ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΑΤΡΩΝ
UNIVERSITY OF PATRAS

ΑΝΟΙΚΤΑ ακαδημαϊκά μαθήματα ΠΠ

Φύλο και εγκέφαλος

Ενότητα 1: Κεντρικό νευρικό σύστημα
Νεοκλής Α. Γεωργόπουλος
Σχολή Επιστημών Υγείας
Τμήμα Ιατρικής

Σκοποί ενότητας

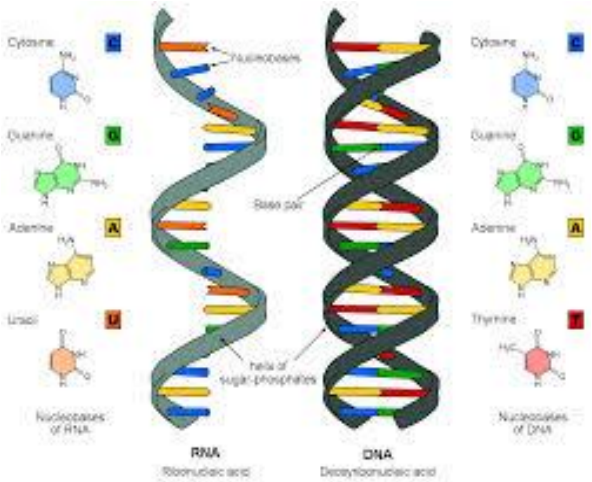
- Αλληλεπίδραση ορμονών και νευρωνικών κυκλωμάτων.

- Συσχέτιση ορμονικών παραγόντων με αναπαραγωγικούς και συμπεριφορικούς φαινότυπους.

Περιεχόμενα ενότητας

- Φύλο και εγκέφαλος
- Λειτουργική υποθαλαμική αμηνόρροια
- Διαφυλικοί
- Η ψυχική συνιστώσα της ανθρώπινης σεξουαλικότητας
- Female sexual dysfunction

Genes and Jeans



http://upload.wikimedia.org/wikipedia/commons/3/37/Difference_DNA_RNA-EN.svg

- Για την ανάπτυξη άρρενος τύπου ταυτότητας φύλου απαραίτητη η άμεση δράση των ανδρογόνων στον εγκέφαλο μέσω του ανδρογονικού υποδοχέα

https://www.flickr.com/photos/jasonstaten/3158074766/

Pope Joan

- Pope Joan: A Recognizable Syndrome*
- Maria I. New and ElizabethS. Kitzinger, JCEM 1993

http://en.wikipedia.org/wiki/Pope_Joan#/media/File:Woodcut_illustration_of_Pope_Joan_-_Penn_Provenance_Project.jpg

http://en.wikipedia.org/wiki/Pope_Joan#/media/File:Papesse_Jeanne_BnF_Fran%C3%A7ais_599_fol._88.jpg

Baubo

- Baubo : a Case of Ambiguous Genitalia in the Eleusinian Mysteries

  Neoklis A. Georgopoulos, George A. Vagenakis, Apostolos L. Pierris

  Hormones 2003

- Ως ειπούσα πέπλους ανεσύρετο, δείξε δε πάντα σώματος ουδέ πρέποντα τύπον.

  Παίς δ'ήεν Ίακχος Βαυβούς υπο κόλπους

http://upload.wikimedia.org/wikipedia/commons/c/c5/Terracotta_Baubo_figurine.jpg

Masculinization of the canary brain

The sing of the canary

- Male: Singing
- Female: No singing
- Female + Testosterone: Singing

Female brain

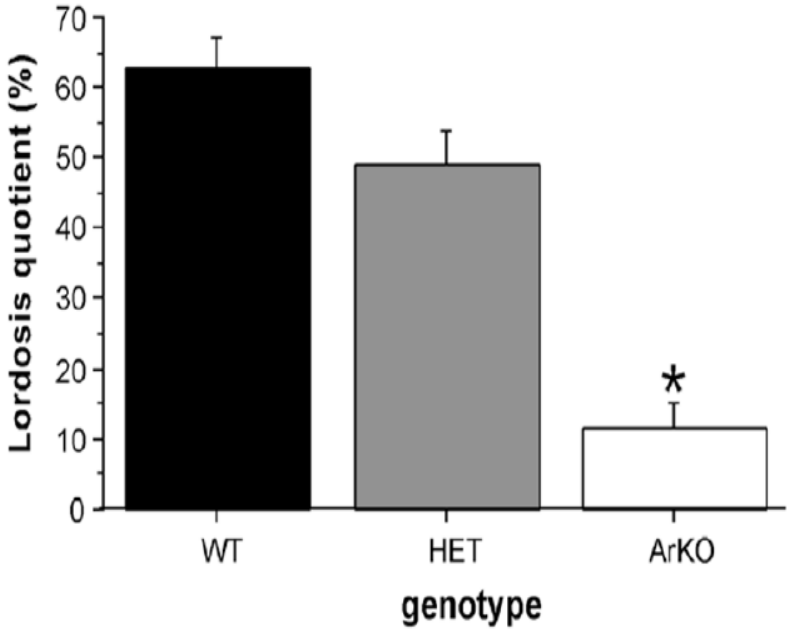


Fig. 2.
Lordosis quotients of female wild-type (WT), heterozygous (HET), and aromatase knockout (ArKO) mice. All females were ovariectomized in adulthood and subsequently treated with estradiol and progesterone prior to each behavioral test with a sexually active male. *$p < 0.05$ compare to WT and HET females. Data shown are means (±SEM) of a total of five tests.

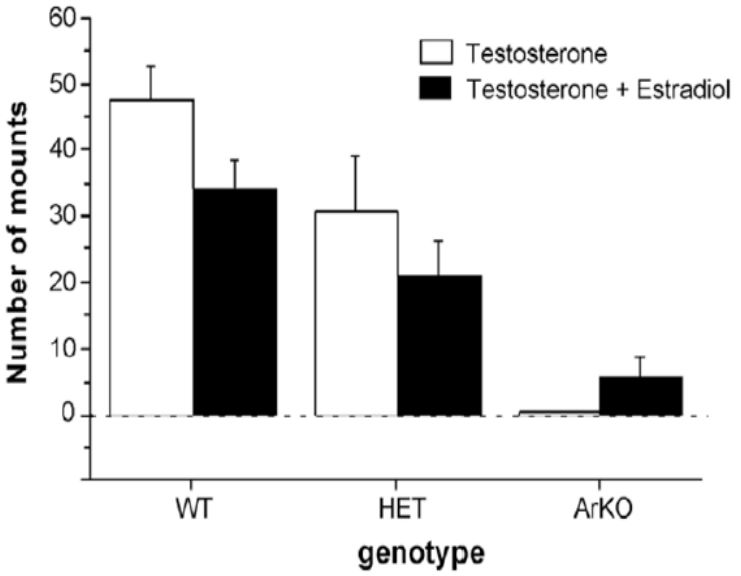


Fig. 3.
Mounting behavior of female wild-type (WT), heterozygous (HET), and aromatase knockout (ArKO) mice. All females were ovariectomized in adulthood and tested once for mounting behavior with an estrous female when treated with testosterone and then once more when treated with both testosterone and estradiol (5 µg/mouse/day). *$p < 0.05$ compared to WT and HET females, $^{\#}p < 0.05$ compared to WT females. Data shown are means ± SEM.

Estrogens are required for female typical brain and behavioral sexual differentiation

Bakker J. Neuroendocrinology 2007

Φυλετικός διμορφισμός ΚΝΣ

Brain Sexual Differentiation

Fetal brain development

- **Organizational actions**
- Neuroactive steroids:

  Neurotrophic factors

  Neurotransmitters

  Second messenger pathways cross-talks

Adult brain

- **Activational actions**
- Neural and Endocrine conditions
- Endocrine disruptors

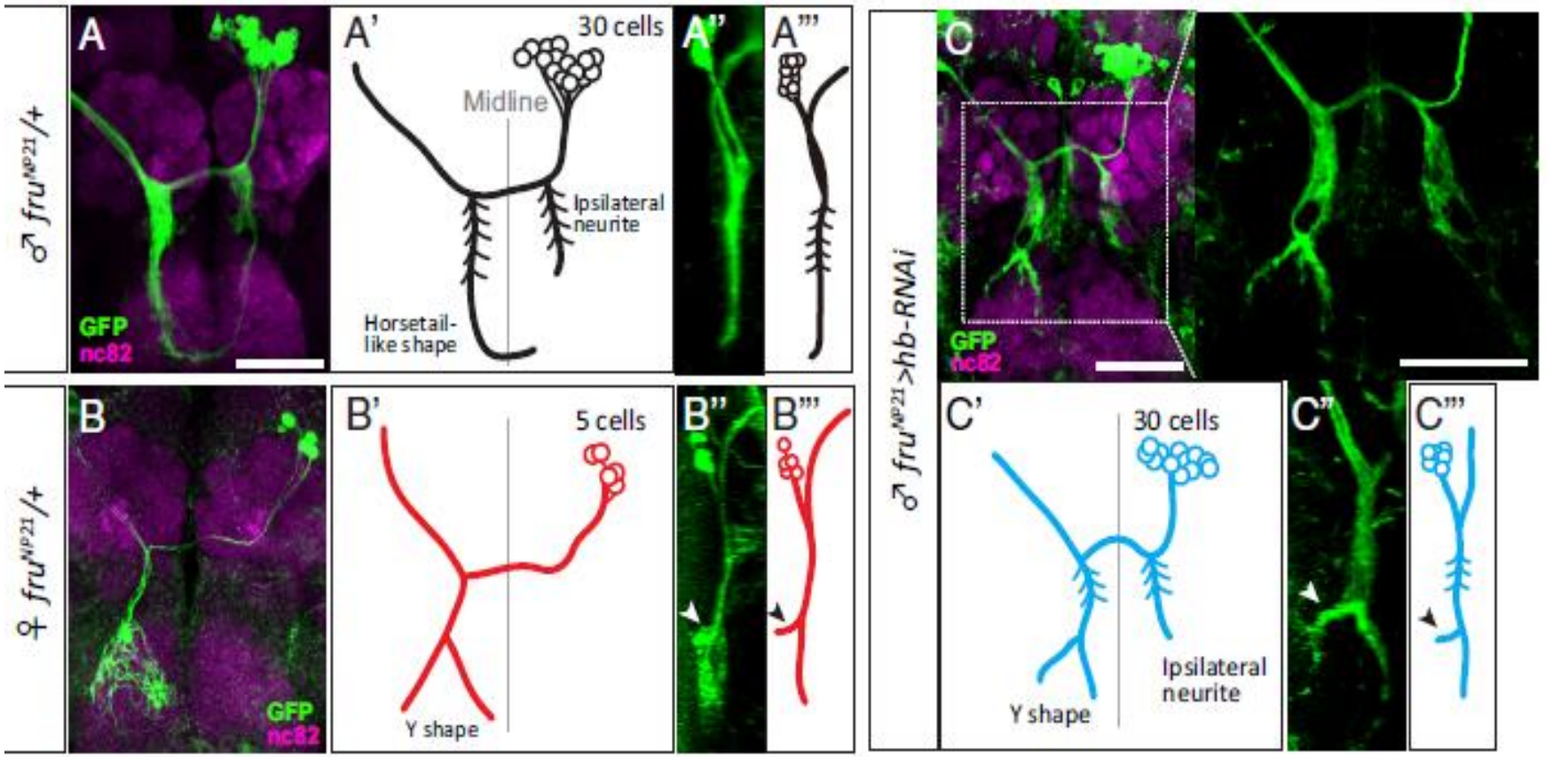
Behavior: Male, Female

Central metabolism of sex steroids

- Testosterone is converted to Dihydrotestosterone via 5a-reductase
- Dihydrotestosterone binds to Androgen receptor
- Dihydrotestosterone is converted to 3$^{\alpha}$-DIOL derivatives
- 3$^{\alpha}$-DIOL derivatives bind to Estrogen receptor β and exert non-genomic signals via GABA-A receptors

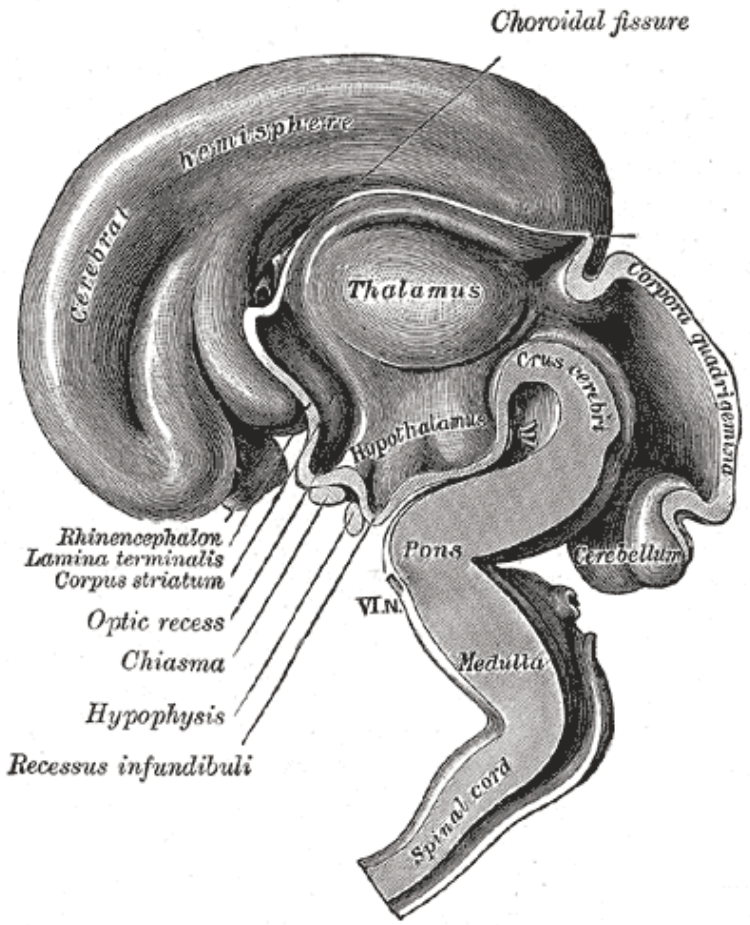
- Testosterone is converted to Estradiol via CNS aromatase
- Estradiol binds to Estrogen receptor α
- CNS aromatase is expressed in frontal cortex, diencephalon, hippocampus, amygdala, bed nucleus of the stria terminalis, hypothalamus.

Male-typical shape of neurites: substantial evidence



Goto et al, 2011

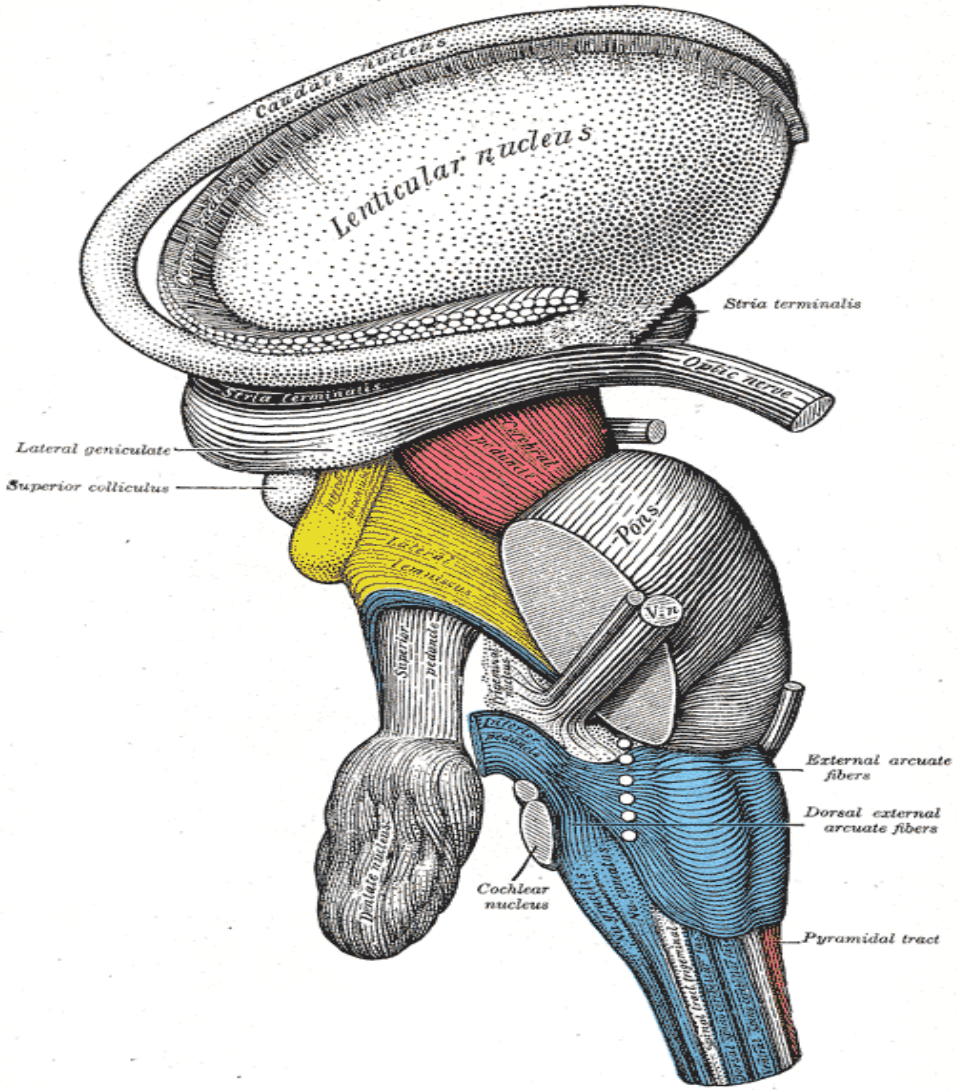
Sexually dimorphic nuclei - Hypothalamus



- Πυρήνες - SDN of MPOA, SCN, BST, INAH 2
- Μέγεθος, σχήμα, αριθμός νευρώνων
- Οι περιοχές του εγκεφάλου διαφοροποιούνται μέχρι και την ενήλικο ζωή

http://en.wikipedia.org/wiki/Hypothalamus#/media/File:Gray654.png

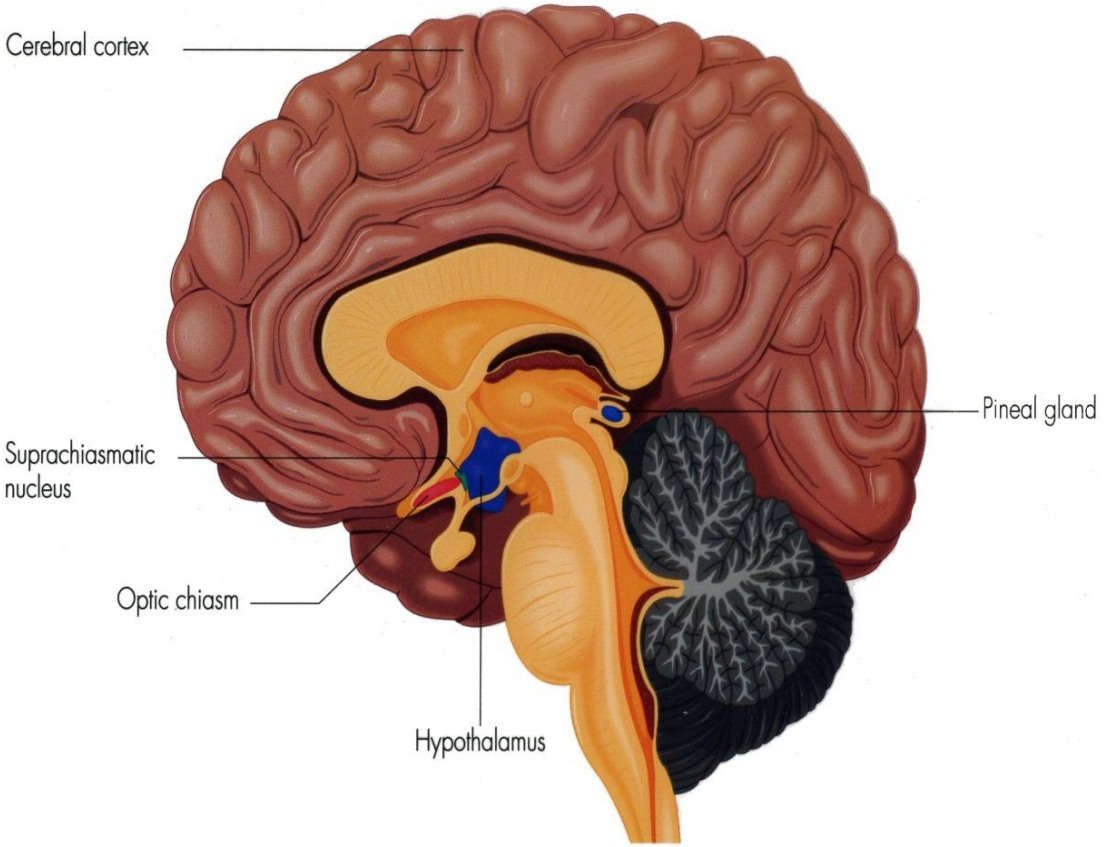
Bed nucleus of Stria Terminalis



- **BST Bed nucleus of Stria Terminalis**
- Males : increased size and number of neurons

http://en.wikipedia.org/wiki/Stria_terminalis#/media/File:Gray683.png

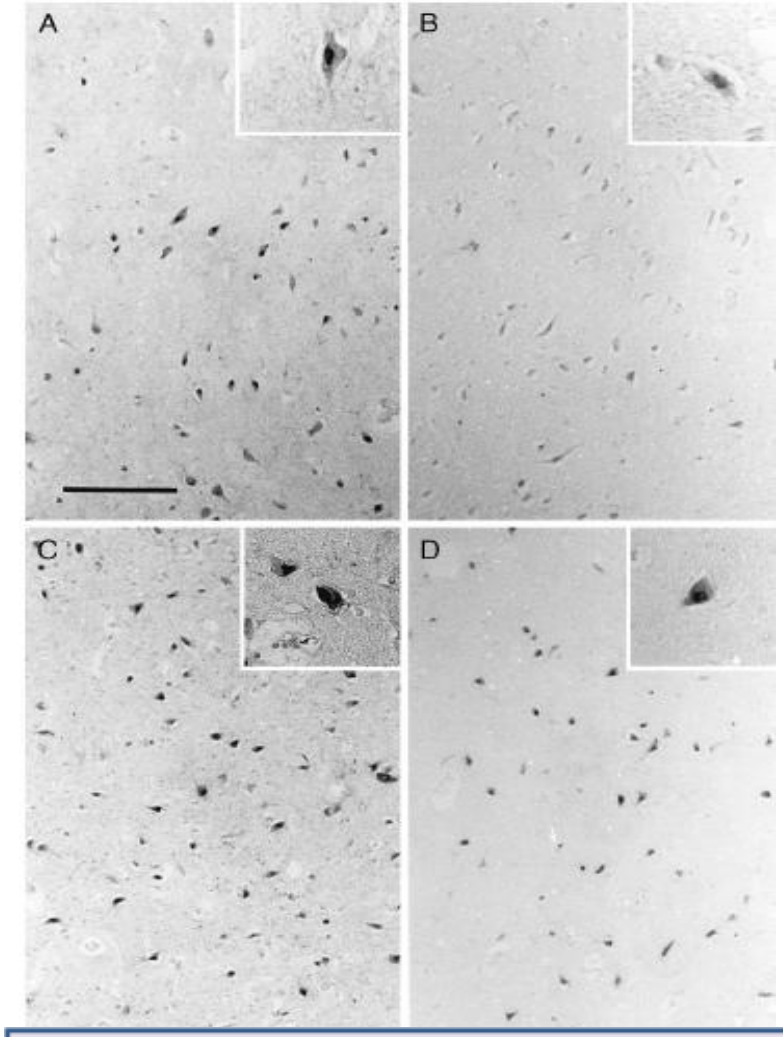
Suprachiasmatic nucleus



- **SCN**
- Males : Spherical vs Elongated in Females

http://upload.wikimedia.org/wikipedia/commons/8/80/Suprachiasmatic_Nucleus.jpg

Androgen receptors of the human mamillary bodies-1



Kruijver et al, 2001

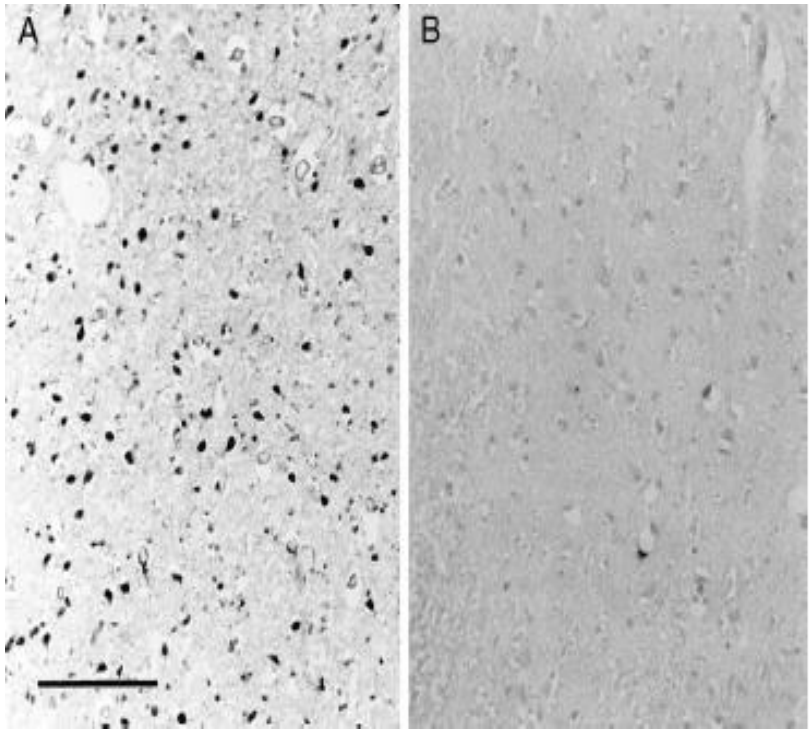
- Sex differences in androgen receptors (AR) of the human mamillary bodies: differences in circulating levels of androgens.

- A: Heterosexual man
- B: Heterosexual woman
- C: Homosexual man
- D: Woman with high levels of androgens

- Conclusions:

1. Sex difference in the nuclear AR immunoreactivity between A and B.
2. No difference in the intensity of AR staining between A, C and D

Androgen receptors of the human mamillary bodies-2



Kruijver et al, 2001

- Sex differences in androgen receptors (AR) of the human mamillary bodies: differences in circulating levels of androgens

- A: Non-castrated male-to-female transsexual
- B: Castrated male-to-female transsexual

- Conclusions:

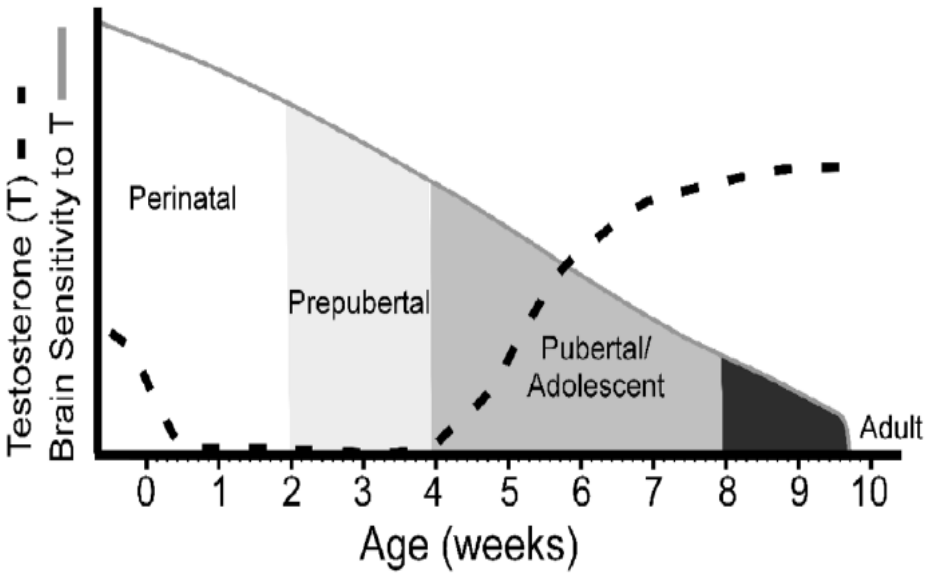
  Sex difference in the nuclear AR immunoreactivity between A and B.

Φυλετικός διμορφισμός ΚΝΣ
Πώς και πότε δημιουργείται;

Organizational-Activational hypothesis

- Phoenix et al, 1959: Organizational-activational hypothesis of hormone-driven sex differences in brain and behavior
- Prenatal/early postnatal transient rise in testosterone: Masculinizes and defeminizes neural circuits in males
- Absence of the transient rise in testosterone: Feminine neural phenotype
- Puberty: Testicular and ovarian hormones act on previously sexually differentiated circuits to facilitate expression of sex-typical behaviors in particular social contexts.

Revised Organizational hypothesis



- Revised Organizational hypothesis: **One protracted sensitive period for the organizing actions of testosterone**

Schulz et al, 2009

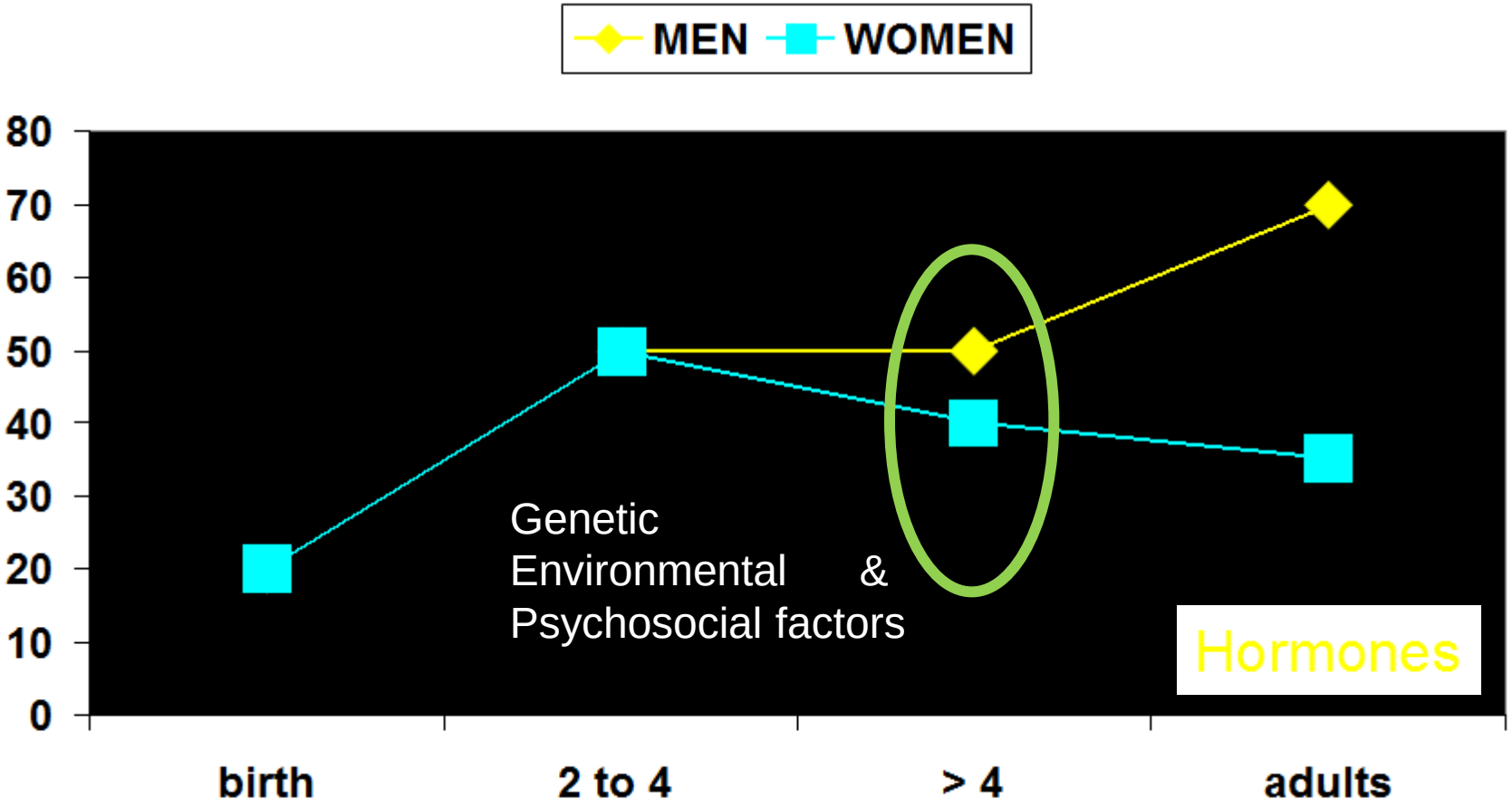
Illustration depicting the overall findings of our study investigating the effects of early, on-time, and late adolescent testosterone treatments on adult mating behavior. Given that early adolescent testosterone treatment was initiated immediately following the period of sexual differentiation (postnatal day 10), our data suggest that adolescence is part of a protracted sensitive period for the organizing actions of testosterone (area under the solid gray curve). In addition, because early adolescent treatments most effectively organized adult mating behavior, we propose that sensitivity to the organizing actions of testosterone decreases across postnatal development. The dashed line approximates testosterone secretions across development, whereas the solid line depicts decreasing sensitivity to the organizing actions of testosterone across development. Shading approximates the timing of perinatal, prepubertal, adolescent periods in the Syrian hamster.

Sex dimorphism of CNS

- Masculinization of behavioral traits
- Organizational effect of prenatal androgen exposure
- Sex dimorphism of the central nervous system

We cannot evaluate the organizational effect of prenatal androgen exposure in humans based on animal studies

Postnatal period of hypothalamic differentiation



Sexual differentiation of SDN Sexually Dimorphic Nucleus

SDN-POA and Testosterone

- Neonatal testosterone influences the size of SDN-POA.

- In order of increasing size:

1. Female control
2. Female and Testosterone
3. Male castrated
4. Male control

Intrauterine androgen exposure and behavior

i) individuals who have genetic disorders that cause abnormalities in the amount or activity of testosterone, beginning prenatally;

(ii) individuals whose mothers were prescribed hormones during pregnancy for medical reasons; and

(iii) individuals with no history of hormone abnormality, but for whom information on prenatal hormone levels is available and can be related to postnatal behaviour.

Intrauterine androgen exposure and behavior

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Causes of hyperandrogenic states in pregnancy

A. Fetal causes

- Congenital adrenal hyperplasia (CAH)

B. Maternal causes

- Ovarian tumors
- Non- tumor ovarian conditions (pregnancy luteoma, hyperreaction luteinalis, PCOS)
- Adrenal tumors (rare)
- Non-tumor adrenal causes (Cushing's syndrome, irregular secretion of CRH in the placenta, non-functional adenomas in the cortex of the adrenal glands containing receptors with aberrant activity for CRH)
- Iatrogenic (preparations containing androgens or progestins)

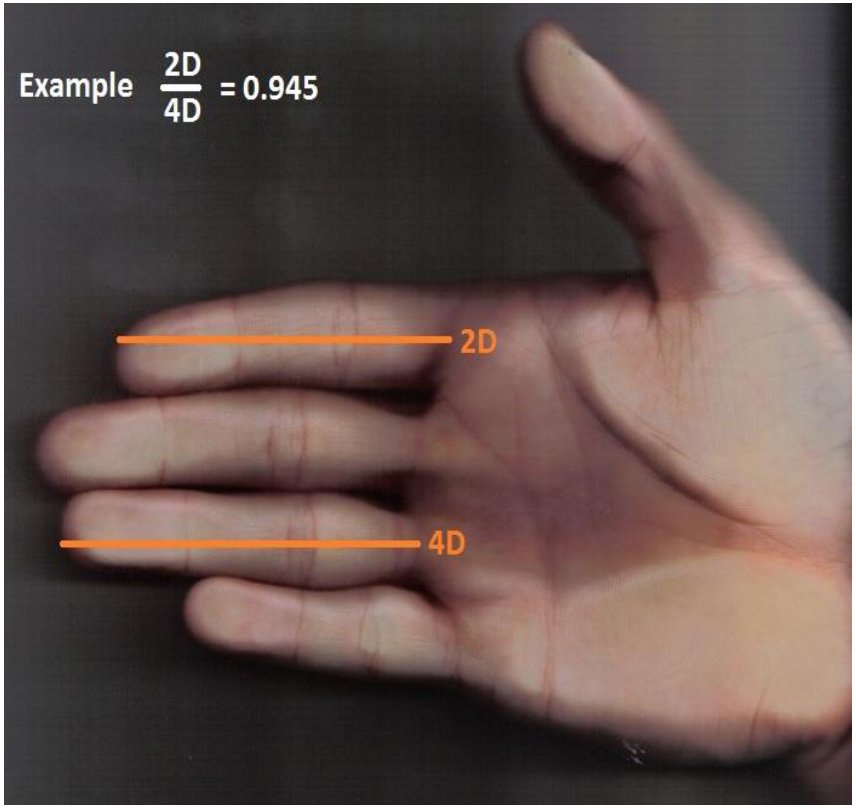
Congenital Adrenal Hyperplasia as a model of prenatal exposure to androgens

Sex differences in human behavior

Behavior/psychological characteristic	Approximate size in standard deviation units (d)
Core gender identity [23,74]	11.0–13.2
Sexual orientation [24,75]	6.0–7.0
Childhood play	
Play with girls' toys [8]	1.8
Play with boys' toys [8]	2.1
Feminine preschool games [76]	1.1
Masculine preschool games [76]	0.7–1.8
Playmate preferences [76]	2.3–5.6
Composite of sex-typed play (PSAI) [77,78]	2.7–3.2
Cognitive and motor abilities (adolescents/adults)	
Targeting [37,38,79–81]	1.1–2.0
Fine motor skill [38,82,83]	0.5–0.6
Mental rotations [84,85]	0.3–0.9
Spatial perception [84,85]	0.3–0.6
Spatial visualization [84,85]	0.0–0.6
SAT mathematics [86]	0.4
Computational skills [86]	0.0
Math concepts [86]	0.0
Verbal fluency [87,88]	0.5
Perceptual speed [89]	0.3–0.7
Vocabulary [90]	0.0
SAT Verbal [90]	0.0
Personality (assessed with questionnaires)	
Tendencies to physical aggression [35,91]	0.4–1.3
Empathy [34,92]	0.3–1.3
Dominance/assertiveness [92]	0.2–0.8

Hines, 2010

2D:4D



- Ratio of the length of the second digit divided by the length of the fourth digit (2D:4D):
- Prenatal androgens?
- Perinatal androgens?
- AMH?
- Sex chromosomes?
- Behavioral?

http://en.wikipedia.org/wiki/Digit_ratio#/media/File:Hand_zur_Abmessung_2D4D.jpg

CAH and 2D:4D-1

- Females with CAH had a significantly smaller 2D:4D on the right hand than did females without CAH.
- Males with CAH had a significantly smaller 2D:4D than did males without CAH. A subset of six males with CAH had a significantly smaller 2D:4D on both hands compared with their male relatives without CAH.
- These results are consistent with the idea that prenatal androgen exposure reduces the 2D:4D and plays a role in the establishment of the sex difference in human finger length patterns.

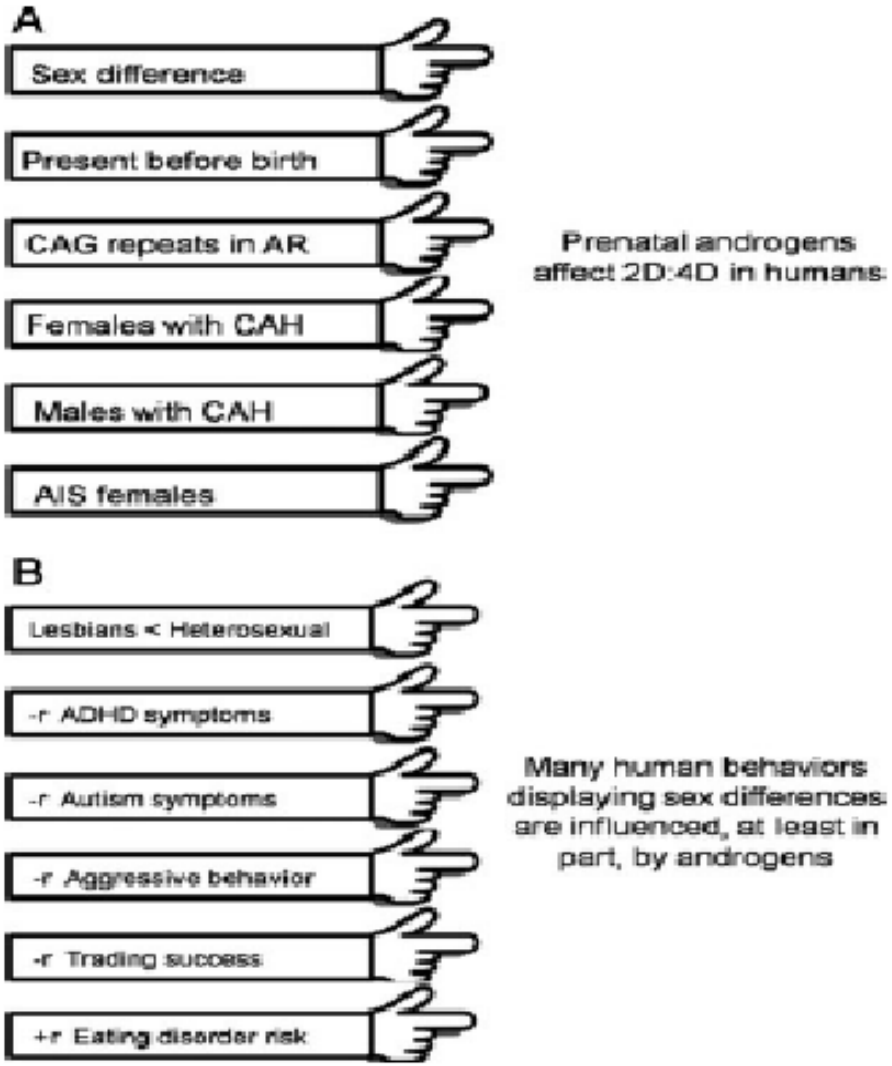
Brown WM, Hines M, Horm Behav 2002

CAH and 2D:4D-2

We found lower 2D/4D ratio in female patients with 21-hydroxylase deficiency compared to healthy girls (p=0.000) and equal 2D/4D ratio for female patients when compared to male controls. Male patients with 21-hydroxylase deficiency had significantly lower 2D/4D ratio than female and male controls in the right hand. Healthy boys had lower 2D/4D ratio than healthy girls.

Okten A, Kalyoncu M, Early Hum Dev 2002

2D:4D and Organizational hypothesis



- Ratio of the length of the second digit divided by the length of the fourth digit (2D:4D): a test of the organizational hypothesis that androgens act early in life to masculinize various human behaviors.
- Fingerpost reflect total androgenic stimulation rather than just prenatal androgen exposure.

Breedlove, 2010

Congenital Adrenal Hyperplasia: a model of prenatal exposure to androgens

- Low rates of child-bearing in CAH?
- Low rates of heterosexual drive in CAH?

- FORMS

1. SIMPLE VIRILIZING (SV)
2. SALT WASTING (SW)

- PREGNANCY

1. 60% for SV
2. 7% for SW

- Among SV + SW with adequate and heterosexual activity

Low “maternalism” in CAH

- Decreased interest in getting married- performing childcare/housewife role.

- “… Jim and I can’t stand children. They’ re cute and everything, but I had never had any maternal feeling like that, like I wanted to have a baby… Most people look at babies and think they’ re cute and they coo over them. I never felt anything. It’ s just a baby. I have cats. Those are my babies…”

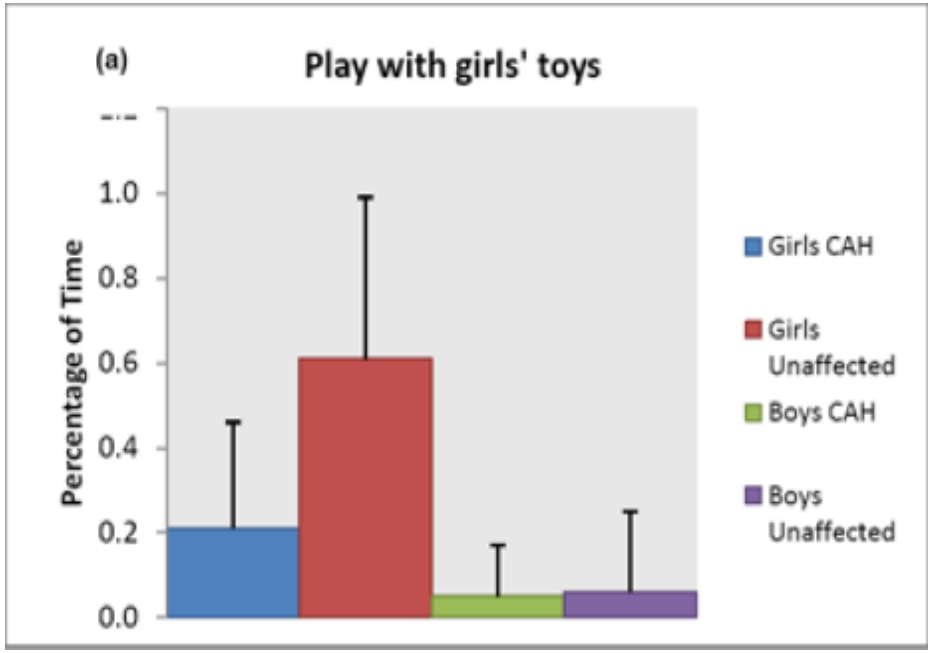
Sexual interest in women with CAH

- Low levels of sexual interest and activity associated with low fertility have been reported in women with CAH.

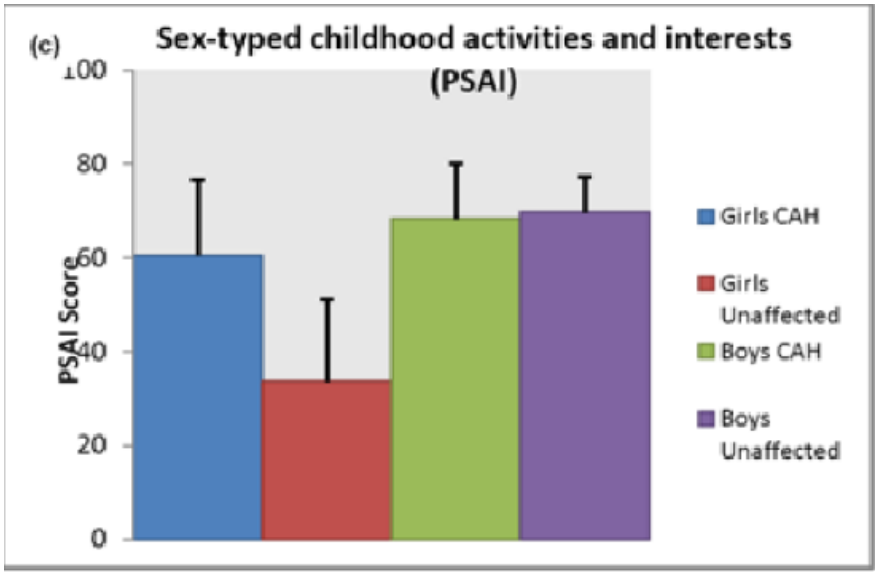
Meyer-Bahlburg, 1999

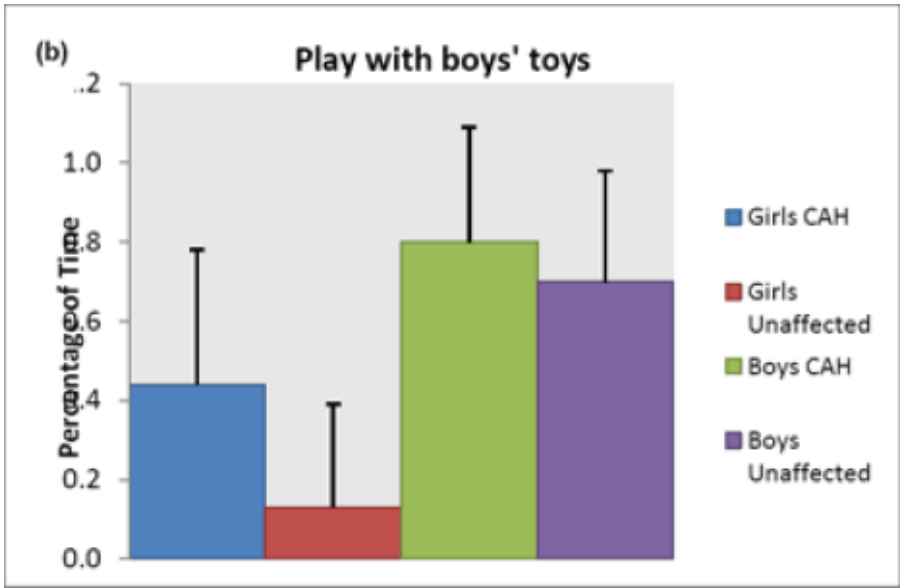
- Possible cause: **Desensitization Hypothesis** (Bancroft, 2003)
- Exposure to high levels of testosterone during fetal and early postnatal life desensitize CNS to testosterone effects in males.
- If males were as sensitive to CNS effect of testosterone as females, then the behavioral masculinizing effects could be maladaptive.
- Physiologically, no such desensitization process occurs in females.

CAH and Toys



Hines M, Trends Cogn Sc 2010





Sexual orientation in women with CAH

TABLE 2. Relationships and sexuality in the 62 women with CAH and the different *CYP21A2* genotype groups compared to controls

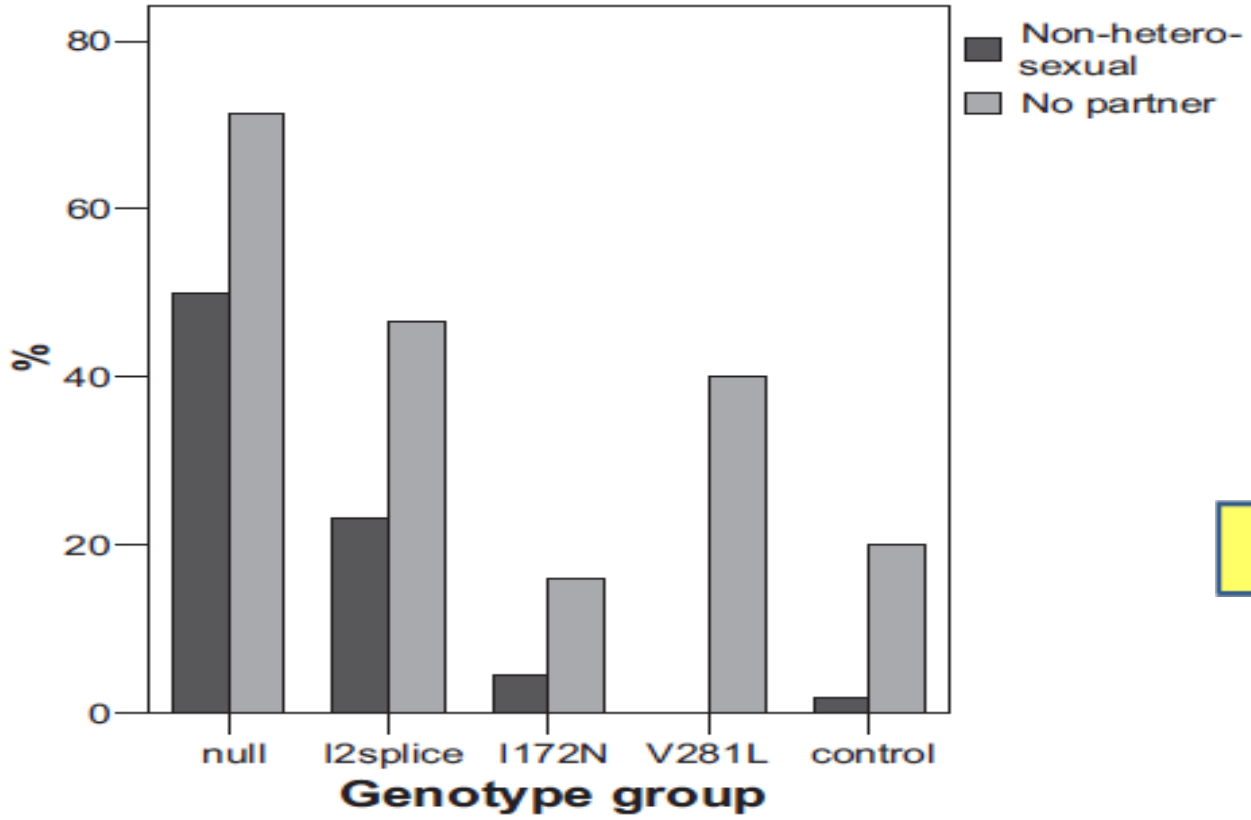
	CAH	Null	I2splice	I172N	Miscellaneous	V281L	Controls
n	62	14	15	25	3	5	62
Relationships							
Partner	38 (61%)	4 (29%)	8 (53%)	21 (84%)		2 (40%)	50 (81%)
P value (patients vs. controls)	0.01	0.0004	0.04	NS (0.7)		NS (0.3)	
Not debuted sexually	8 (13%)	2 (14%)	5 (33%)	1 (4%)		0 (0%)	1 (2%)
P value (patients vs. controls)	0.02	NS (0.09)	0.0008	NS (0.5)		NS	
Sexual orientation							
Heterosexual	43	5	10	21	2	5	56
Bisexual	7	3	2	1	1	0	0
Homosexual	3	2	1	0	0	0	1
Total	53	10	13	22	3	5	57
No answer	9	4	2	3	0	0	5
Bi/homosexual	19%	50%	30%	5%	33%	0	2%
P value (patients vs. controls)	0.005	0.0001	0.02	NS (0.5)	NS (0.1)	NS	

Frisen et al, 2009

Mutations
1. Null,I2splice: salt-wasting (SW)
2. I172N: simple virilizing (SV)
3. V281L: non-classical (NC)

	CAH	controls
Active sexually	52%	71%
Sexual interest	73%	90%

Sexual orientation in women with CAH in correlation with genotype



Frisen et al, 2009

FIG. 2. Women with bi- or homosexual orientation and women with no partner given as percentage for the *CYP21A2* genotype groups and the controls.

CAH: Behavioral effects

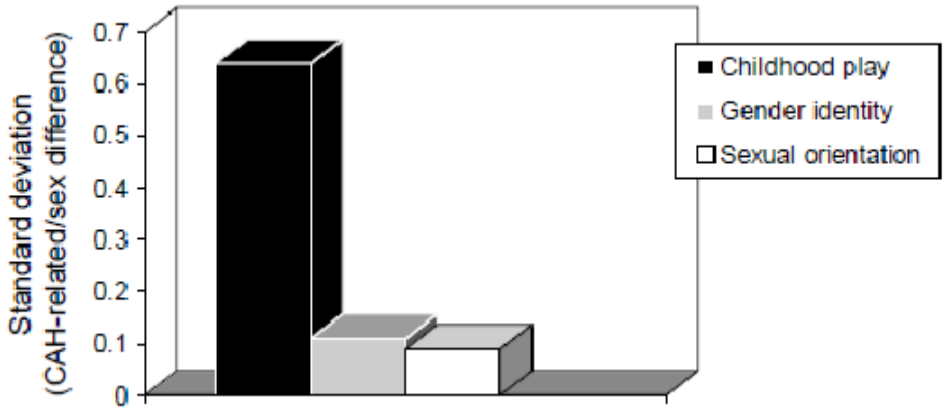


Figure 1 The size of the difference between females with congenital adrenal hyperplasia (CAH) and those without CAH relative to the size of the sex difference in three characteristics: childhood play behaviour (sex-typed toy, activity, temperamental and playmate preferences); sexual orientation (preferences for erotic partners of the same or the other sex); and core gender identity (sense of self as male or female). Group differences (CAH versus control; male versus female) are expressed in standard deviation units.

Hines, 2006

- Testosterone effect of CAH on gender identity is smaller than the effect on sex-typed childhood play behavior and similar to the effect on sexual orientation
- Childhood play behaviour: females with CAH moved about 60% of the distance toward mean male-typical behaviour.
- Sexual orientation: 10%

Occupation and interests in women with CAH in correlation with genotype-1

TABLE 1. Choice of occupation and leisure activities in the 62 women with CAH and the different *CYP21A2* genotype groups compared to controls

	CAH	Null	I2splice	I172N	V281L	Controls
n	62	14	15	25	5	62
Occupation						
Male dominant	13/43	6/11	3/12	2/17	2/3	6/47
P value (patients *vs.* controls)	0.04	0.006[a]	NS (0.3)	NS (0.7)	NS	
Extreme male dominant	6/43	5/11	1/12	0/17	0/3	1/47
P value (patients *vs.* controls)	0.04	0.0005[b]	NS (0.4)	NS	NS	
Females in occupation (%)	50	35	48	61	41	63
P value (patients *vs.* controls)	0.009	0.01	NS (0.1)	NS (0.6)	NS	
Interests						
Sports	47/57	12/13	10/14	20/25	5/5	41/60
P value (patients *vs.* controls)	NS (0.06)	NS (0.07)[c]	NS (0.5)	NS (0.2)	NS	
Rough sports	42/57	12/13	10/14	17/25	3/5	30/60
P value (patients *vs.* controls)	0.007	0.004[d]	NS (0.1)	NS (0.1)	NS	
Motor vehicles	8/57	4/13	3/14	1/25	0/5	0/60
P value (patients *vs.* controls)	0.002	0.000	0.006	NS (0.3)	NS	

Mutations
1. Null,I2splice: salt-wasting (SW)
2. I172N: simple virilizing (SV)
3. V281L: non-classical (NC)

Frisen et al, 2009

Occupation and interests in women with CAH in correlation with genotype-2

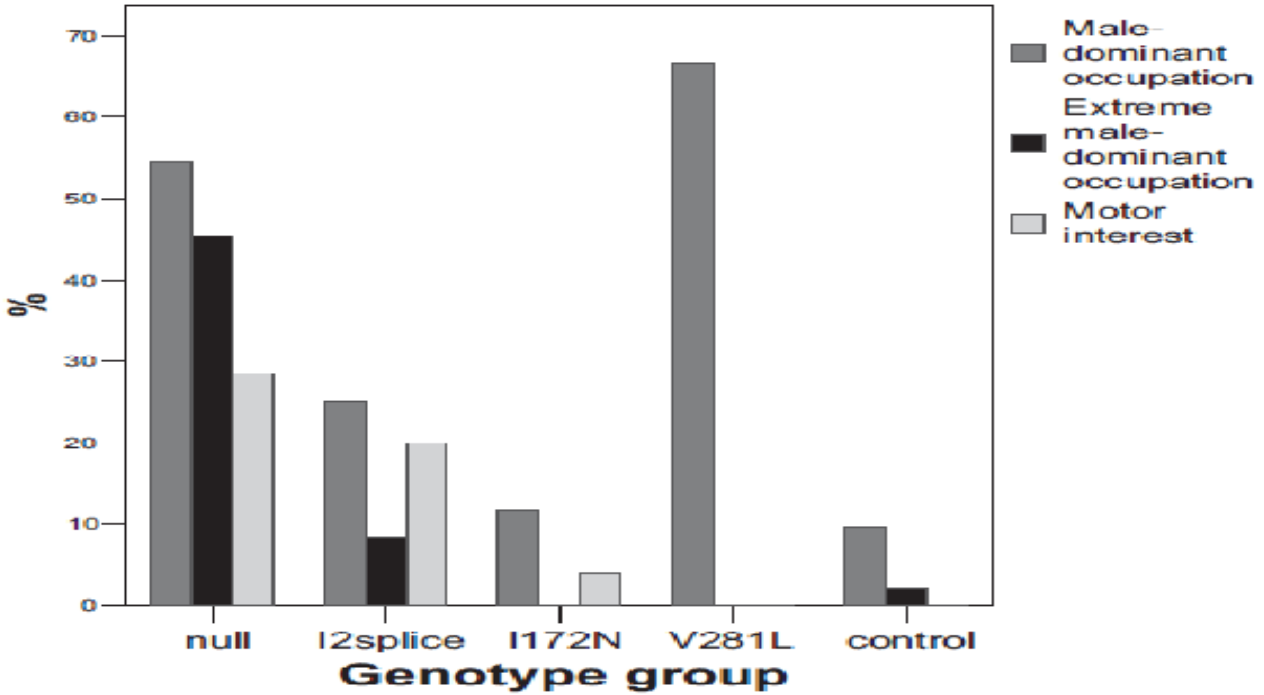


FIG. 1. Male-dominant occupations (≤25% females in occupation), extreme male-dominant occupations (≤11% females in occupation) and motor vehicles as main interest, given as the percentage for the different *CYP21A2* genotype groups and the controls.

Mutations
1. Null,I2splice: salt-wasting (SW)
2. I172N: simple virilizing (SV)
3. V281L: non-classical (NC)

Frisen et al, 2009

Psychosexual outcomes in women with CAH

Table 1. Control Variables and Psychosexual Outcomes in Women and Men With and Without CAH (Means + *SD*)

	Women		Men	
	CAH (n = 16)	Control (n = 15)	CAH (n = 9)	Control (n = 10)
	Control variables			
Age (years)	23.6+6.7	22.7+3.4	28.1+8.4	24.3+7.8
Vocabulary	8.19+1.51	9.07+1.62	9.00+2.45	8.90+2.01
	Psychosexual outcomes			
Recalled childhood gender role behavior [a]	60.5+16.1***	33.6+17.6	68.3+11.8	69.8+7.4***
Core gender identity [b] (past 12 months)	5.44+3.01*	3.93+1.28	3.22+0.67	3.80+1.13
Core gender identity [b] (lifetime)	6.75+4.84*	4.27+1.22	3.44+0.88	4.20+1.14
Sexual orientation [c] (past 12 months)	3.75+2.62*	2.27+0.59	2.44+1.33	2.10+0.32
Sexual orientation [c] (lifetime)	3.69+2.60*	2.33+0.72	2.22+0.67	2.20+0.42

[a] Numbers of participants for recalled childhood gender role behavior = 14 women with CAH, 11 control women, 8 men with CAH, and 8 control men. [b] Scores can range from 3 to 21. Lower scores indicate stronger identification with the assigned gender. [c] Scores can range from 2 to 10. Lower scores indicate stronger heterosexual orientation.

* Differs from mean for control women, $p < .05$. *** $p < .001$.

Hines et al, 2004

Those girls who are most behaviorally masculinized as children are also the most likely to evolve a bisexual or homosexual orientation as adults

Gender identity in women with CAH

TABLE 1. Frequency of male-typical responses to items on the gender identity interview

	CAH girls (n = 43)	Tomboys (n = 7)	Control girls (n = 29)	Significant group differences
1. Prefers short hair	10 (23%)	3 (43%)	6 (21%)	
2. Does not like dresses	25 (58%)	3 (43%)	10 (35%)	cah/ctl[a]
3. Better to be boy	2 (5%)	2 (29%)	0 (0%)	cah/tb[a], tb/ctl[b]
4. Not happy as girl	4 (9%)	3 (43%)	0 (0%)	cah/tb[a], tb/ctl[c]
5. Wishes to be boy	12 (28%)	3 (43%)	5 (17%)	
6. Try boy for a while	23 (54%)	5 (71%)	11 (38%)	
7. Boy forever	1 (2%)	3 (43%)	0 (0%)	cah/tb[c], tb/ctl[c]
8. Rather be father	2 (5%)	3 (43%)	0 (0%)	cah/tb[c], tb/ctl[c]
9. Pretends male	9 (21%)	5 (71%)	2 (7%)	cah/tb[b], cah/ctl[b], tb/ctl[c]

cah, Girls with CAH; tb, tomboys; ctl, control girls.
Group differences on items scored 0, 1, or 2 tested by χ^2, [a] $P < 0.10$; [b] $P < 0.05$; [c] $P < 0.01$.

Berenbaum et al, 2003

Gender dysphoria and gender change in females with CAH

- Patients raised as females: 94.8% later developed a gender identity as girls and did not feel gender dysphoric.
- 5.2% of those girls, expressed gender identity dysphoria.

- Among patients raised as males, 12.1% of those expressed gender identity problems.

5a reductase deficiency as a model of prenatal exposure to androgens

Prenatal Hormones and Sexual Orientation

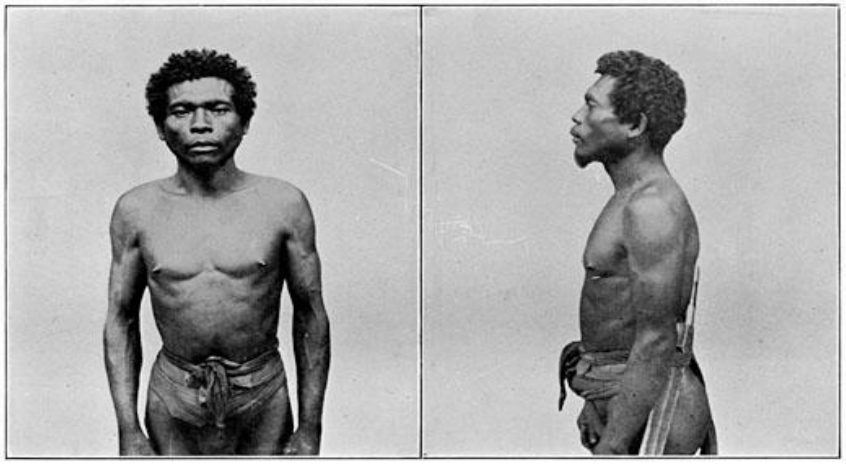
- 5-α Reductase deficiency
- Clinical presentation
- 46 XY neonate with
- Female phenotype
- Ambiguous genitalia
- Blind vagina

5a reductase deficiency- Ambiguous genitalia

- Bifid scrotum
- Urogenital sinus
- Small phallus

Ανεπάρκεια 5α αναγωγάσης

http://landmark.lambeth.gov.uk/journeys_in_time.asp#9



http://pixshark.com/aeta-people-drawing.htm

- Virilization at puberty
- Gender change
- Raised as girls: 18/38
- 17/18: changed to a male-gender role

Androgen Insensitivity Syndrome (AIS) as a model of prenatal exposure to androgens

Androgen role in male gender identity

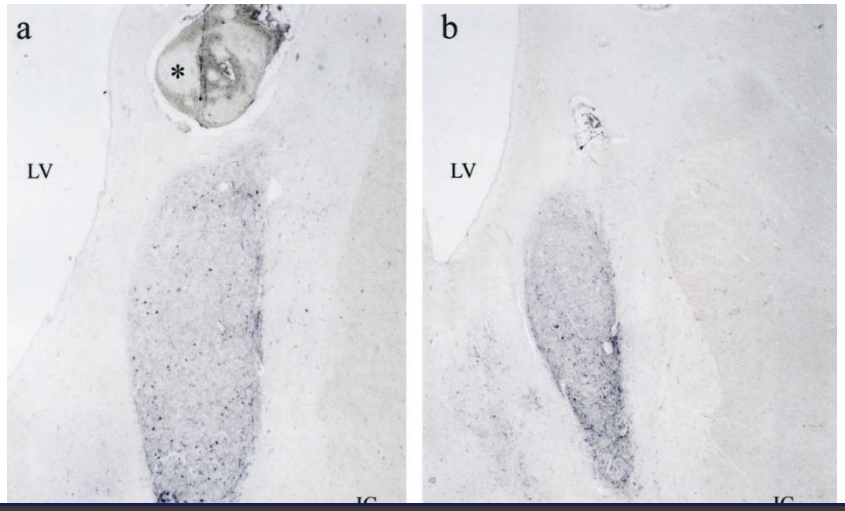
- Gender: Gender identity (self estimation)
  Gender role (objective estimation)
  Sexual orientation (hetero- or homosexual)
- Female gender identity: presence of ovaries or lack of gonads (gonadal dysgenesis)
- Male gender identity: testicular issue irrespective of female or hermaphrodite (intersex) phenotype.
- Complete androgen insensitivity syndrome: Female gender identity
- Partial androgen insensitivity syndrome:
- Female or male gender identity.

Kula et al, 2000

Ταυτότητα φύλου και ΚΝΣ

BSTc in transsexuals

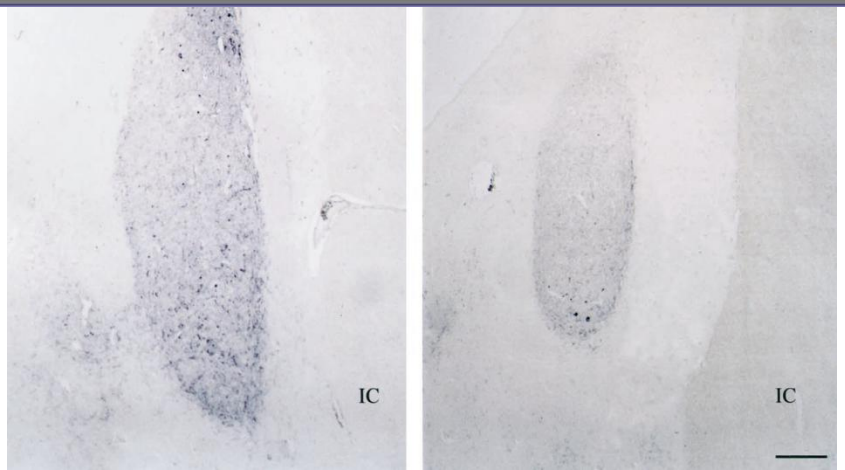
Het MAN



Het FEMALE

Male to female transsexuals have female SOM neuron numbers in BSTc

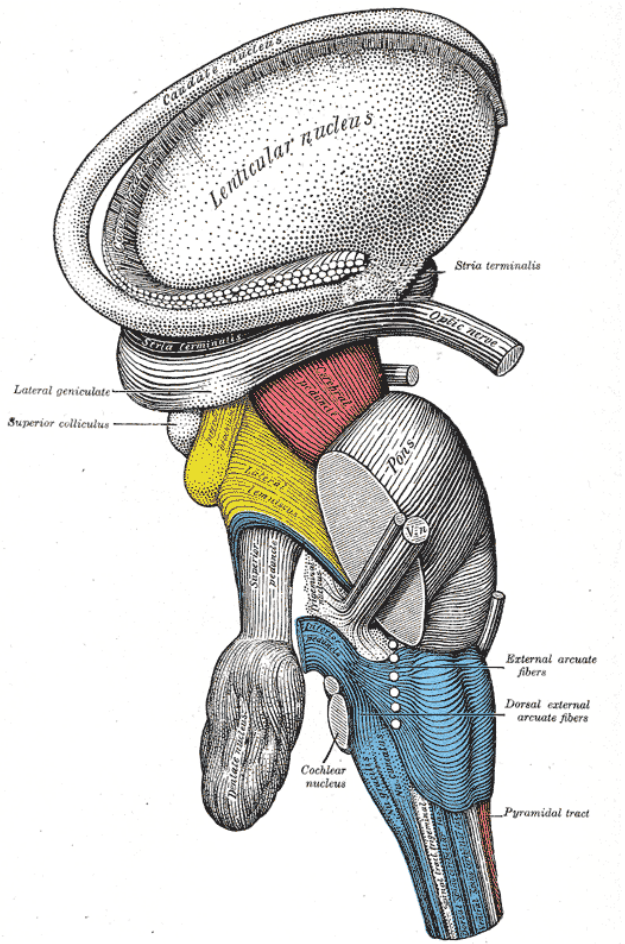
Hom MAN



M to F TRANS

Kruijver JCEM 2000

BST in MTF transsexuals



- **BST Bed nucleus of the Stria Terminalis**
- Males : increased size and number of neurons
- Male to Female transsexuals have

1. female size and
2. number of neurons

http://en.wikipedia.org/wiki/Stria_terminalis#/media/File:Gray683.png

Sex atypical cerebral asymmetry and functional connections in Transsexuals?

Linked to neurobiological entities

Neuroimaging Differences in Spatial Cognition between Men and Male-to-Female Transsexuals Before and During Hormone Therapy

Sonja Schöning, PhD,*† Almut Engelien, MD,*†‡ Christine Bauer,*† Harald Kugel, PhD,§

Transsexuals and hormone therapy

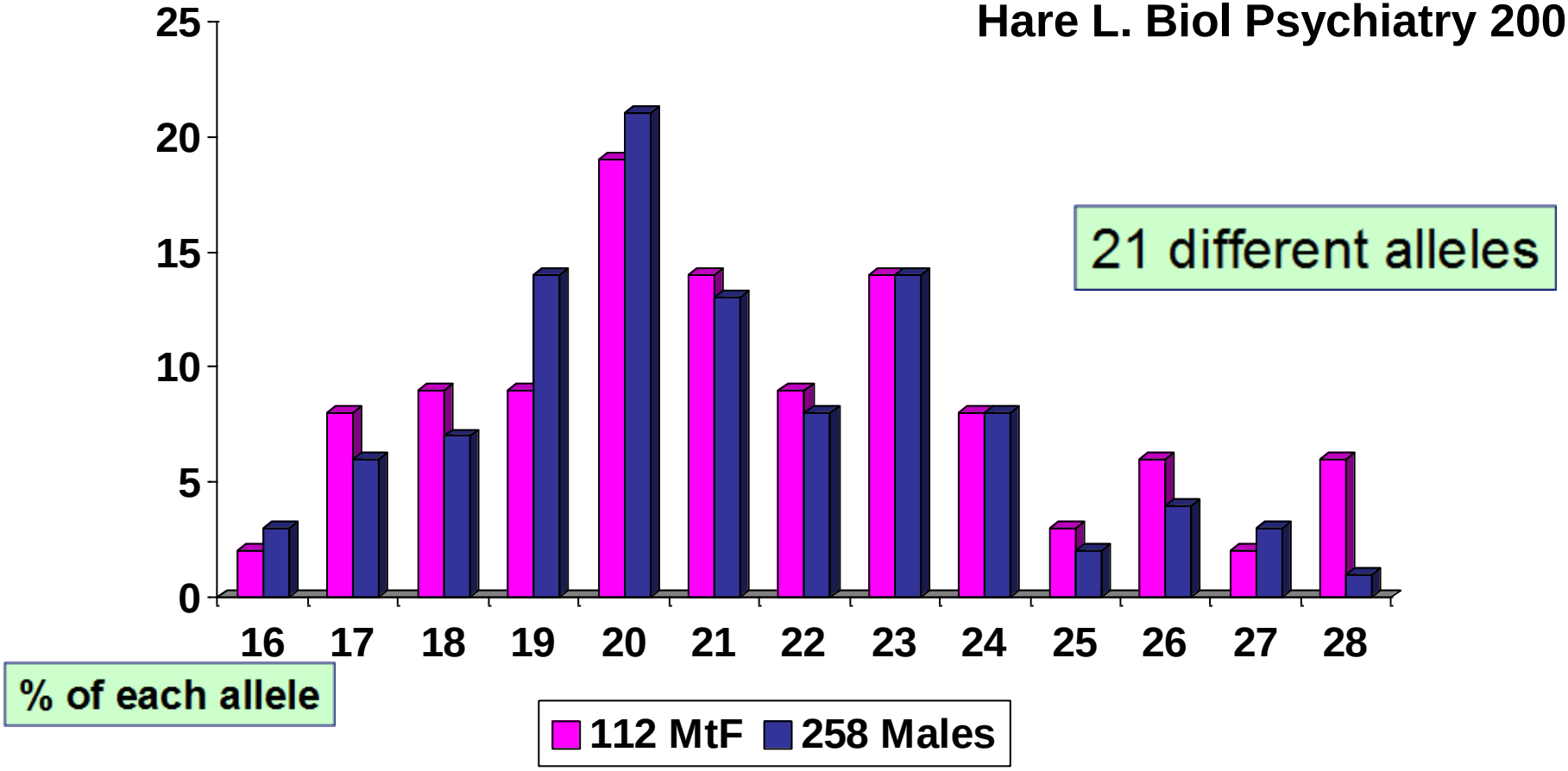
- Trans show cortical activation patterns for a mental rotation distinct from their biological sex

- **a priori Neuroimaging differences**
- in spatial cognition between MEN and M to F trans caused by different Neurobiological processes,
- which remain stable over hormonal therapy

Androgen Receptor repeat length polymorphism and MTF

MTF trans have significantly longer mean repeat lengths

Hare L. Biol Psychiatry 2009



Σεξουαλικότητα και ΚΝΣ

Science and consensus

Michael Crichton (2003): “…the work of science has nothing whatever to do with consensus.

Consensus is the business of politics.

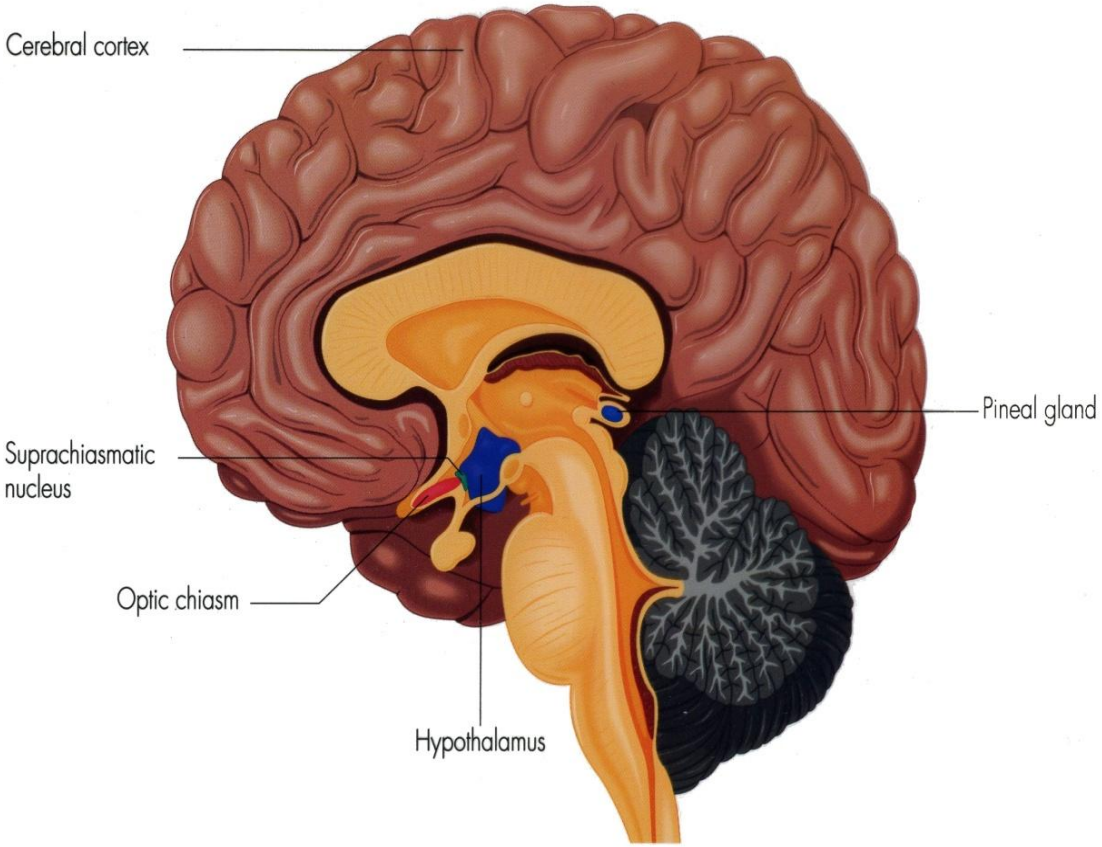
Science, on the contrary, requires only one investigator who happens to be right, which means that he or she has results that are verifiable by reference to the real world. In science consensus is irrelevant. What is relevant are reproducible results. The greatest scientists in history are great precisely because they broke with the consensus . . . There is no such thing as consensus science. If it’s consensus, it isn’t science. If it’s science, it isn’t consensus…

Consensus is invoked only in situations where the science is not solid enough”.

Σεξουαλικός προσανατολισμός

- Προγεννητικοί παράγοντες πιθανώς επηρεάζουν τον σεξουαλικό προσανατολισμό.
- Swaab, Best Practice&Research Clinical Endocrinology & Metabolism,2007
- Γενετικοί
- Χημικοί
- Κοινωνικοί
- Ορμόνες
- Ανατομικοί
- Ανοσολογικοί
- Παιδιά από οικογένειες transsexual ή ομοφυλοφίλων δεν εμφανίζουν διαταραχή σεξουαλικού προσανατολισμού

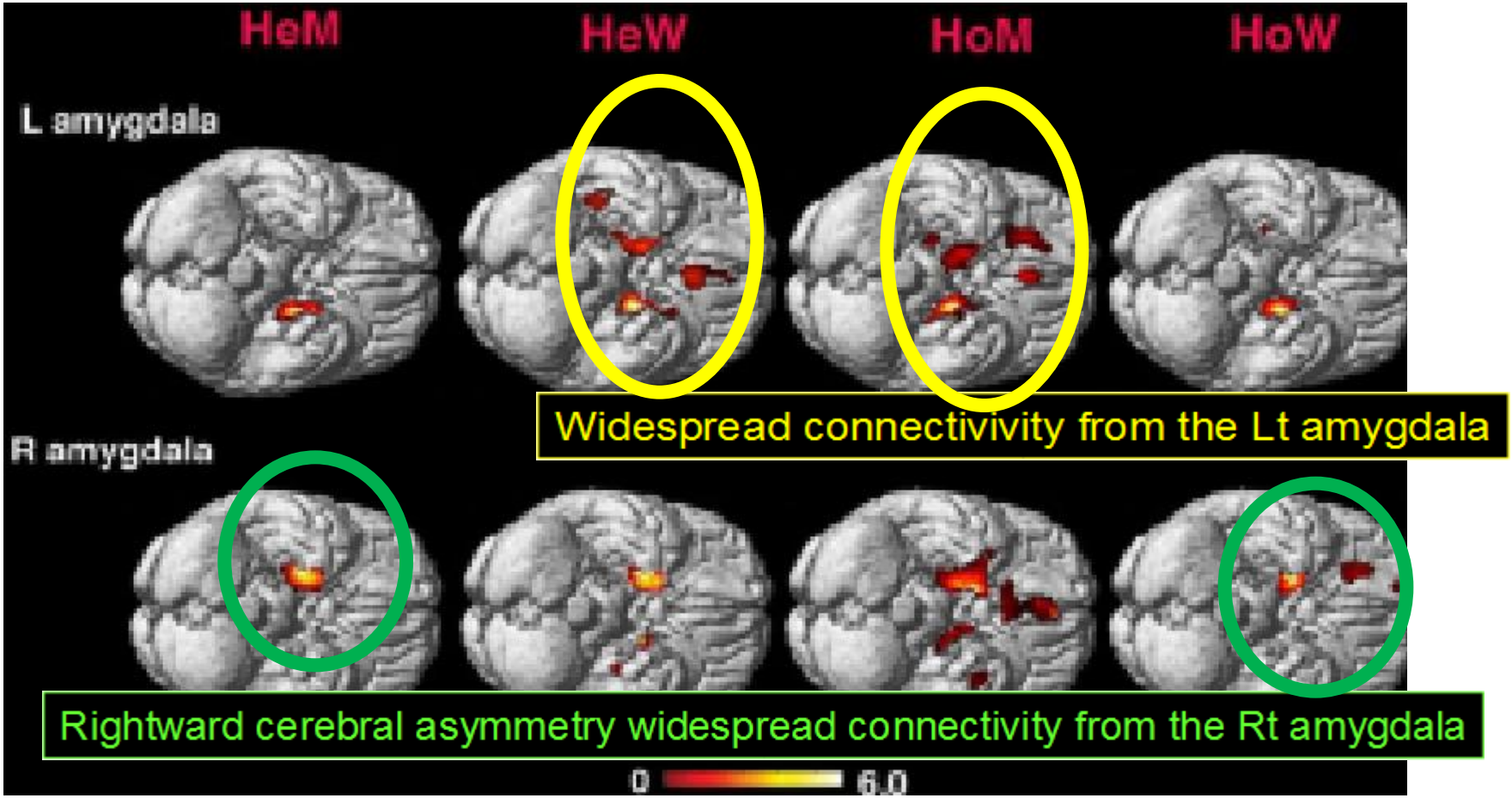
Suprachiasmatic nucleus



- **SCN**
- Males : Spherical vs Elongated in Females
- Homo- twice as many cells vs Hetero- sexual men

http://upload.wikimedia.org/wikipedia/commons/8/80/Suprachiasmatic_Nucleus.jpg

Neuroimaging and sexual orientation



- PET and MRI show differences in cerebral asymmetry and functional connectivity between homo and heterosexual subjects
- Savic I. PNAS, 2008

INAH-3

- Interstitial Nuclei of Anterior Hypothalamus
- Le Vay, Science,1991
- larger in Het men VS Women and Hom men
- ? a small INAH3 cause homosexuality
- ? homosexuality reduce the size of INAH3
- ? unknown 'third factor' responsible for homosexuality and reduced INAH3 volume

Sexual dimorphism and orientation

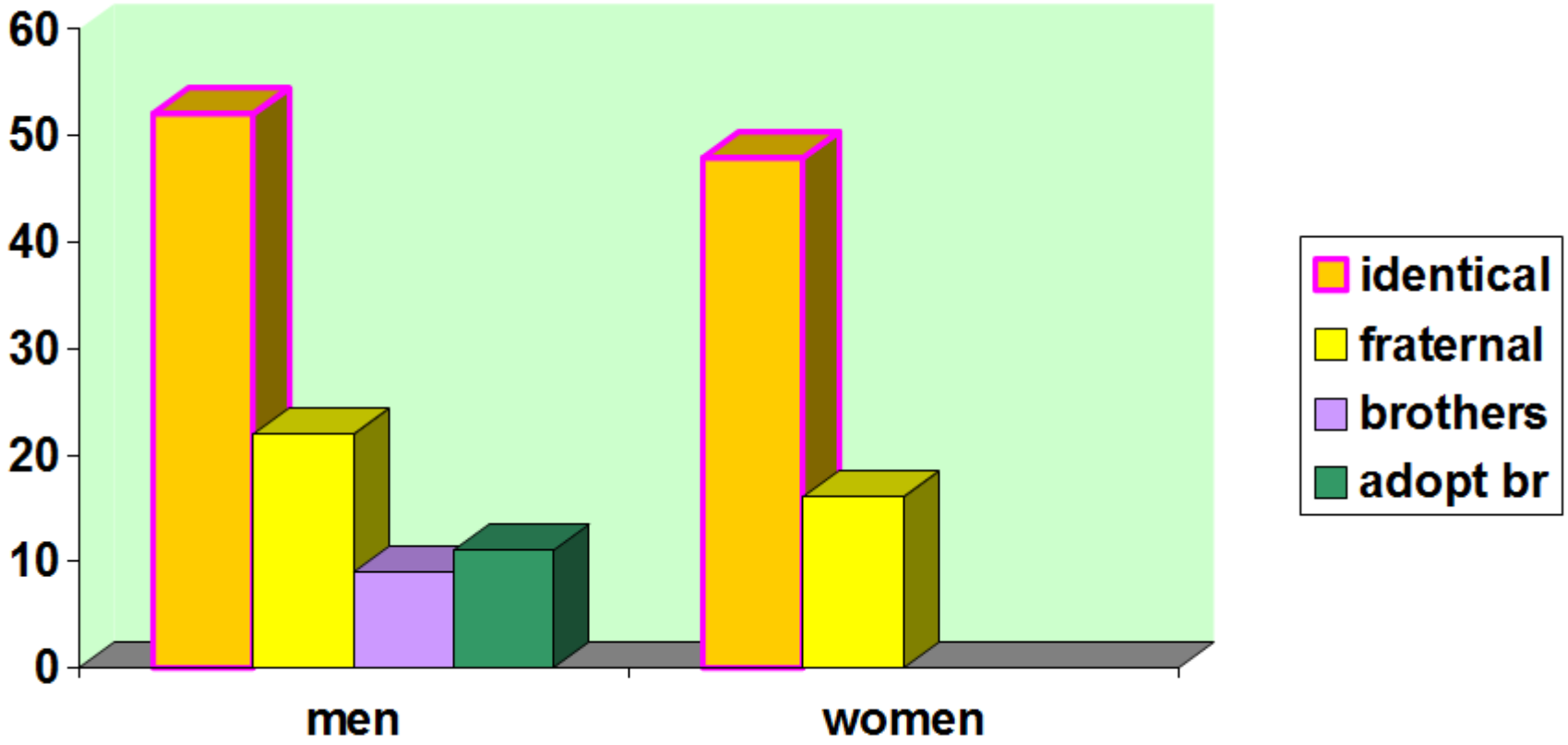
- ? Certain sexually dimorphic features in the brain may differ between individuals of the same sex but different sexual orientation.

- PET and MRI : Sexual dimorphism with respect to hemispheric asymmetry and the functional connections from the RT and LT amygdala

- MRI volumetry of cerebral hemispheres

- PET measurement of cerebral blood flow for analysis of functional connections from the RT to the LT amygdala.

Genetic basis of sexual orientation



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- Essentials of Endocrinology. PG Malan and RP Gould. Edited by JLH O'Riordan. Second edition.
- Functional Endocrine Pathology. Editors Kalman Kovacs, Sylvia L.Asa. Blackwell Scientific Publications.
- Clinical Endocrinology. Editor Ashley Grossman. Foreword by Michael Besser. Blackwell Scientific Publications.
- Endocrinology and Metabolism. Philip Felig, John D. Baxter, Lawrence A. Frohman. Third Edition.
- Molecular Endocrinology. Franklyn F. Bolander. Third Edition. Elsevier.

Σημείωμα Αναφοράς

Χρηματοδότηση

- Το παρόν εκπαιδευτικό υλικό έχει αναπτυχθεί στο πλαίσιο του εκπαιδευτικού έργου του διδάσκοντα.
- Το έργο «**Ανοικτά Ακαδημαϊκά Μαθήματα στο Πανεπιστήμιο Αθηνών**» έχει χρηματοδοτήσει μόνο την αναδιαμόρφωση του εκπαιδευτικού υλικού.
- Το έργο υλοποιείται στο πλαίσιο του Επιχειρησιακού Προγράμματος «Εκπαίδευση και Δια Βίου Μάθηση» και συγχρηματοδοτείται από την Ευρωπαϊκή Ένωση (Ευρωπαϊκό Κοινωνικό Ταμείο) και από εθνικούς πόρους.

Σημείωμα Αδειοδότησης

Διατήρηση Σημειωμάτων

Οποιαδήποτε αναπαραγωγή ή διασκευή του υλικού θα πρέπει να συμπεριλαμβάνει:

- το Σημείωμα Αναφοράς
- το Σημείωμα Αδειοδότησης
- τη δήλωση Διατήρησης Σημειωμάτων
- το Σημείωμα Χρήσης Έργων Τρίτων (εφόσον υπάρχει)

μαζί με τους συνοδευόμενους υπερσυνδέσμους.