

PUBERTY

Reproduction Block

Physiology Lecture # 4

(Puberty)

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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

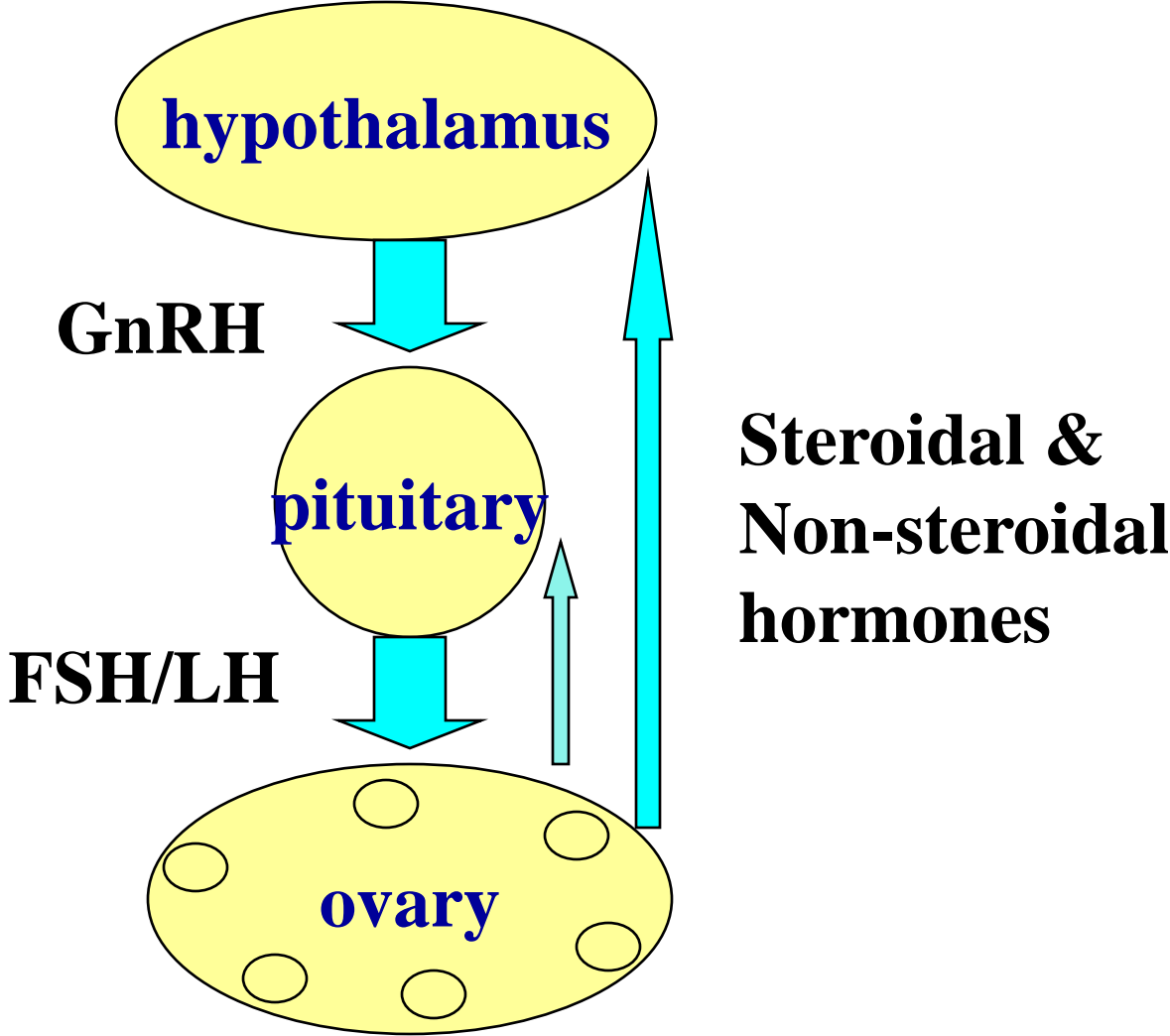
Puberty – hormonal changes

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
- 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

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 > growth of pubic hair, lowering of voice, growth of bone, increased secretion from sebaceous glands

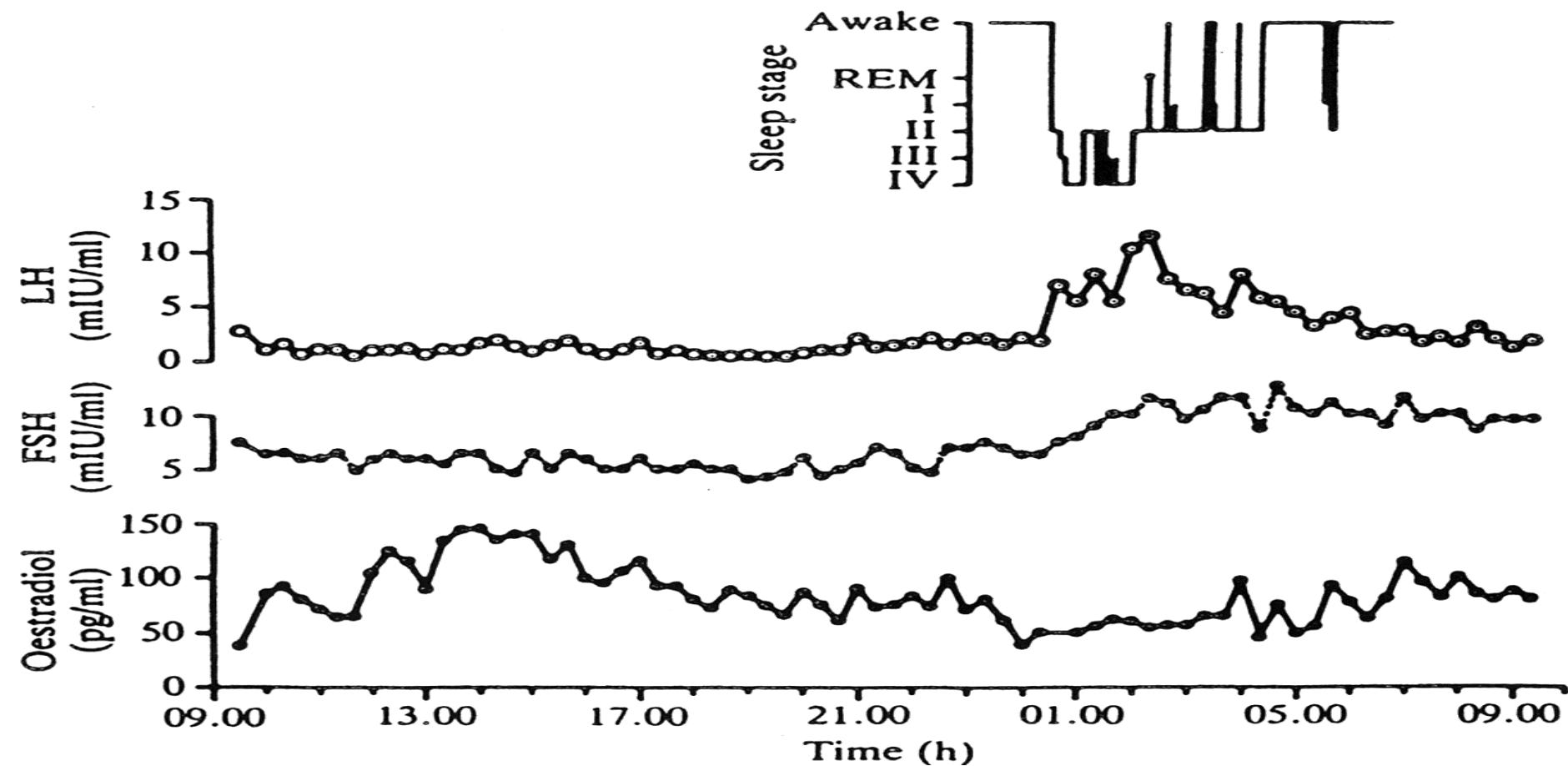
Puberty – Male hormonal changes

- 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)

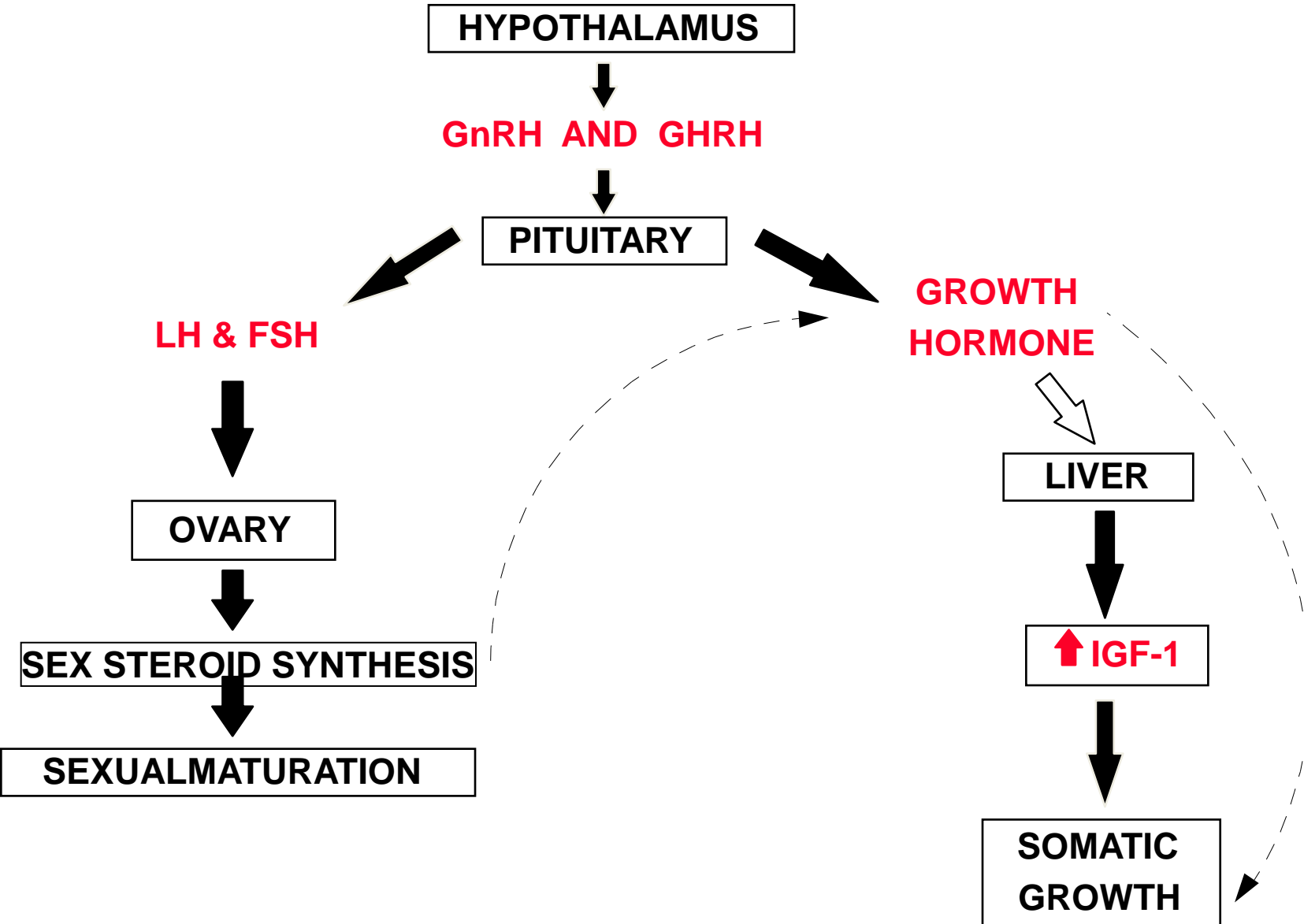
Puberty –Male hormonal changes

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

Sleep dependent nocturnal rise in LH



Puberty – hormonal changes



Staging of pubertal development (Tanner)

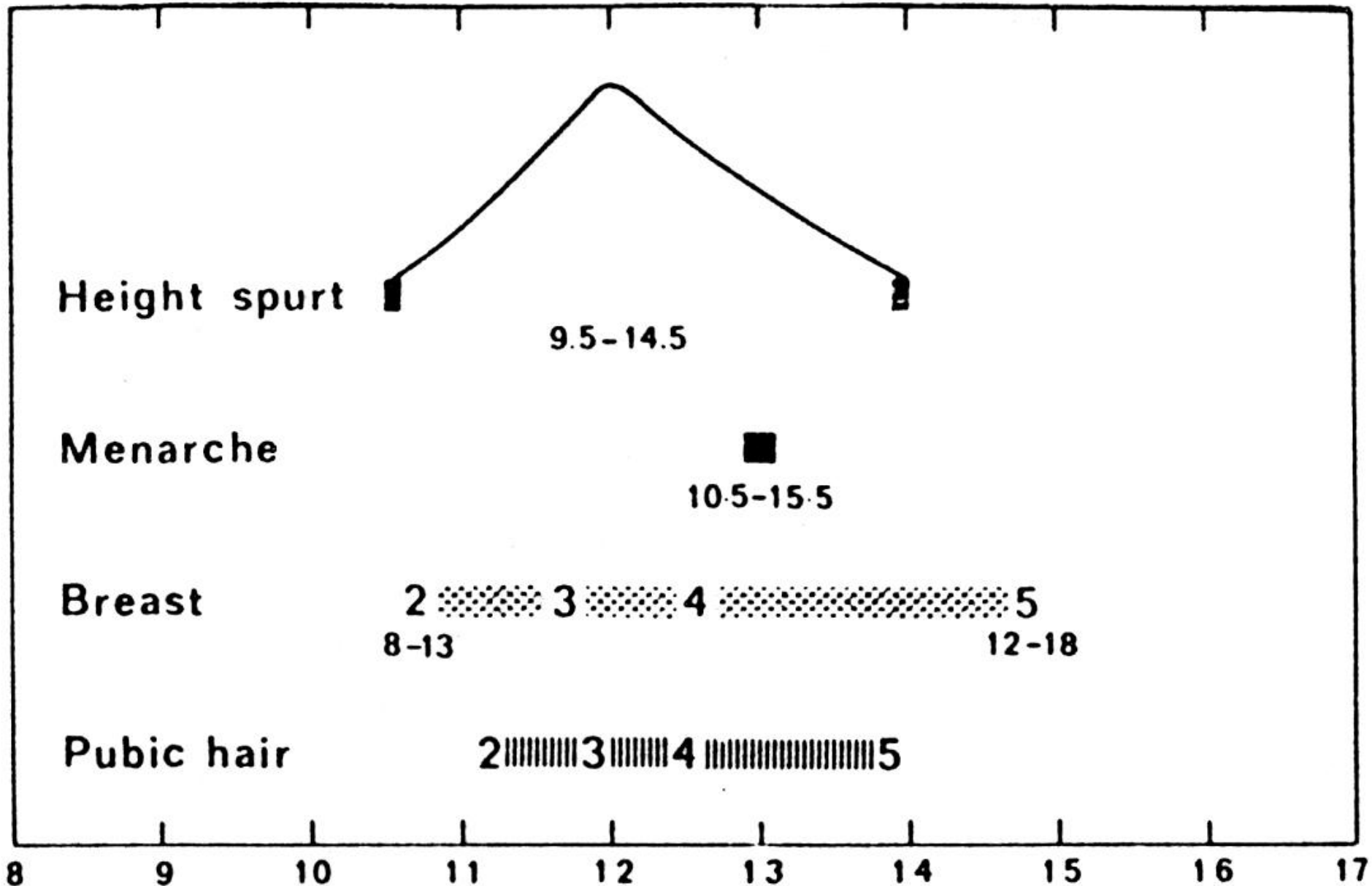
Pubertal development is classified according to the Tanner standard – 5 different stages

- **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

Sequence of normal puberty in girls



Normal pubertal development

	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)

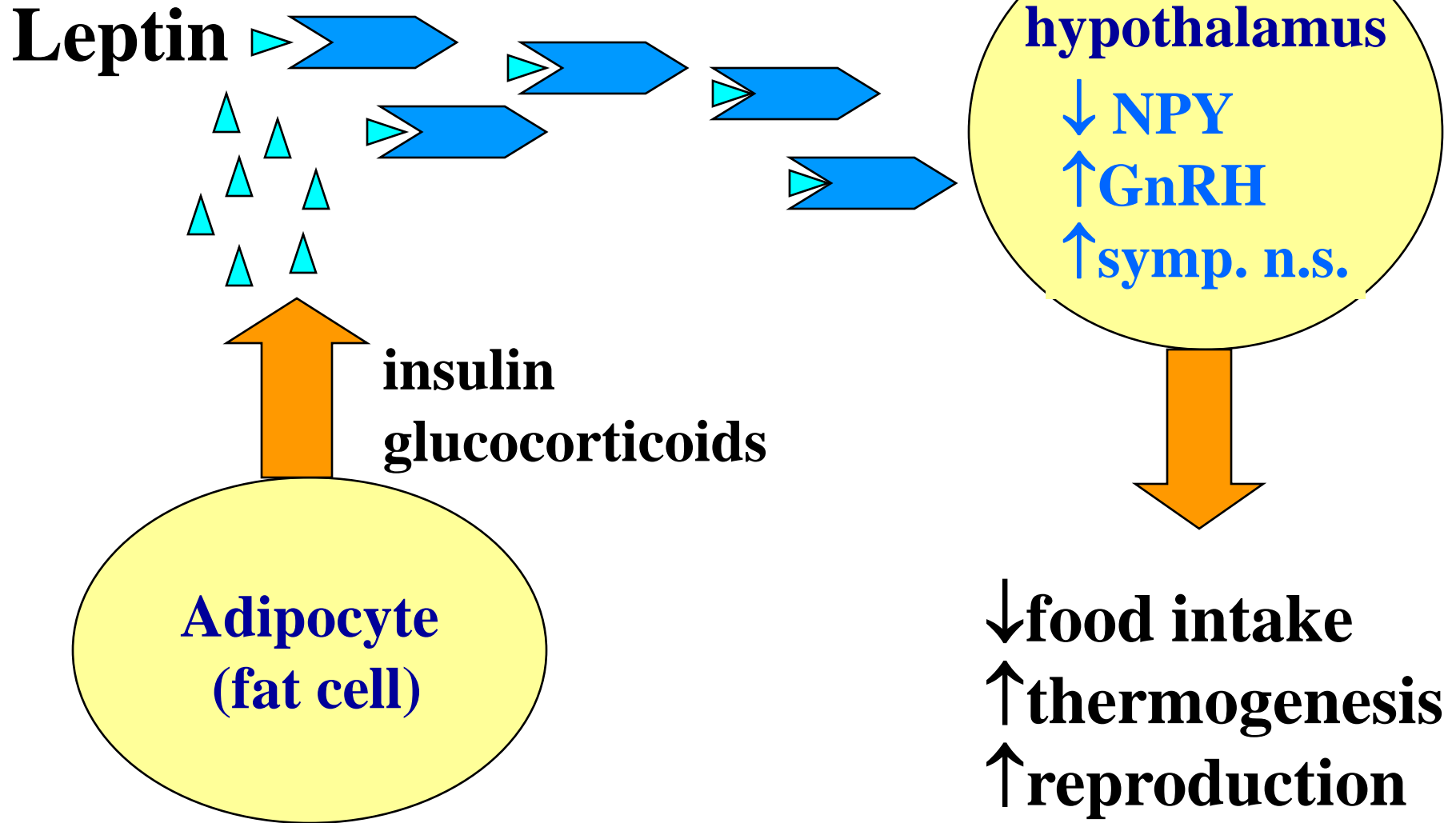
Timing of Puberty

- 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

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

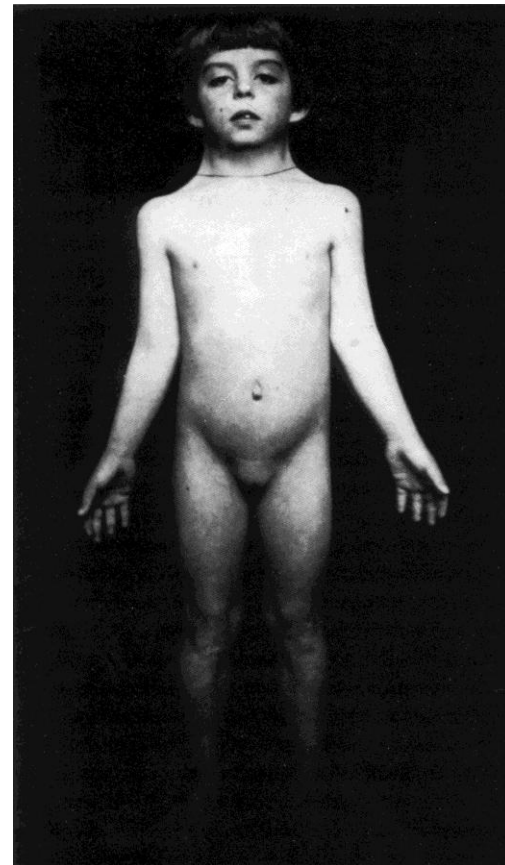
Cardiac and kidney malformation

Dysmorphic face

No mental defect

Impairment of cognitive function)

Therapy: growth hormone, sex hormone substitution



H. Turner, 1938