REBRODUCTIVE BLOCK

Physiology Team

LECTURE 5

PUBERTY

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Believe you can & you're halfway there !
Theodore Roosevelt

OBJECTIVES

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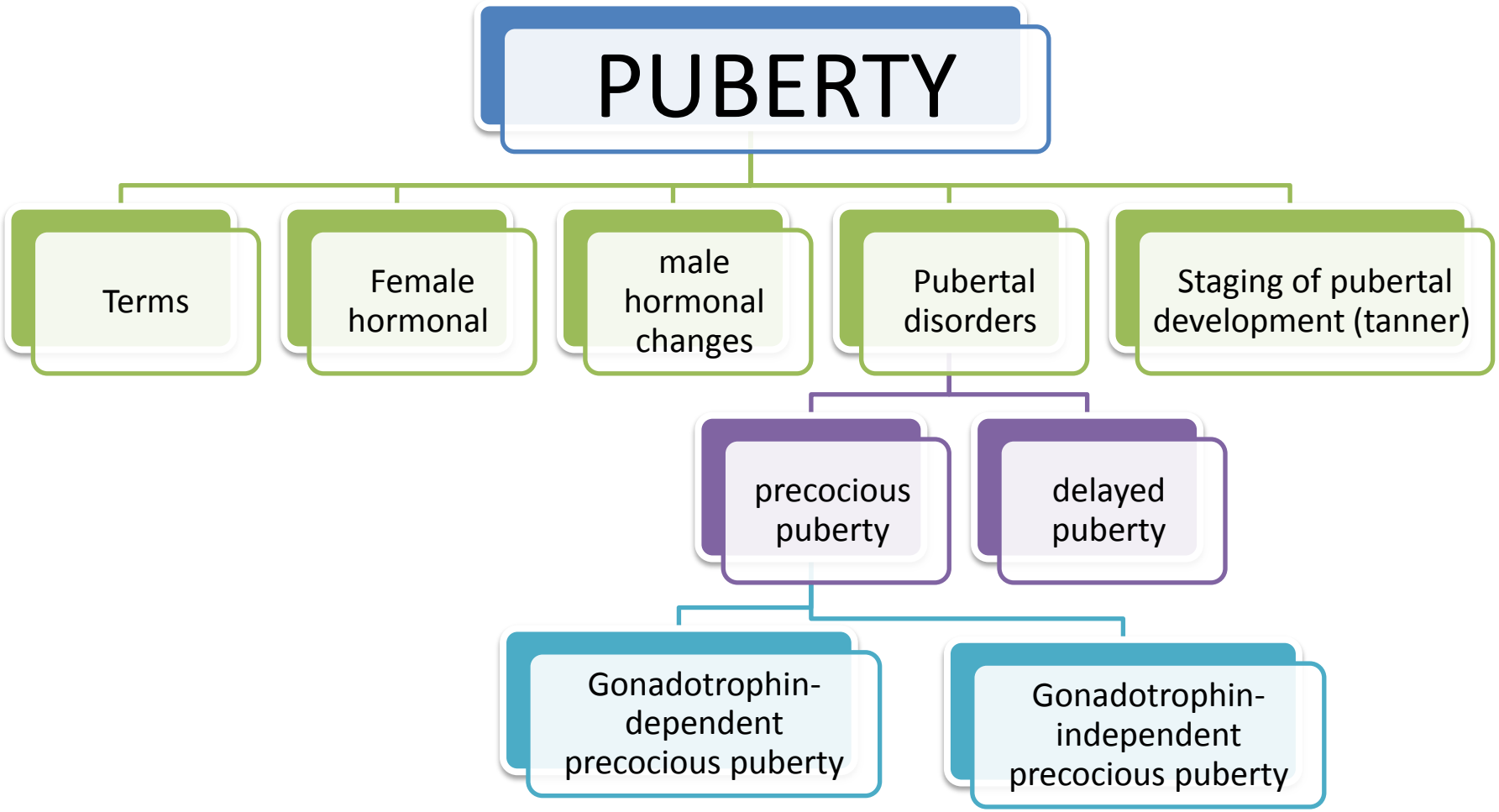
1. **Definition** of puberty.
2. **Terms** and **events** (thelarche, pubarche, menarche).
3. Hormonal **changes** (gonadal and extra gonadl).
4. **Female hormonal changes** and male hormonal changes and secondary sexual characters.
5. Staging of **pubertal development** (tanner) in boys and girls.
6. **Pubertal disorders** (precocious puberty and delayed puberty).


PUBERTY
Terms
Female hormonal
male hormonal changes
Pubertal disorders
Staging of pubertal development (tanner)
precocious puberty
delayed puberty
Gonadotrophin-dependent precocious puberty
Gonadotrophin-independent precocious puberty

Puberty

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A stage of human development when sexual maturation and growth are completed and result in ability to reproduce.

- Accelerated somatic growth:
  1. Maturation of *primary sexual characteristics* (gonads and genitals)
  2. Appearance of *secondary sexual characteristics* (pubic and axillary hair, female breast development, male voice changes,...)
  3. *Menstruation and spermatogenesis* begin:
     - Occurs between 8 and 14 years in girls
     - Occurs between 9 and 14 years in boys.

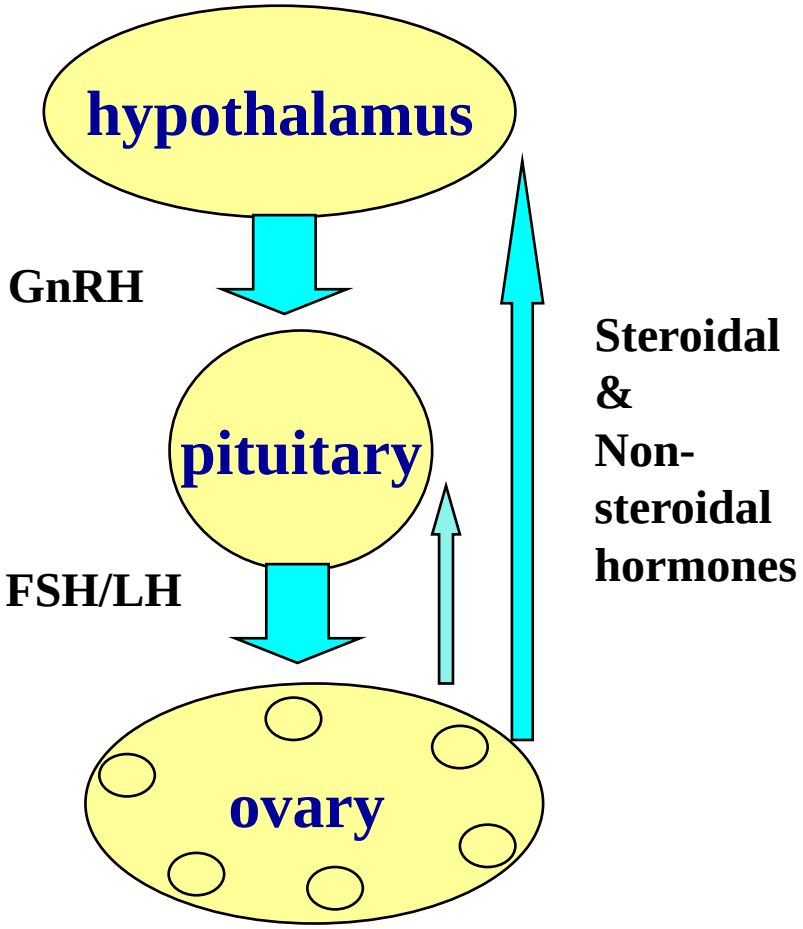
Puberty – Terms & Events

- Thelarche: development of breast.
- Puberache: development of axillary & pubic hair.
- Menarche: the first menstrual period
- Adrenarche: the onset of an increase in the secretion of androgens, responsible for development of pubic and axillary hair, body odour and acne.

Puberty – hormonal changes:

- Hormonal changes procede physical changes
- *Increased stimulation of hypothalamo-pituitary-gonadal axis:*
  1- gradual activation of the GnRH (LHRH)
  2- increases frequency and amplitude of LH pulses.
  3- gonadotropins stimulate secretion of sexual steroids (estrogenes and androgenes)
  4- extragonadal hormonal changes (elevation of IGF-I (from the liver), and adrenal steroids).

- Nocturnal GnRH pulsatility (LH secretion) precedes phenotypic changes by several years.
- First phenotypic changes:
  breast development / testicular enlargement.



Puberty – hormonal changes:

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in young children, LH and FSH levels insufficient to initiate gonadal function
between 9-12 yrs., blood levels of LH, FSH increase.
Hormonal changes precede physical changes.
amplitude of pulses increases, especially during sleep
high levels of LH, FSH initiate gonadal development.

GH secretion from pituitary also increases

TSH (thyroid stimulating hormone) secretion from pituitary increases in both sexes:

- increases metabolic rate
- promotes tissue growth

Puberty - Physical Changes:

Marshall and Tanner (P1 – P5):

- Reflect progression in changes of the external genitalia and of sexual hair

Secondary sexual characteristics:

1. Mean age 10.5yrs in **girls**
2. Mean age 11.5 – 12yrs in **boys**

Puberty – Female hormonal changes

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→ surge of LH release initiates 1st ovarian cycle but usually not sufficient to cause ovulation during 1st cycle.

- brain and endocrine systems mature soon thereafter
- estrogen levels in blood increase, due to growing follicles.

→ estrogen induces secondary sex characteristics:

- growth of pelvis
- deposit of subcutaneous fat
- growth of internal reproductive organs, external genitalia

→ androgen release by adrenal glands increases (not as much as in male) growth of pubic hair, lowering of voice, growth of bone, increased secretion from sebaceous glands.

Staging of pubertal development (Tanner)

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Pubertal development is classified according to the Tanner standard – 5 different stages

Girls: *breast (B_{1-5}), pubic hair (Pu_{1-5}), axillary hair (A_{1-5}), menarche*
Boys: *testicular volume > 4 ml (Te), penis enlargement (G_{1-5}), pubic hair (Pu_{1-5}), axillary hair (A_{1-5}), spermarche*

Monitoring of the pubertal growth acceleration

- growth velocity is 2-3 times greater than prepubertal
- sexual dimorfism in pubertal growth.

Puberty: Girls

1. Breast enlargement usually first sign → "Thelarche".
2. Menarche usually 2-3 years after breast development
3. Growth spurt peaks before menarche
4. Pubic and axillary hair growth: sign of adrenal androgen secretion
5. Starts at similar stage of apocrine gland sweat production and associated with adult body odour.

Puberty – Male hormonal changes

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- LH and FSH release increases ~ 10 years of age
- spermatogenesis; androgen secretion
- Adrenal gland also secrete androgens
- androgens initiate growth of sex accessory structures (e.g. prostate), male secondary sex characteristics (facial hair, growth of larynx)

→ androgens causes retention of minerals in body to support bone and muscle growth
→ Sertoli cells also secrete some estrogen (estrogen is important in spermatogenesis)

Puberty: Boys

- First signs often go unnoticed
- Testicular enlargement (12-13 years)
- Prepubertal testis – 2mls diameter
- Puberty begins when volume reaches 4mls
- Penile and scrotal enlargement occur approx 1 year after testicular enlargement + Pubic hair appears at same time
- Begins of spermatogenesis; depends on androgen secretion

Pubertal Stages (Tanner)

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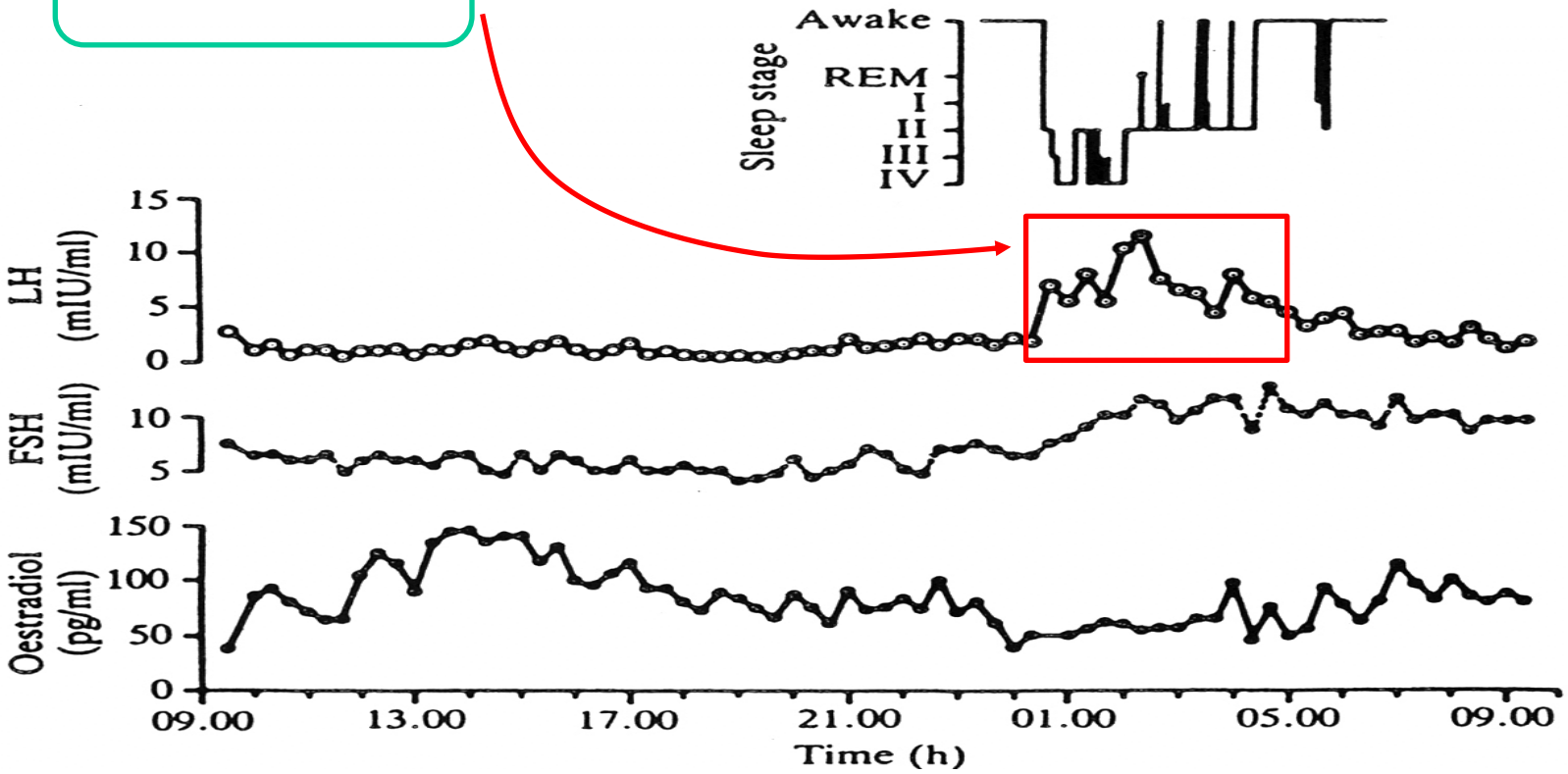
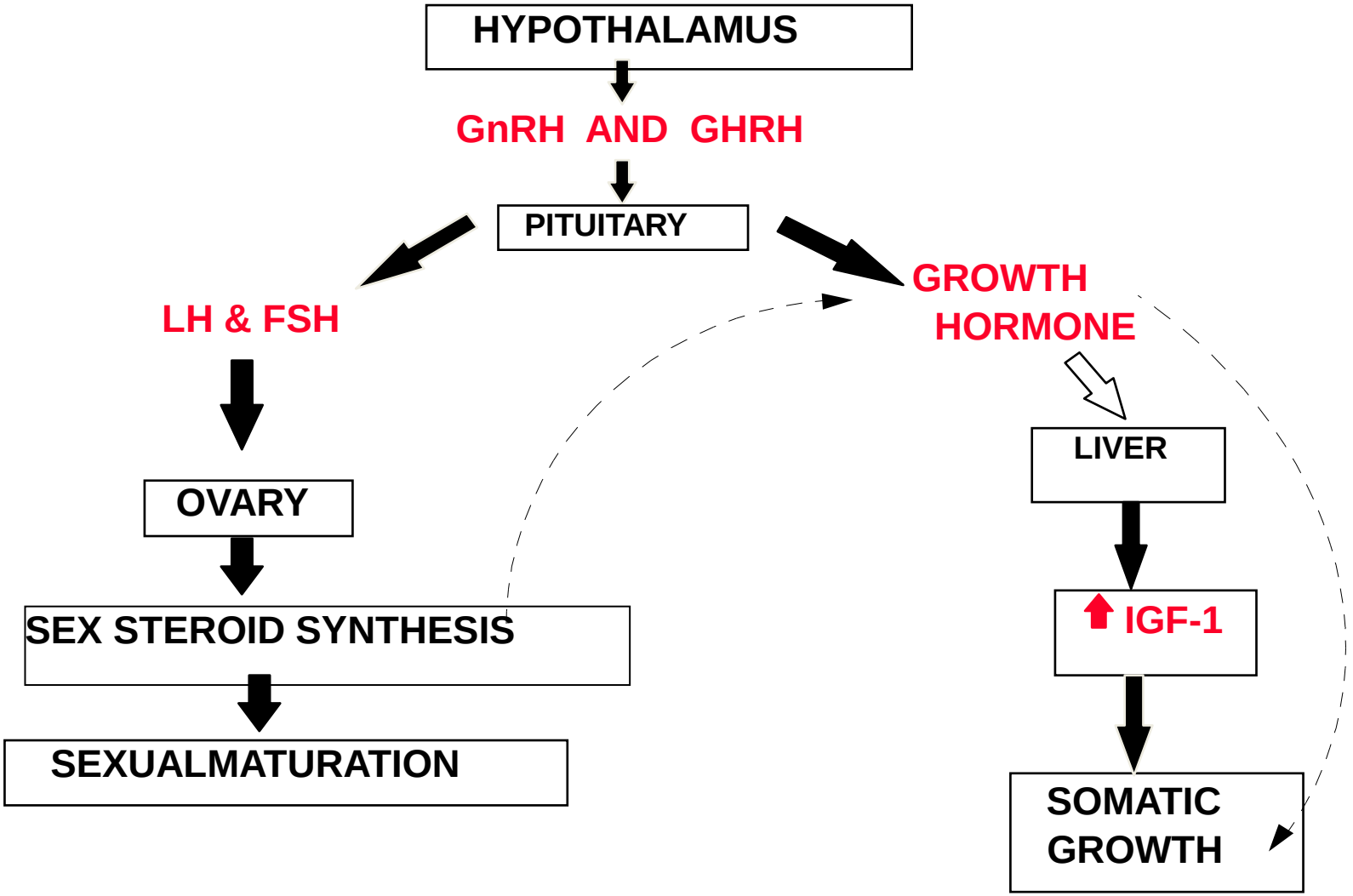
Pubertal Stages	Female	Male
P1	Prepubertal	Prepubertal, testicular volume < 2mls
P2	Early development of subareolar breast bud +/- small amounts of pubic and axillary hair	Enlargement of scrotum and penis. Scrotum slightly pigmented. Few pubic hairs
P3	Increase in size of palpable breast tissue and areolae, increased pubic/axillary hair	Lengthening of penis. Further growth of testes and scrotum. Pubic hair darker
P4	Breast tissue and areolae protrude above breast level, Further increased pubic/axillary hair growth	Penis increases in length and thickness. Increased pigmentation of scrotum. Increased pubic/ axillary hair
P5	Mature adult breast. Complete pubic/axillary hair growth	Genitalia adult in size and shape. Completed pubic/axillary hair growth

Sleep dependent nocturnal rise in LH

Pulsatile release of LH at 1 am during sleep



hormonal changes



Timing of Puberty

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- Puberty usually completed within 3 - 4 years of onset
- trend toward earlier puberty exists within Western Europe and USA
- examination of lifestyle changes may give clues regarding mechanisms inducing onset

Influencing Factors :

1. Genetics: 50-80% of variation in pubertal timing
2. Environmental factors e.g. nutritional status
3. Leptin hormone → regulates appetite and metabolism through hypothalamus permissive role in regulating the timing of puberty

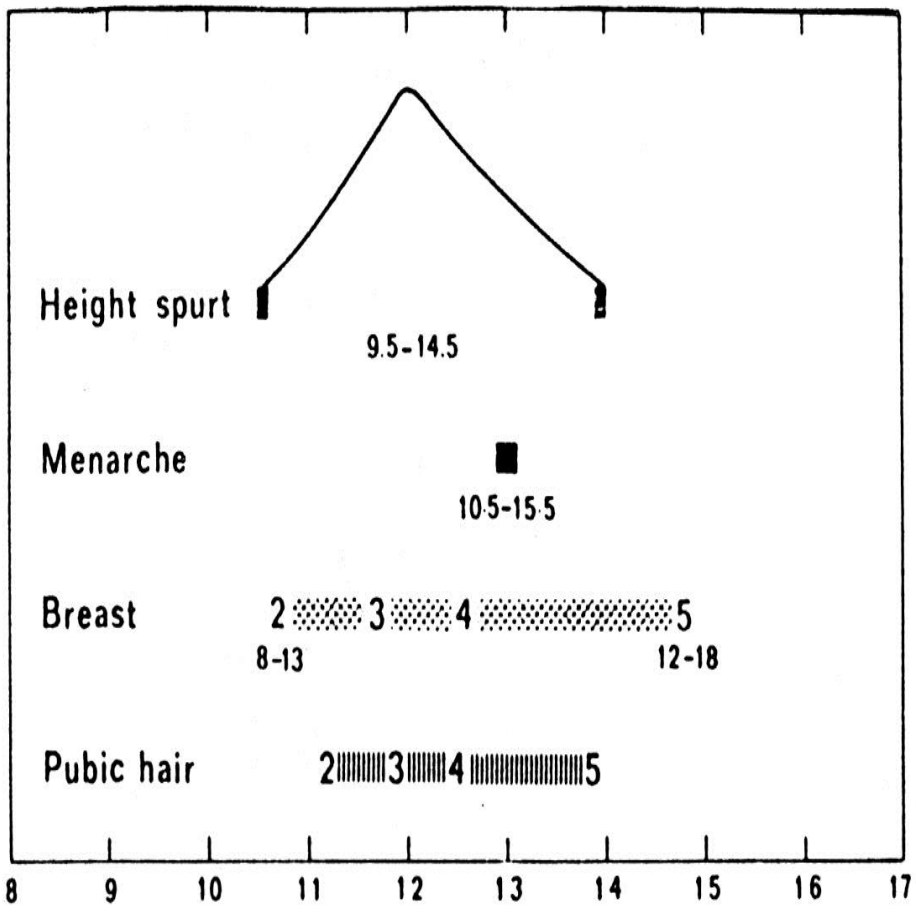
Nutrition:

- Critical body weight must be attained before activation of the reproductive system.
- even though age of menarche is decreasing, the average body weight of menarche remains the same.
- earlier puberty due to improvement of nutrition, living conditions, healthcare.

evidence supporting hypothesis:

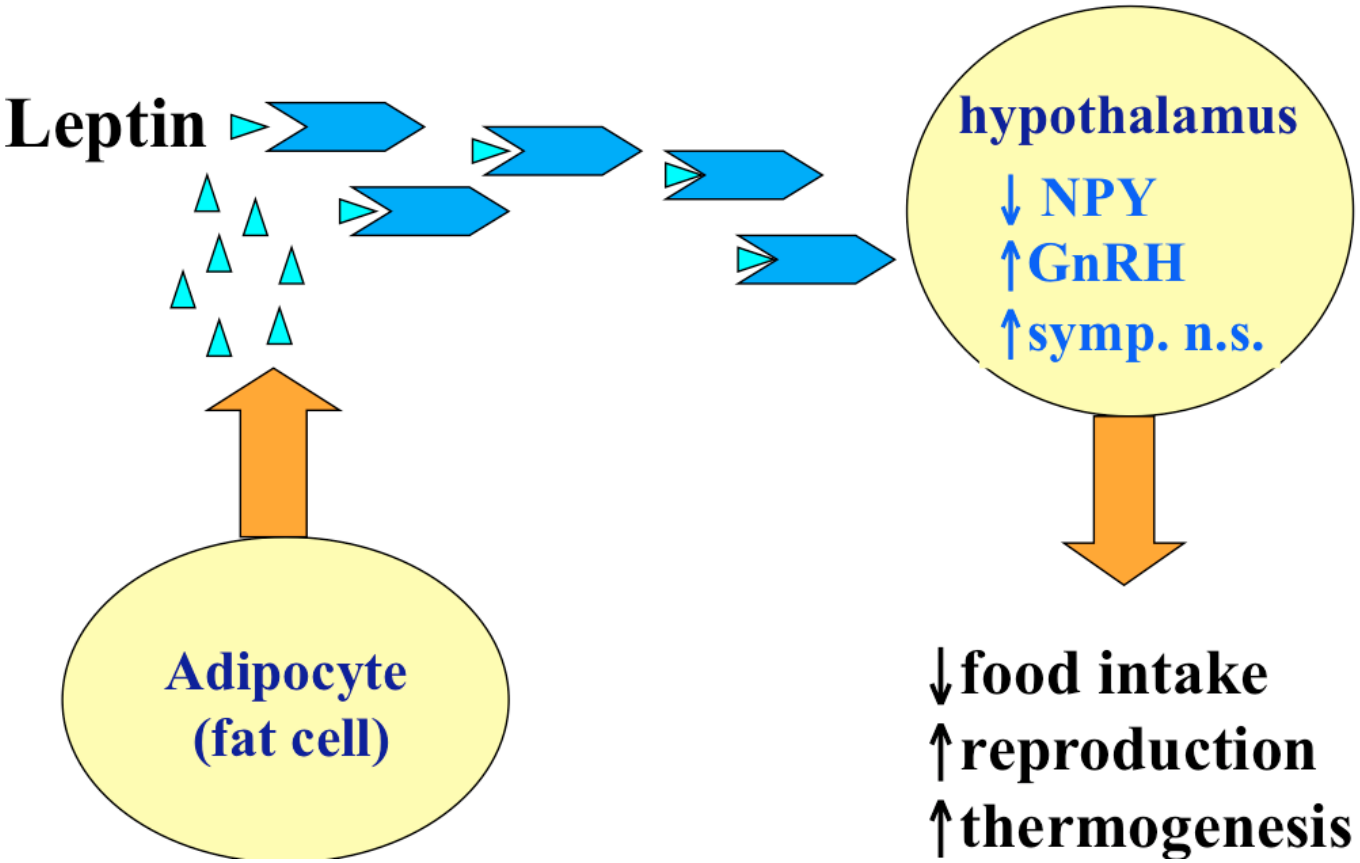
1. obese girls go through early menarche
2. malnutrition is associated with delayed menarche
3. primary amenorrhea common in lean female athletes (anorexia nervosa usually present with amenorrhea)
4. "bodyfat" setpoint very noticeable in girls with fluctuating body weight due to anorexia nervosa

Illustration: FYK



	Boys	Girls
Age of start (yrs)	12,5 (10 - 14)	11,5 (9 - 13)
First sign of puberty	G2 (testicular volume up to 4 ml)	B2
Growth velocity (cm/yr)	10,3 (Tanner III-IV)	9,0 (Tanner II-III)
Duration of puberty (yrs)	3,2 ± 1,8 (adult size of testis)	2,4 ± 1,1 (menarché)

Potential involvement of Leptin:



NPY= neuropeptide Y which increase the appetite. If we suppresse the NPY the appetite and food intake will decreased

A) Precoccious puberty

Precocious onset of puberty is defined as occurring younger than 2 years before the average age:

- Girls <8 years old
- Boys <9 years old

- More common in females.
- Uncommon in males (usually pathological).
- Maybe associated with a growth spurt.
    1. Gonadotrophin-dependent (true / central)
    2. Gonadotrophin-independent

Gonadotrophin-dependent precocious puberty	Gonadotrophin-independent precocious puberty
(true / central) Premature activation of the (HPG) axis Intra-cranial lesions (tumours, hydrocephalus, CNS malformations Gonadotrophin secreting tumours – v. rare	Precocious pseudopuberty No spermatogenesis or ovarian development (No menarche) FSH & LH suppressed • Congenital adrenal hyperplasia (CAH) • Sex steroid secereting tumours • adrenal or ovarian

B. Delayed puberty

- Initial physical changes of puberty are not present by age 13 years in girls (or primary amenorrhea at 15.5-16y), by age 14 years in boys (no testicular enlargement)
- Pubertal development is inappropriate.
- the interval between first signs of puberty and menarche in girls/completion genital growth in boys is > 5 years

Causes of delayed puberty:

Gonadal failure (Hypergonadotrophic hypogonadism):

1. Turner's Syndrome
2. Post-malignancy chemo / radiotherapy / surgery (because of the destruction of the ovary and testis)
3. Polyglandular autoimmune syndromes (affect many glands in the body)

Gonadal deficiency

1. Congenital **hypo**gonadotrophic hypogonadism (+anosmia = is the inability to perceive odor)
2. Hypothalamic/pituitary lesions (tumours, post-radiotherapy)
3. Rare gene mutations inactivating FSH/LH or their receptors

Turner syndrome

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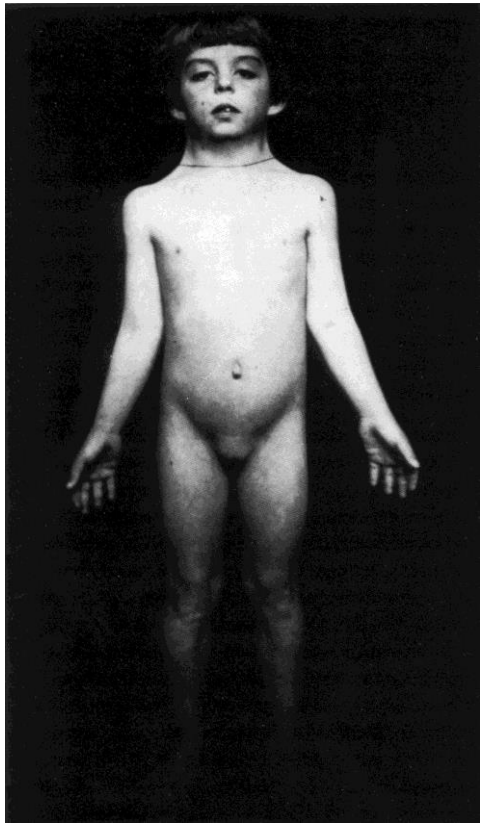
Karyotype 45,X (45,X/46,XX, structural abnormalities of X chromosome)

- Short stature (final height 144-146 cm)
- Gonadal dysgenesis
- Skletal abnormalities
- Cardiac and kidney malformation
- Dysmorfic face



No mental defect
No Impairment of cognitive function

Therapy:
growth hormone + sex hormone substitution

SUMMARY

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- **PUBERTY**: A stage of human development when sexual maturation and growth are completed and result in ability to reproduce .
- The signs of reaching puberty: **Menstruation** and **spermatogenesis** begin
- First phenotypic changes: **breast development** (in female) **- testicular enlargement** (in male)
- **Thelarche:** development of breast (first sign of maturation).
- **Puberache:** development of axillary & pubic hair.
- **Menarche**: the first menstrual period.
- **Adrenarche:** the onset of an increase in the secretion of androgens.
- **Hormonal changes procede physical (body) changes by several years**

- **Increased stimulation of hypothalamo-pituitary-gonadal axis:**
  - Gradual activation of the **GnRH (LHRH)** pulsatile, at night which **stimulate LH release**.
  - Gonadotropins stimulate secretion of **sexual steroids (females estrogenes and androgenes, males)**
  - **Extragonadal hormonal changes** (elevation of IGF-I will stimulate the effect of GH and increases body growth in general, and adrenal steroids)
- **Estrogen** induces **secondary sex characteristics.**
- **androgens** initiate growth of **sex accessory structures (e.g. prostate)**, **male secondary sex characteristics (facial hair, growth of larynx)**
- Pubertal development is classified according to the **Tanner** standard
- Pubertal disorders ; Either **Precoccious puberty** or **Delayed puberty**

QUESTIONS

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1. Hormones released by the brain that activate the sexual glands are:

a) Estrogens
b) Androgens
c) TSH
d) gonadotrophins

2. Which of the following are secondary sex characteristic changes?

a) increased height
b) change in body shape or voice
c) growth of body hair
d) body odor
e) all answers are correct

3. which one of the following is considered to be the first phenotypic change that occurs in female during puberty?

a) Menarche
b) Thelarche
c) Adrenarche
d) Pubarche

4. a 7 year old boy was brought to the pediatric clinic as his mother noticed appearance of hair in his face , axillary and pubic area and deepening in his voice. After investigation the physician diagnosed him as precocious puberty due to pituitary tumor. Which one of the following hormone profile confirms the diagnosis?

a) Low levels of GnRH, FSH, LH and testosterone
b) high levels of GnRH, FSH, LH and low levels of testosterone
c) Low levels of GnRH, high levels of FSH, LH and testosterone
d) high levels of GnRH, low levels of FSH, LH and high testosterone

5. Which one of the following is the first sign of puberty in boys ?

a) Penile enlargement
b) testicular enlargement.
c) Pubic hair appearance

1	d
2	e
3	b
4	c
5	b

THE END

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If there are any Problems or Suggestions, Feel free to contact us:

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THANK YOU

IF YOU WANT TO SHARE ANY INFORMATION REGARDING PHYSIOLOGY OR ANY OTHER SUBJECT .. YOU CAN MENTION THIS ACCOUNT

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