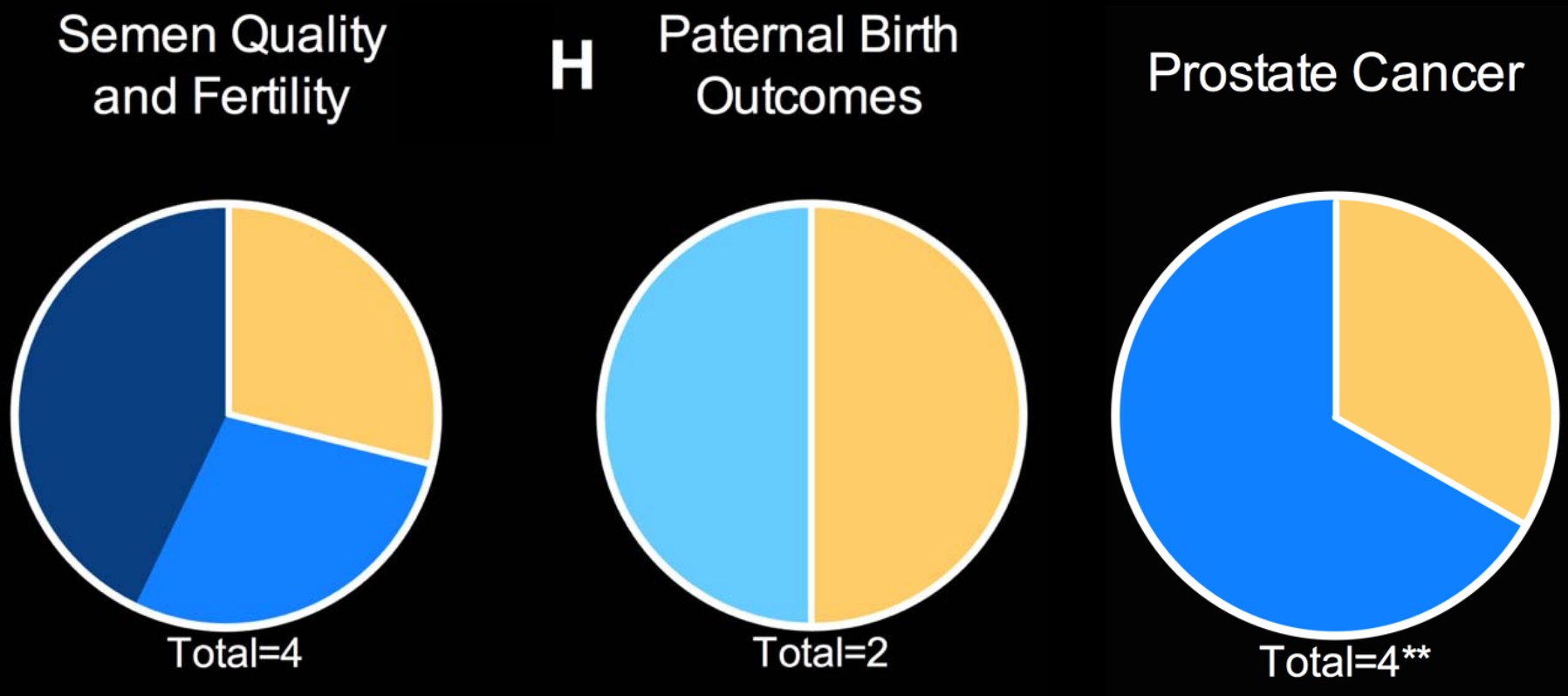
Polina, et al. 2016. Fertility and Sterility

Birth Outcomes Associated with Oil and Gas Activities



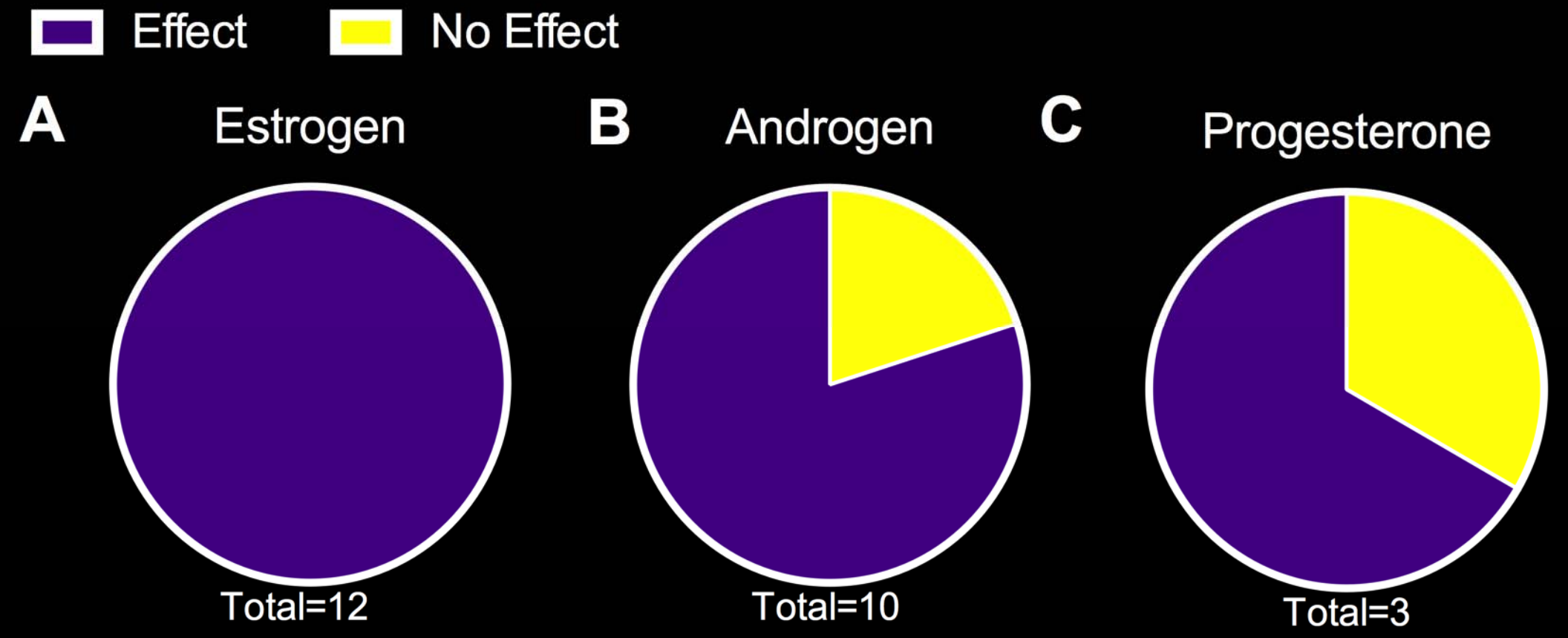
Balise, et al, 2016, Fertility and Sterility

Male Reproductive Health Associated with Oil and Gas Activities



Balise, et al, 2016, Fertility and Sterility

Evidence from Systematic Review that UOG Chemicals can be Endocrine Disruptors



Balise, et al, 2016, Fertility and Sterility

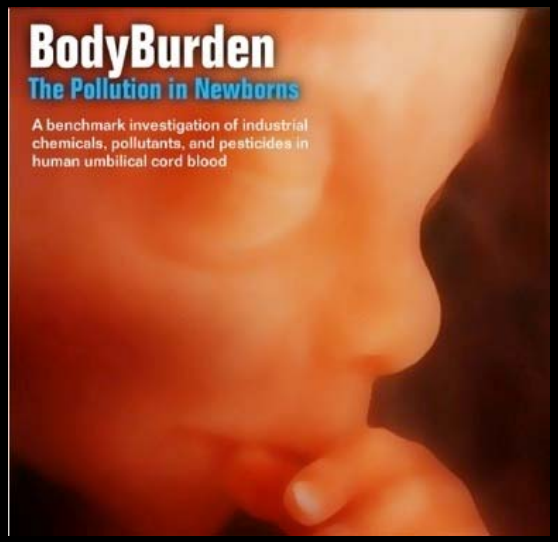
1. Can chemicals used in unconventional oil and gas (UOG) operations disrupt normal endocrine signals?
2. Is there evidence of an association between oil and gas activities and human reproduction?
3. What health effects may be associated with prenatal exposure to chemicals?

Fetal and early life exposure to EDCs is associated with adult disease

Pollutants

Nutrition

Maternal Health and Disease

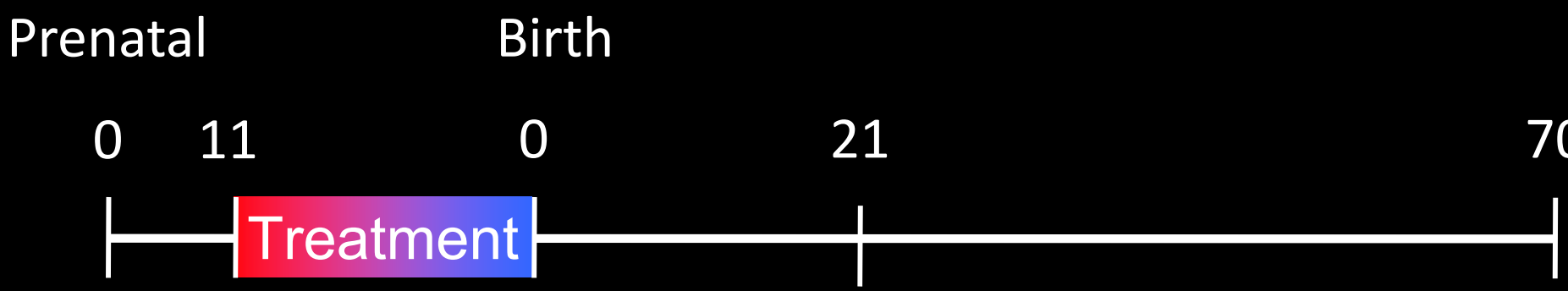


Infertility
Obesity
Heart Disease
Diabetes
Hypertension
Hyperactivity
Bone Health
Endometriosis
Breast Cancer
Testicular Cancer

Developmental exposure to a mixture of 23 UOG chemicals via drinking water

1,2,4-trimethylbenzene
2-(2-methoxyethoxy) ethanol
2-ethylhexanol
Acrylamide
Benzene
Bisphenol A
Bronopol
Cumene
Diethanolamine
Dimethyl formamide
Ethoxylated nonylphenol
Ethoxylated octylphenol
Ethylbenzene
Ethylene glycol
Ethylene glycol butyl ether
Methyl-4-isothiazolin
Naphthalene
Phenol
Propylene glycol
Sodium tetraborate decahydrate
Styrene
Toluene
Triethylene glycol
Xylenes

Developmental exposure to a mixture of 23 UOG chemicals via drinking water

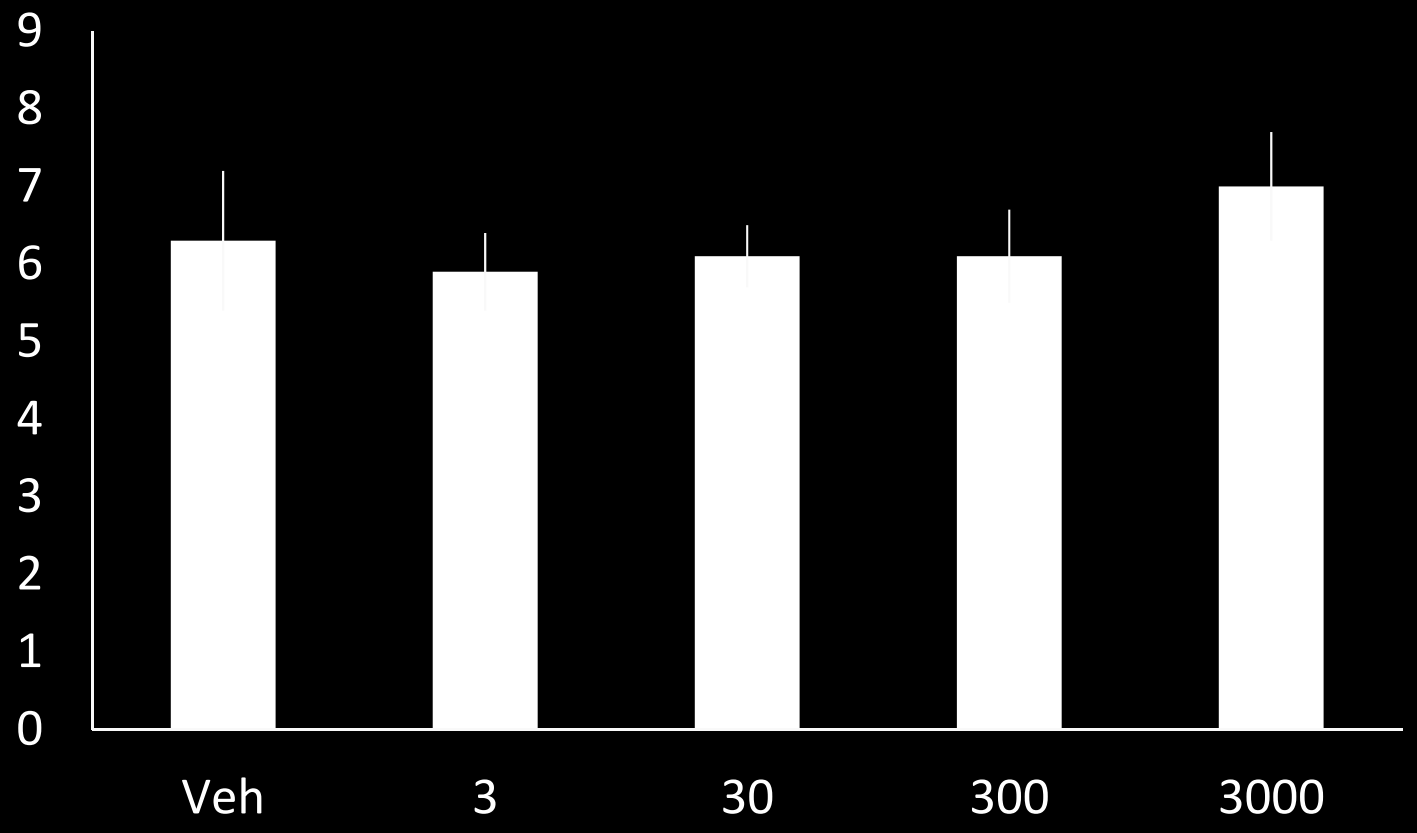


Vehicle	0.2% ethanol
Mix 1	3000 µg/kg
Mix 2	300 µg/kg
Mix 3	30 µg/kg
Mix 4	3 µg/kg

Exposure was equivalent to roughly the second trimester of human pregnancy.

Kassotis, et al, Endocrinology, 2015 and 2016

Prenatal exposure* to UOG mixture did not alter number of pups per litter

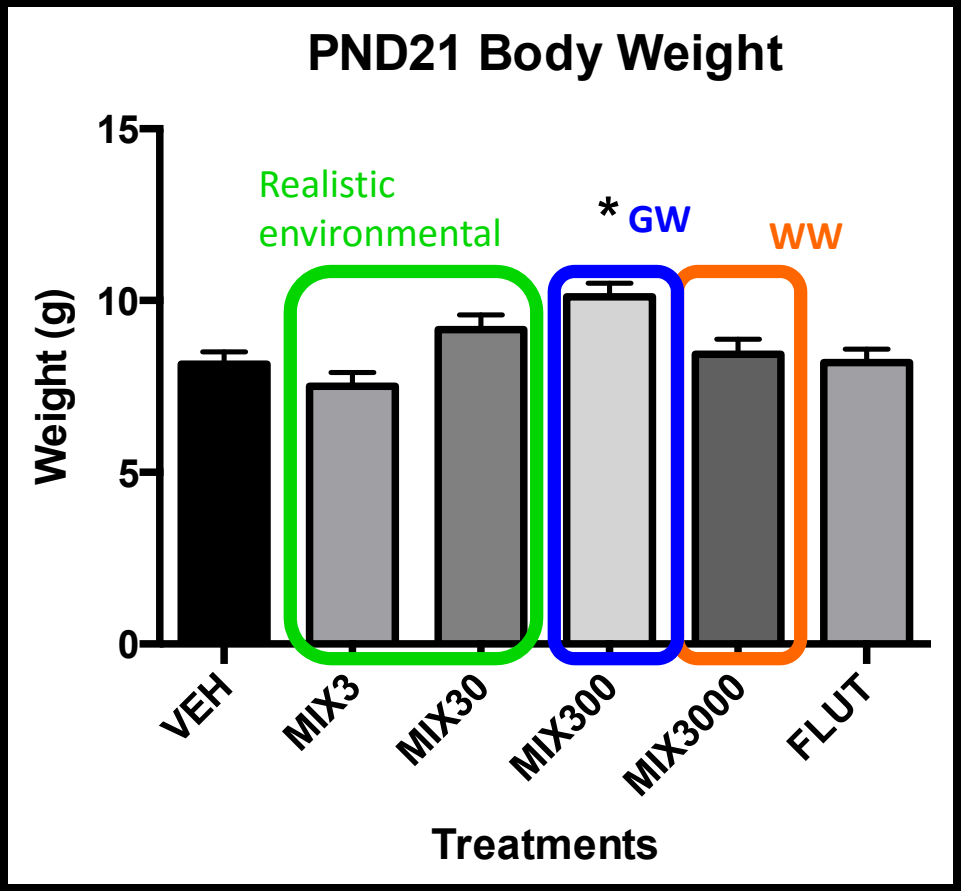


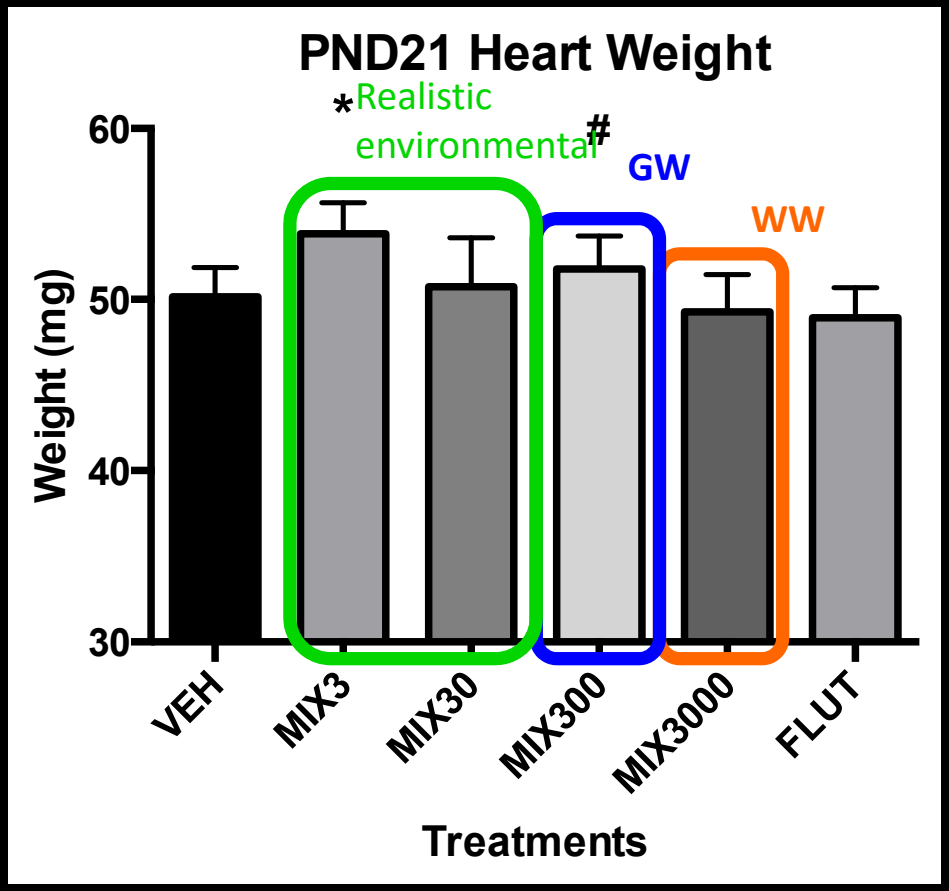
* Exposure equivalent to 2nd trimester of human pregnancy

Kassotis, et al, Endocrinology, 2015 and 2016

Health Effects in Male Offspring

Prenatal exposure to UOG mixture altered body and organ weights in adult male mice

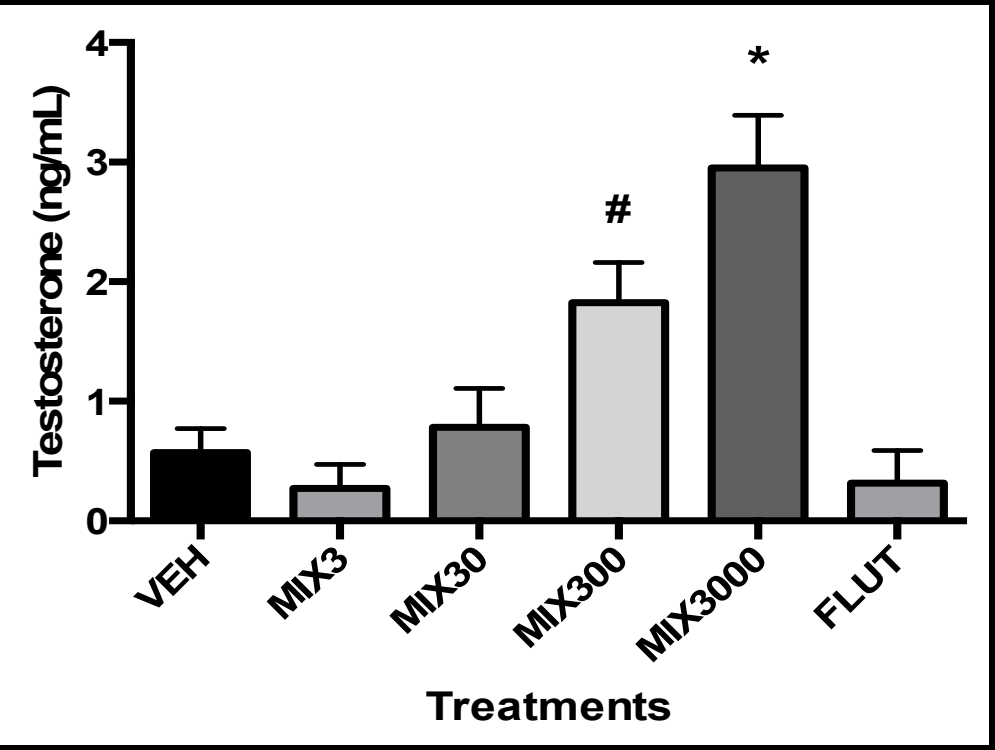


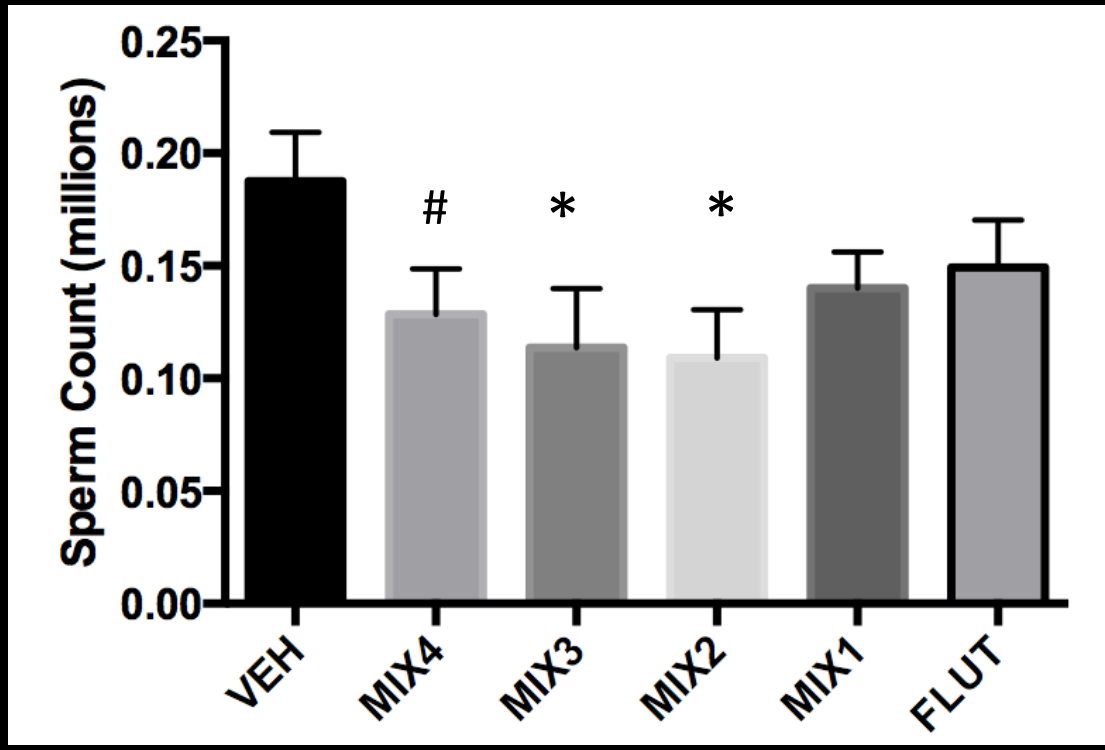


Ground water directly below surface spills, *Gross et al*

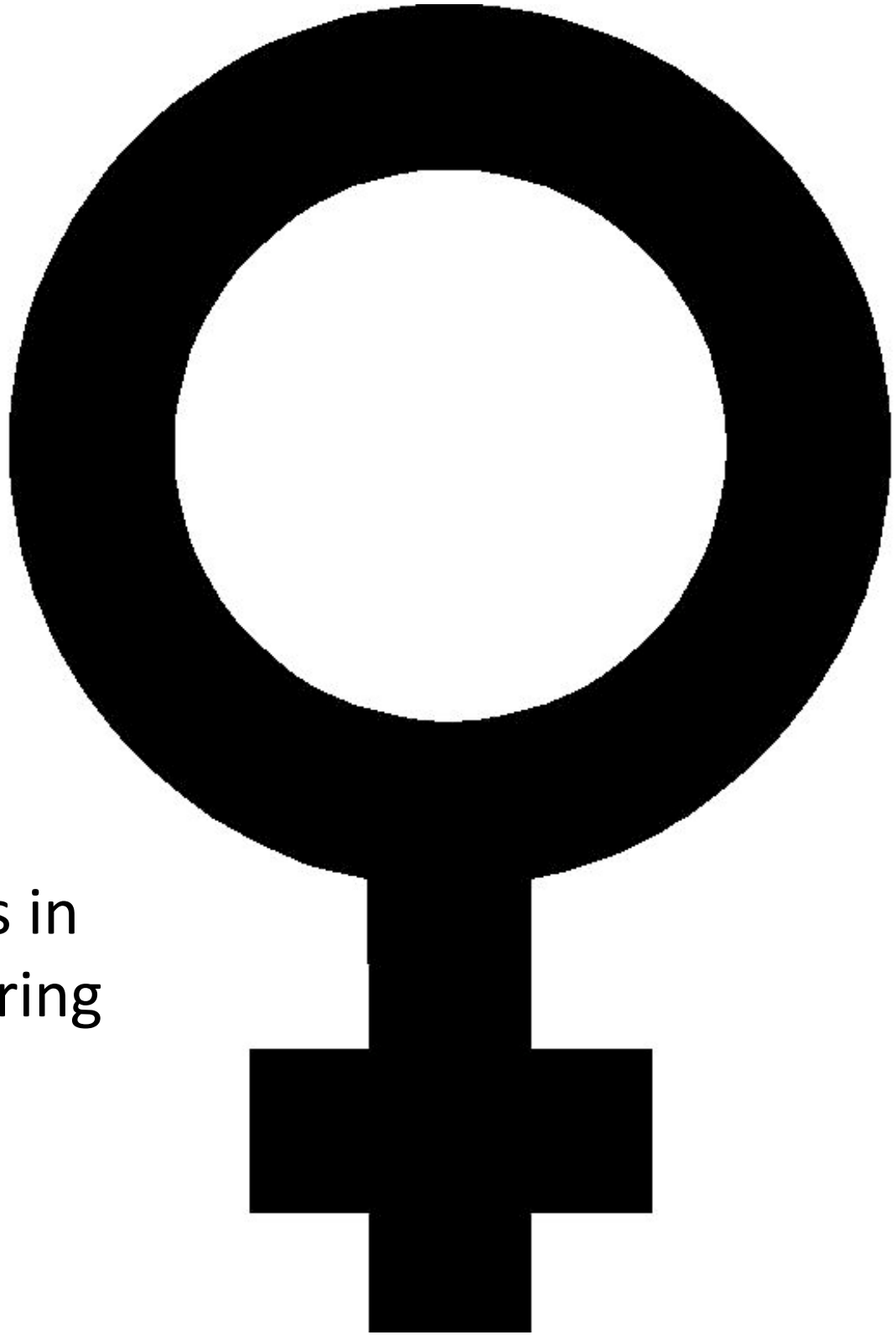
Kassotis et al 2015, Endocrinology

Prenatal exposure to UOG mixture increased adult testosterone and decreased sperm counts



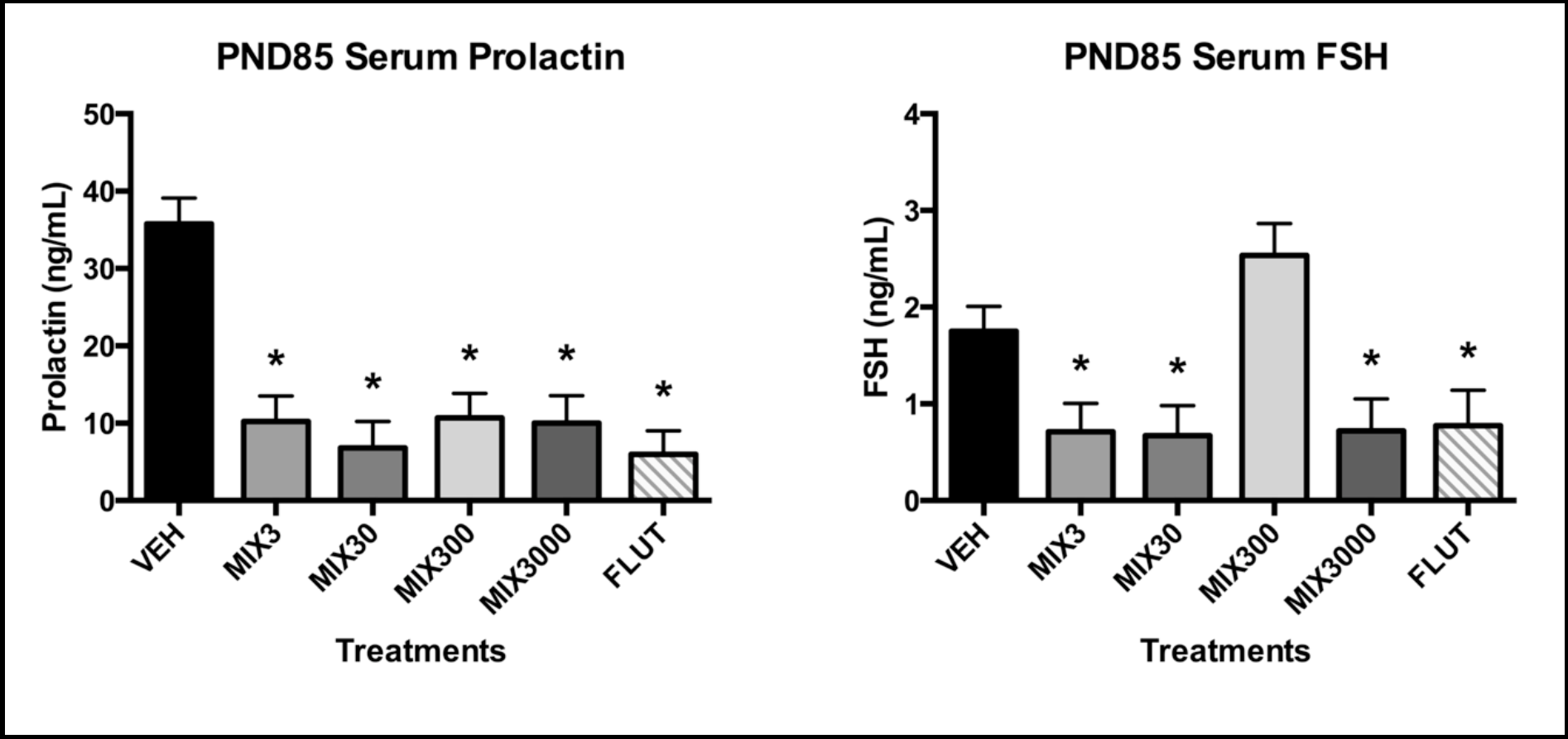


Kassotis et al 2015, Endocrinology



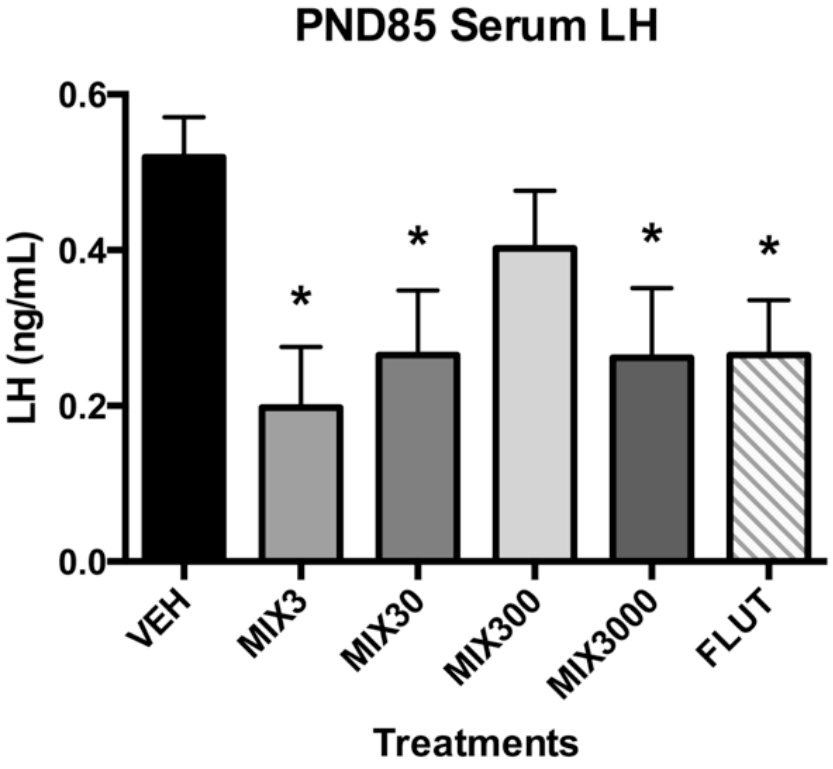
Health Effects in
Female Offspring

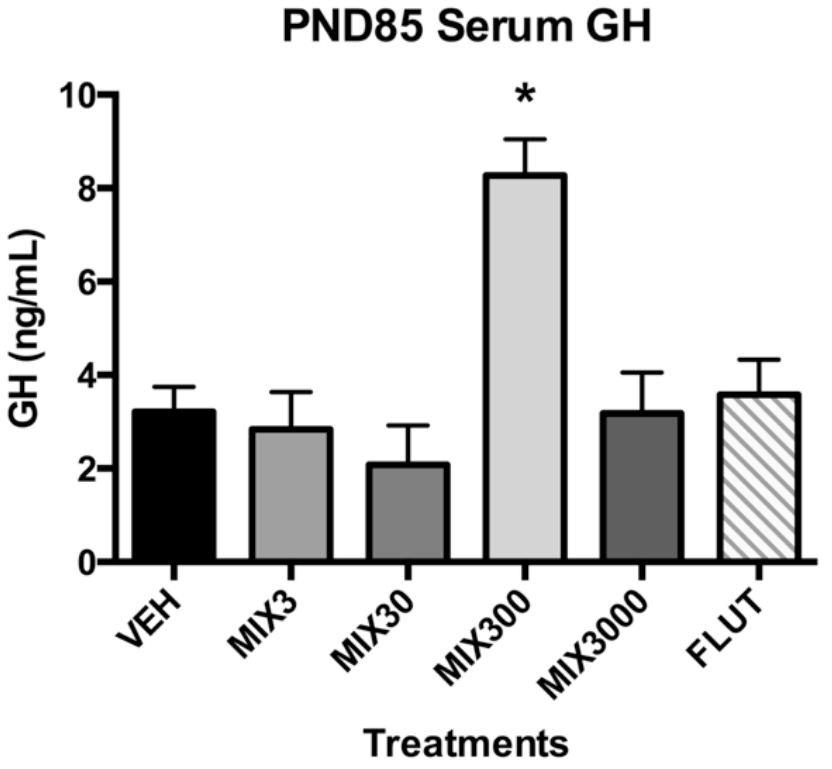
Prenatal Exposure Decreased Reproductive Hormones: Prolactin and FSH



Kassotis, et al 2016, Endocrinology

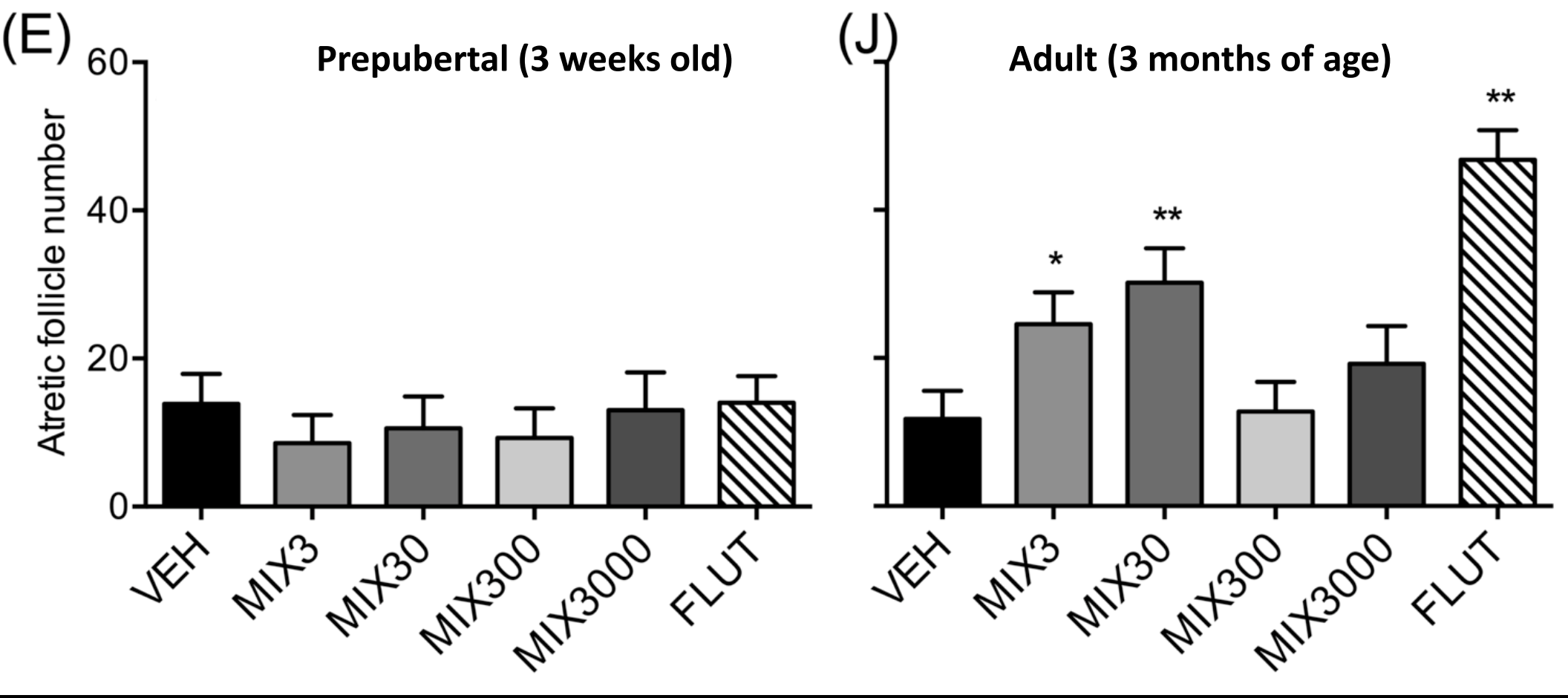
Prenatal Exposure Decreased LH and Increased GH





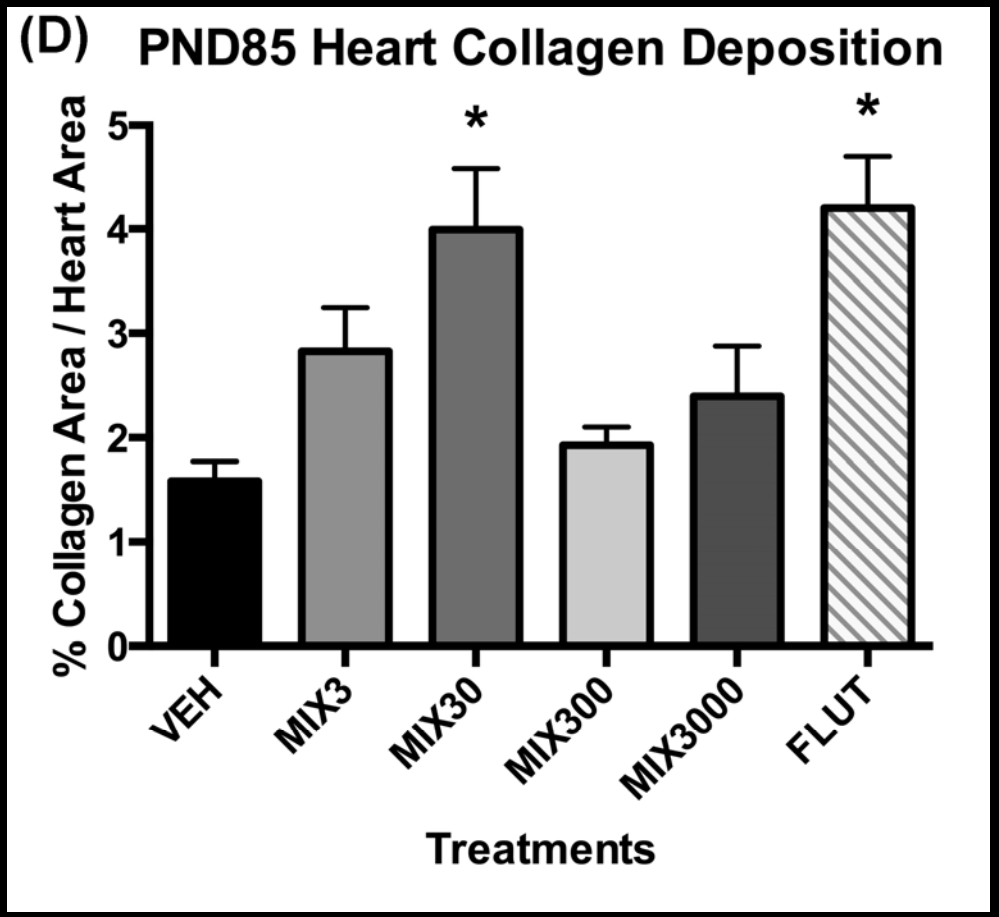
Kassotis, et al 2016, Endocrinology

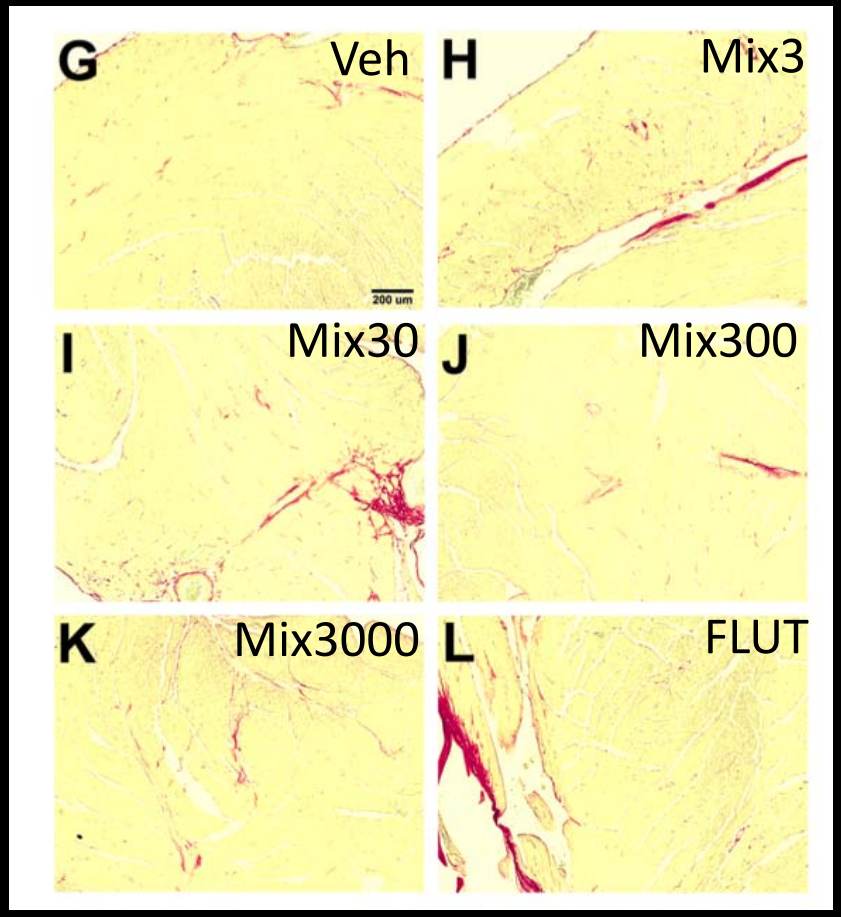
Prenatal Exposure Increased Number of Atretic Follicles at Low Doses



Kassotis, et al 2016, Endocrinology

Collagen deposition was increased in the heart at low doses





Conclusions

- Many chemicals used in and produced by oil and gas activities can be EDCs
- A systematic review of published studies suggests there is evidence for an association between oil and gas activities and negative developmental and reproductive health effects in humans.
- Laboratory studies found an association between prenatal exposure to UOG chemicals and negative developmental and reproductive health outcomes.