

# **PUBERTY**

## **Physiology Lecture # 5 (Puberty)**

**Dr. Laila Al-Dokhi**

**Department of Physiology**

**College of Medicine**

**King Saud University**

## **OBJECTIVES:**

- 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

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

***Accelerated somatic growth***

**Maturation of *primary sexual characteristics* (gonads and genitals)**

**Appearance of *secondary sexual characteristics* (pubic and axillary hair, female breast development, male voice changes,...)**

***Menstruation and spermatogenesis* begin**

# 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.

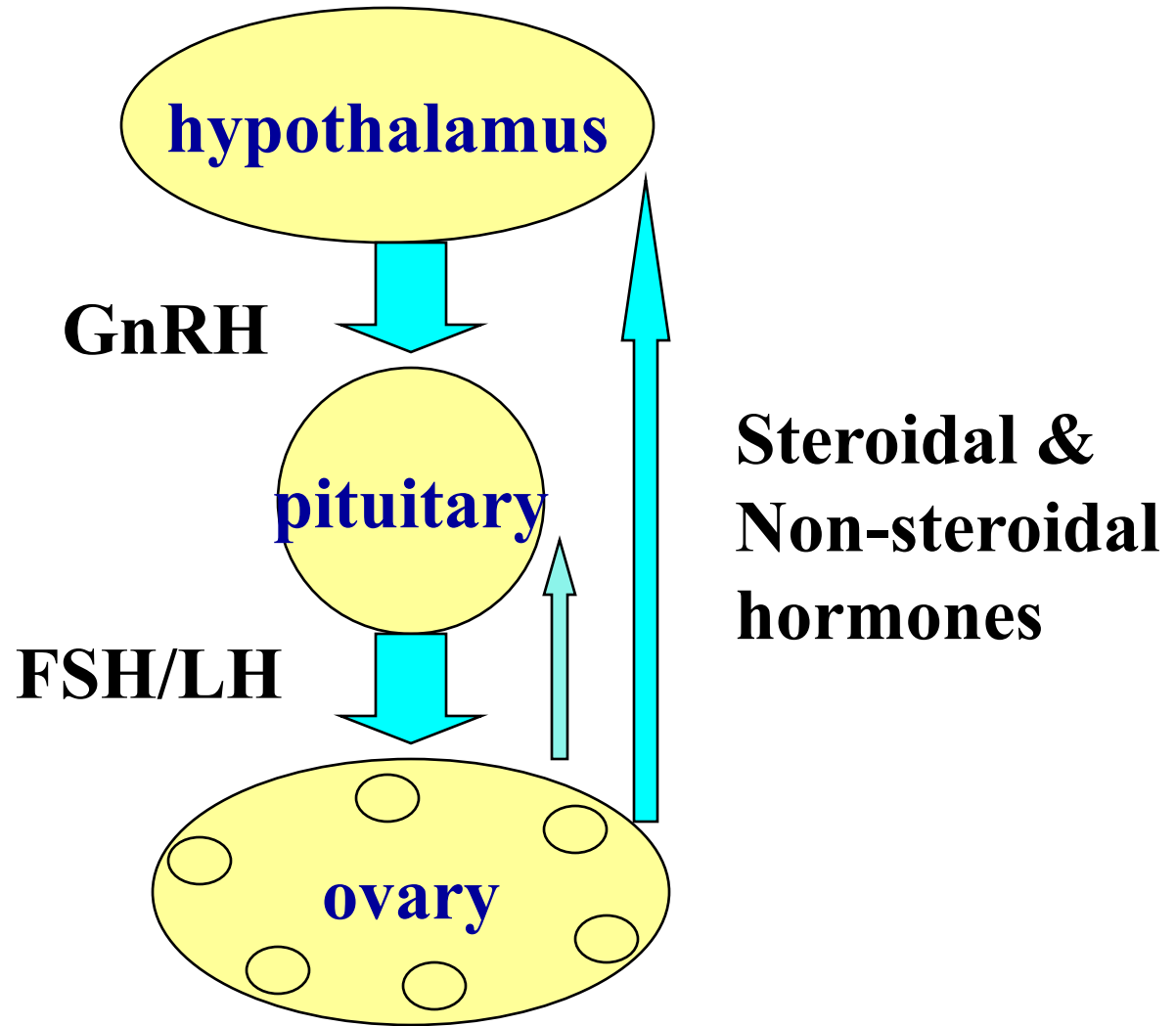
# Puberty – hormonal changes

**Hormonal changes precede physical changes**

***Increased stimulation of hypothalamo-pituitary-gonadal axis***

- gradual activation of the GnRH (LHRH)**
- increases frequency and amplitude of LH pulses.**
- gonadotropins stimulate secretion of sexual steroids (estrogens and androgens)**
- extragonadal hormonal changes (elevation of IGF-I, and adrenal steroids)**

# Hypothalamic-Pituitary-Gonadal Axis



# Puberty – hormonal changes

Nocturnal GnRH pulsatility (LH secretion) precedes phenotypic changes by several years

First phenotypic changes:

breast development / testicular enlargement

# Puberty – hormonal changes

- 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



# Puberty – hormonal changes

- GH secretion from pituitary also increases
- TSH (thyroid stimulating hormone) secretion from pituitary increases in both sexes:
  - increases metabolic rate
  - promotes tissue growth

# Puberty – Female hormonal changes

- surge of LH release initiates 1st ovarian cycle
- 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

# Physical Changes

- 5 stages from childhood to full maturity
- Marshall and Tanner (P1 – P5)
- Reflect progression in changes of the external genitalia and of sexual hair
- Secondary sexual characteristics
  - Mean age 10.5yrs in **girls**
  - Mean age 11.5 – 12yrs in **boys**

# Puberty – Female hormonal changes

- estrogen induces secondary sex characteristics:
  - growth of pelvis
  - deposit of subcutaneous fat
  - growth of internal reprod. 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)

**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 dimorphism in pubertal growth

# Puberty: Girls

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

# Pubertal Stages (Tanner) Female

- **P1** Prepubertal
- **P2** Early development of subareolar breast bud +/- small amounts of pubic and axillary hair
- **P3** Increase in size of palpable breast tissue and areolae, increased pubic/axillary hair
- **P4** Breast tissue and areolae protrude above breast level. Further increased pubic/axillary hair growth
- **P5** Mature adult breast. Complete pubic/axillary hair growth

# Puberty – Male hormonal changes

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



# Puberty –Male hormonal changes

- androgens causes retention of minerals in body to support bone and muscle growth
- Sertoli cells also secrete some estrogen

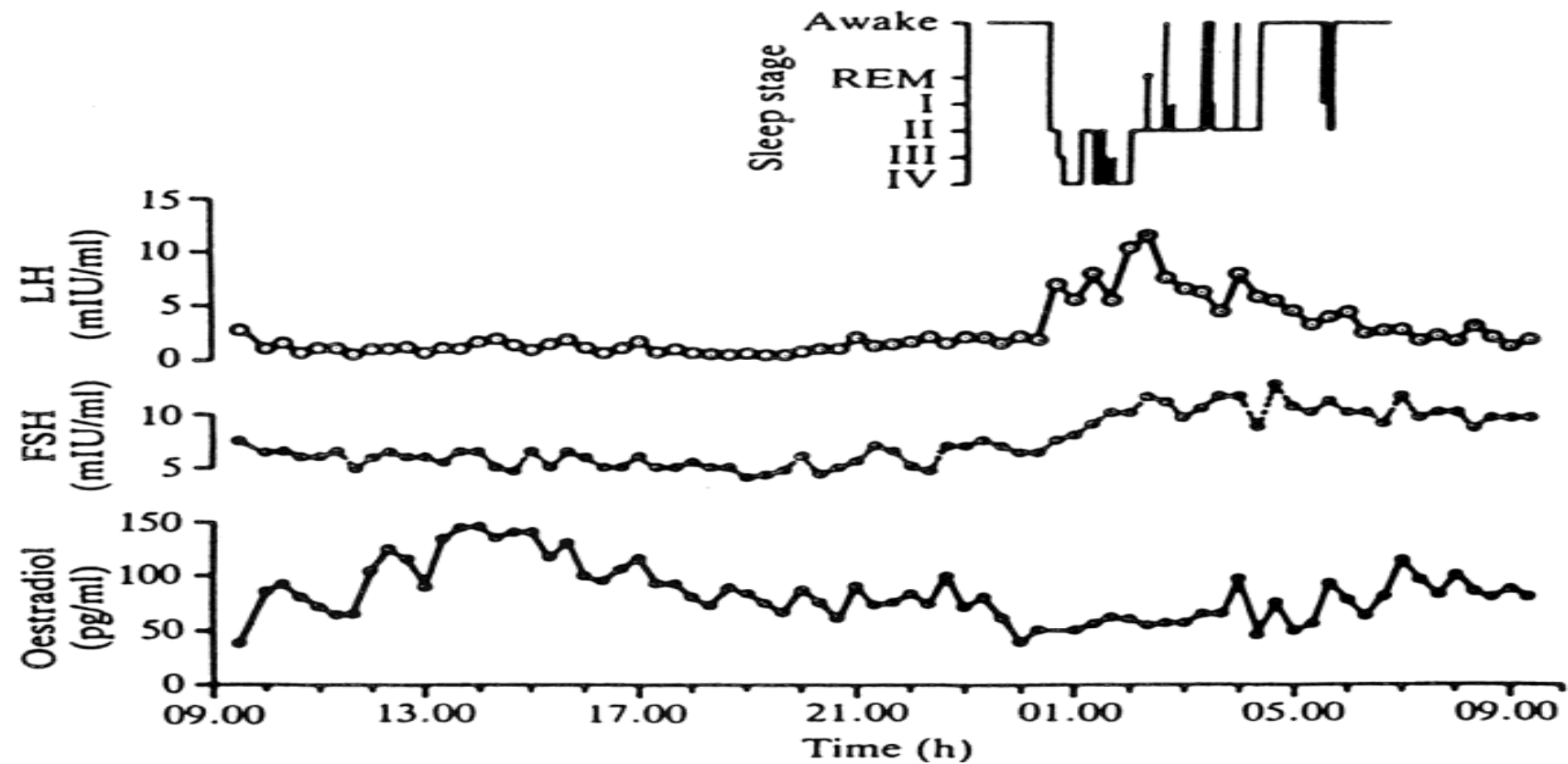
# Puberty: Boys

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

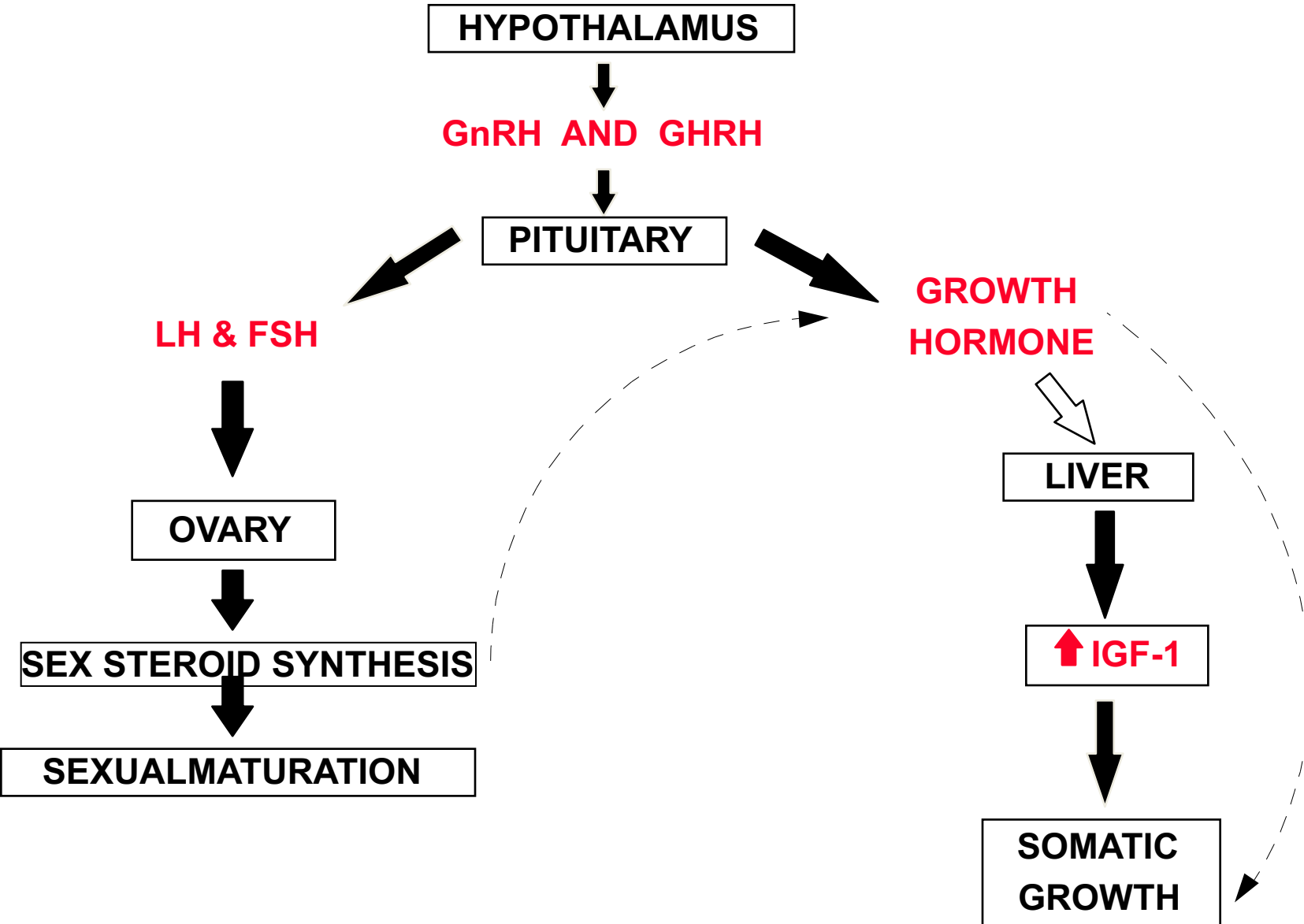
# Pubertal Stages (Tanner) Male

- **P1** Prepubertal, testicular volume < 2mls
- **P2** Enlargement of scrotum and penis. Scrotum slightly pigmented. Few pubic hairs
- **P3** Lengthening of penis. Further growth of testes and scrotum. Pubic hair darker
- **P4** Penis increases in length and thickness. Increased pigmentation of scrotum. Increased pubic/ axillary hair
- **P5** Genitalia adult in size and shape. Completed pubic/axillary hair growth

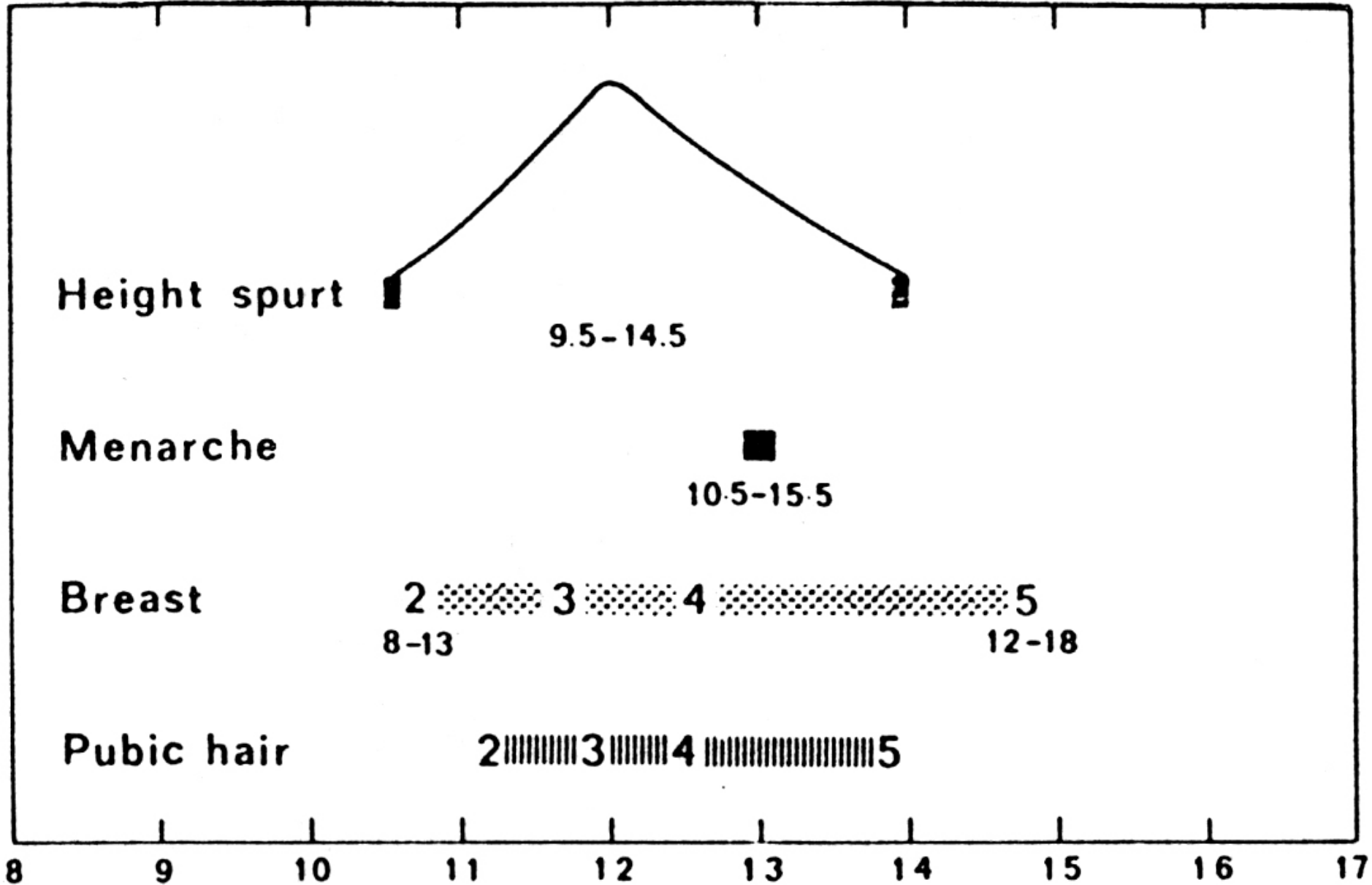
# Sleep dependent nocturnal rise in LH



# Puberty – hormonal changes



# *Sequence of normal puberty in girls*



# Normal pubertal development

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

# Timing of Puberty

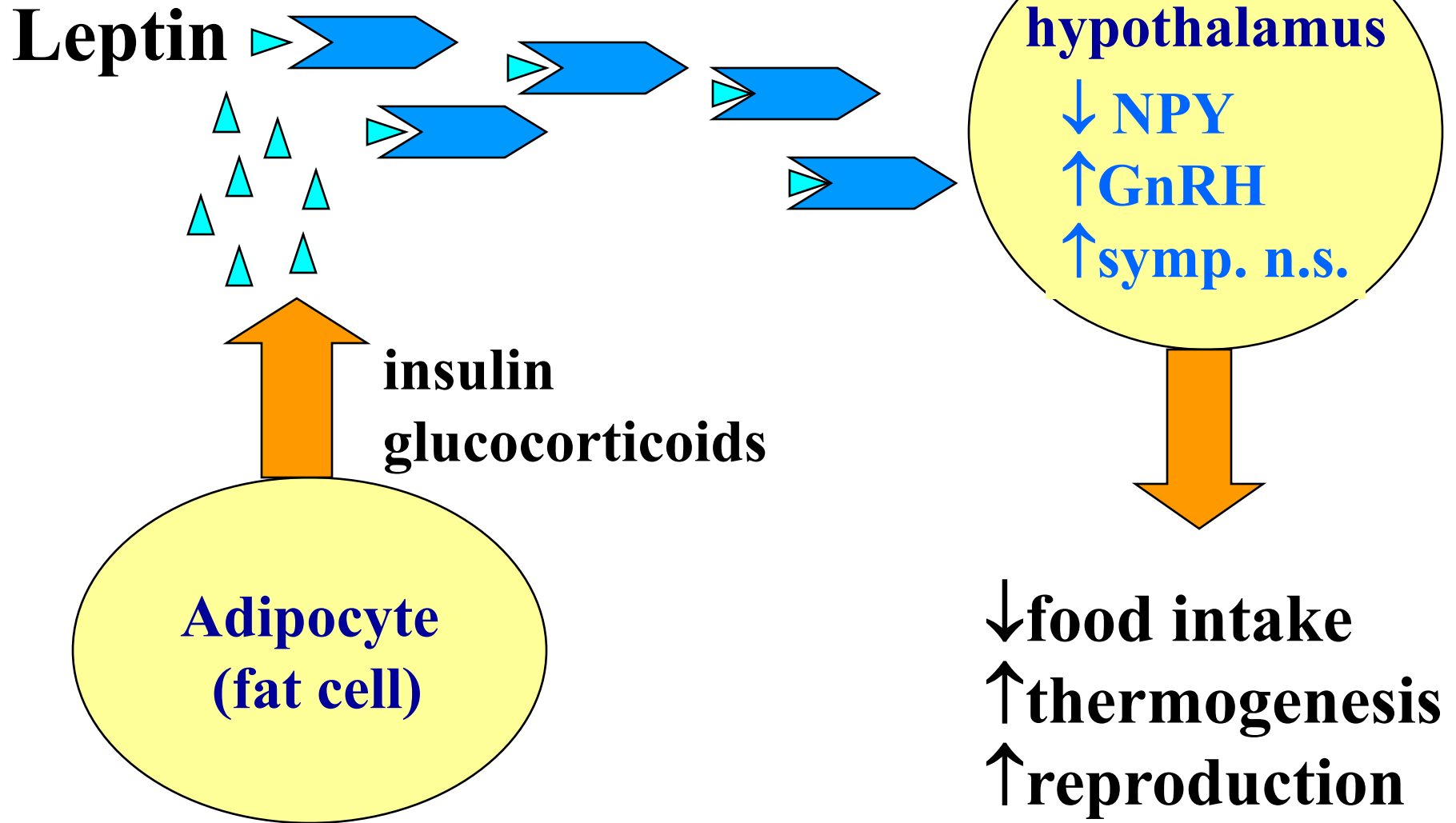
- Genetics: 50-80% variation in pubertal timing.
- trend toward earlier puberty exists within Western Europe and USA
- examination of lifestyle changes may give clues regarding mechanisms inducing onset
- one of the contributing factors: nutrition



# 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:
  - obese girls go through early menarche
  - malnutrition is associated with delayed menarche
  - primary amenorrhea common in lean female athletes
  - “bodyfat” setpoint very noticeable in girls with fluctuating body weight due to anorexia nervosa

# Potential involvement of Leptin:



# Pubertal disorders

**A. Precocious puberty**

**B. Delayed puberty**

# PRECOCIOUS PUBERTY

Precocious onset of puberty is defined as occurring younger than 2 SD 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

- (true / central )
- Intra-cranial lesions  
(tumours, hydrocephalus, CNS malformations)
- Gonadotrophin secreting tumours – v. rare

# Gonadotrophin-independent precocious puberty

- Precocious pseudopuberty
- No spermatogenesis or ovarian development
- FSH & LH suppressed
- Congenital adrenal hyperplasia (CAH)
- Sex steroid secreting tumours
  - adrenal or ovarian

# Delayed puberty - definition

**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**

**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)
  - Turner's Syndrome
  - Post-malignancy chemo / radiotherapy / surgery
  - Polyglandular autoimmune syndromes
- Gonadal deficiency
  - Congenital hypogonadotrophic hypogonadism (+anosmia)
  - Hypothalamic/pituitary lesions (tumours, post-radiotherapy)
  - Rare gene mutations inactivating FSH/LH or their receptors



# Turner syndrome

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

**Short stature (final height 144-146 cm)**

**Gonadal dysgenesis**

**Skeletal abnormalities**

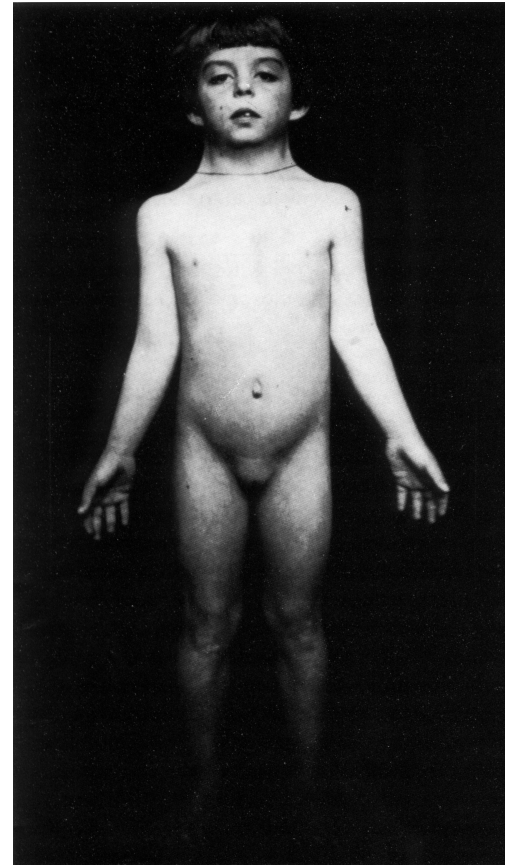
**Cardiac and kidney malformation**

**Dysmorphic face**

**No mental defect**

**Impairment of cognitive function)**

**Therapy: growth hormone, sex hormone substitution**



**H. Turner, 1938**