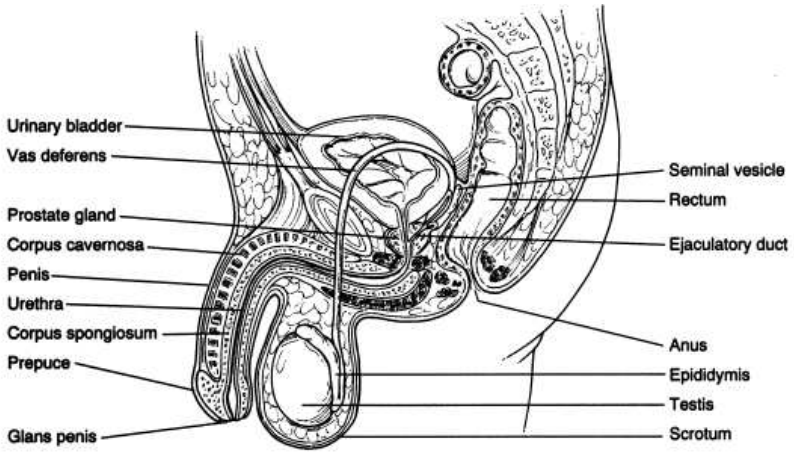
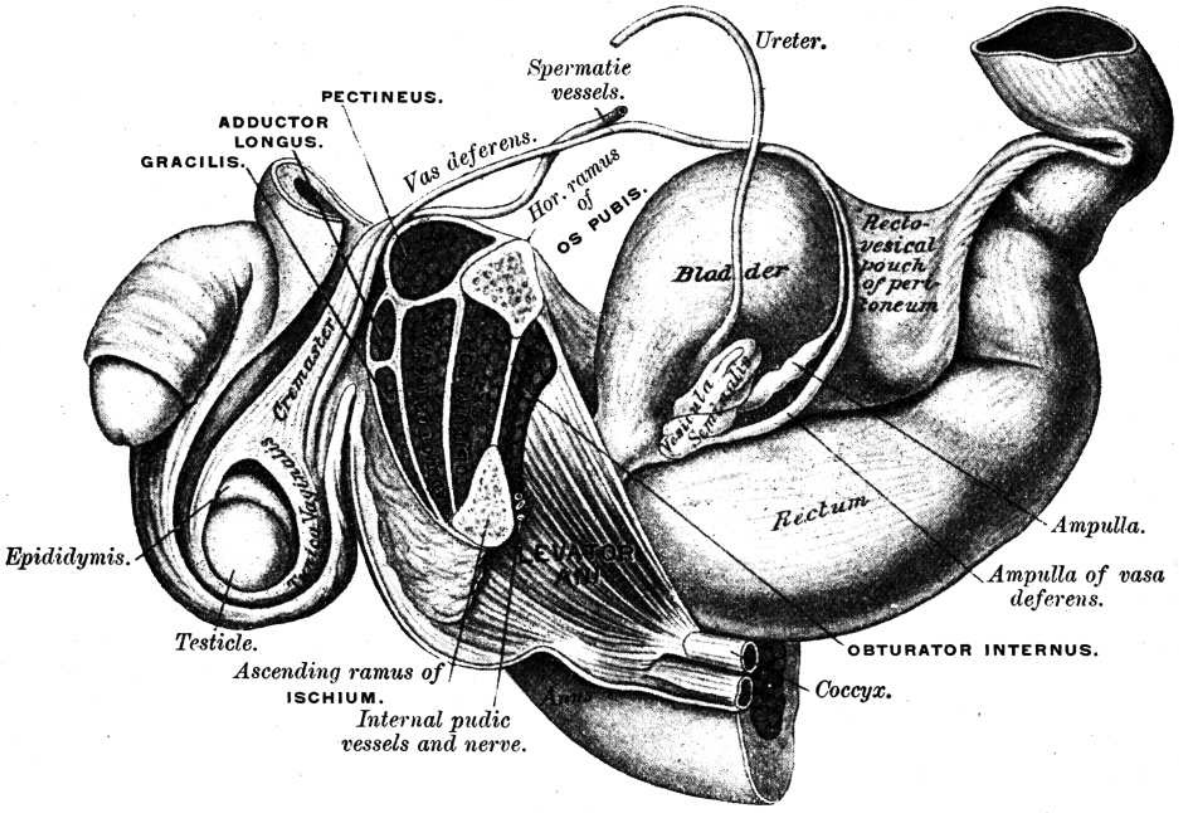
Biomechanics
and
Functional Anatomy
of
Human Male Genitalia

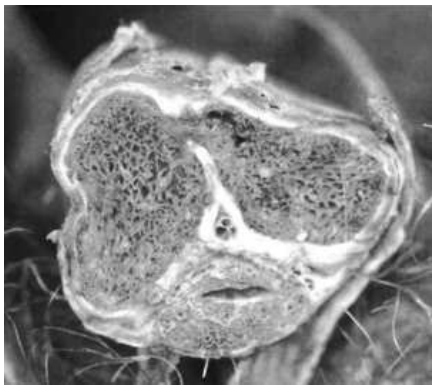
For designers and creators of biomimetic androids, dolls and robots

The Penis

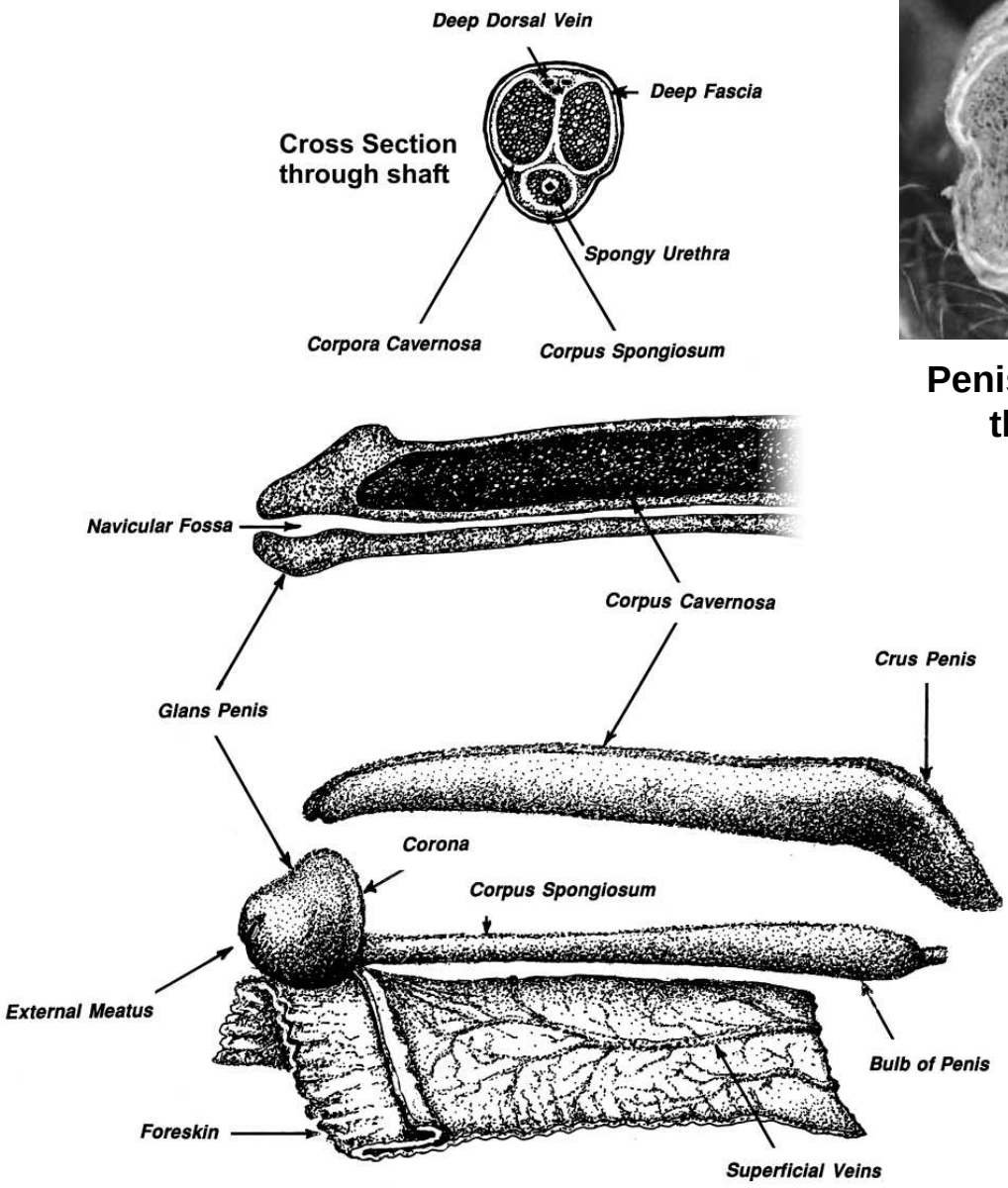
The shaft or body of the penis is formed principally by a fused pair of corpora cavernosa, cylinders of tough fibrous tissue, the tunica albuginea, filled with a sponge-like lattice of vascular spaces or erectile tissue which inflates with blood during erection. The detailed structure of this erectile tissue is of fundamental importance to the mechanism of erection. The bulk of this tissue consists of vascular spaces or sinusoids containing smooth muscle in their walls. Beneath the two fused orpora cavernosa lies another erectile column, the corpus spongiosum which envelops the urethra in its course along the lower surface of the penis. Engorgement of the corpus songiosum occurs in such a way that the urethral lumen avoisd occlusion by compression and remains sufficiently patent for the rapid ejaculation of seminal fluid. This patency is partly maintained by specialized surrounding fiberous architecture. but in any case, the pressures in the spongiosum during erection are much lower than those found in the corpora cavernosa which are consequently the most important structures in the fully erect penis. At the root of the penis the corpora cavernosa diverge to be firmly attached to the pelvic bones. The corpus spongiosum expands around the dilated part of the urethra to form the bulb of the urethra. Near the root fo the penis, the outer surfaces of the erectile columns are invested by layers of muscle, the bulbospongiosus and ischiocavernosus muscles which contract rhythmically during orgasm and also semi-voluntarily during the development of erections.Near the tip of the penis, the corpus spongiosum expands to form the glans, a cushion-like expansion of the penile shaft, separated from it by a shallow grove. In the uncircumcised male, the glans is covered by a hood of lax skin, the prepuce or foreskin which is wholly or partially removed in those males who have been circumcised. On the lower surface, the prepuce is attached to the glans by a longitudinal fold of skin, the frenum. The separation of the foreskin from the underlying glans is sometimes incomplete in the neonate and normally requires androgens for its completion. During erection of the penis, the foreskin is partially retracted by tension of the skin along the elongated penile shaft, exposing the tip of the glans and the urethral orfice. During oital thrusting, the foreskin is intermittently retracted durther by friction with the vaginal walls, exposing the glans completely.



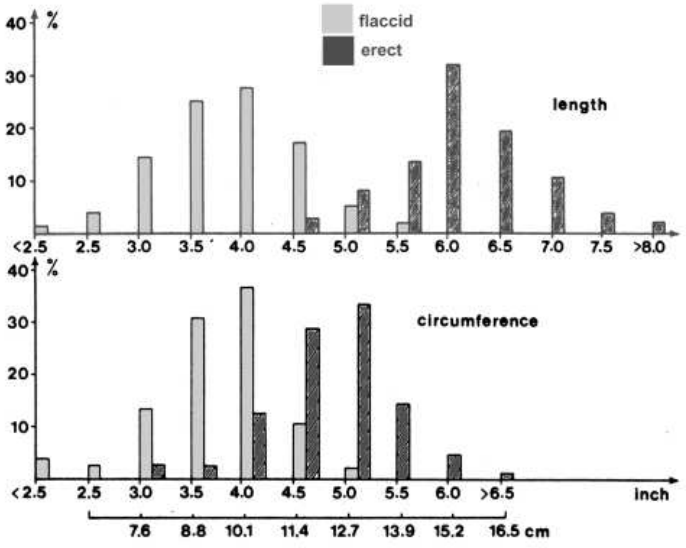




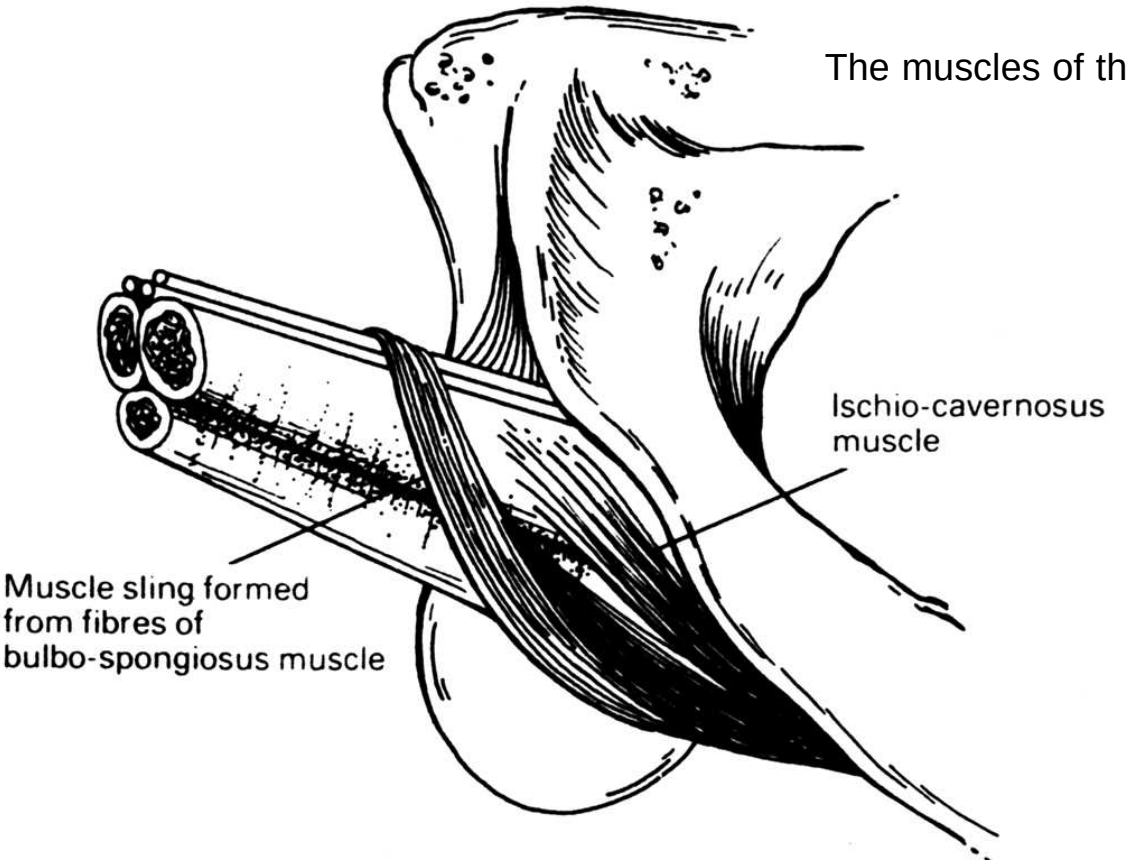
Penis Cross Section through shaft

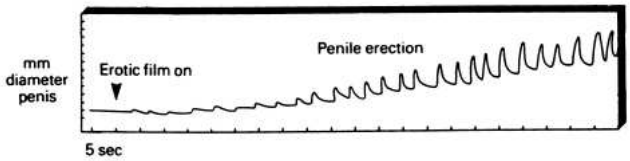


Penis size in the (length, circumference) the flaccid and erect states. Data from 2,310 American males.

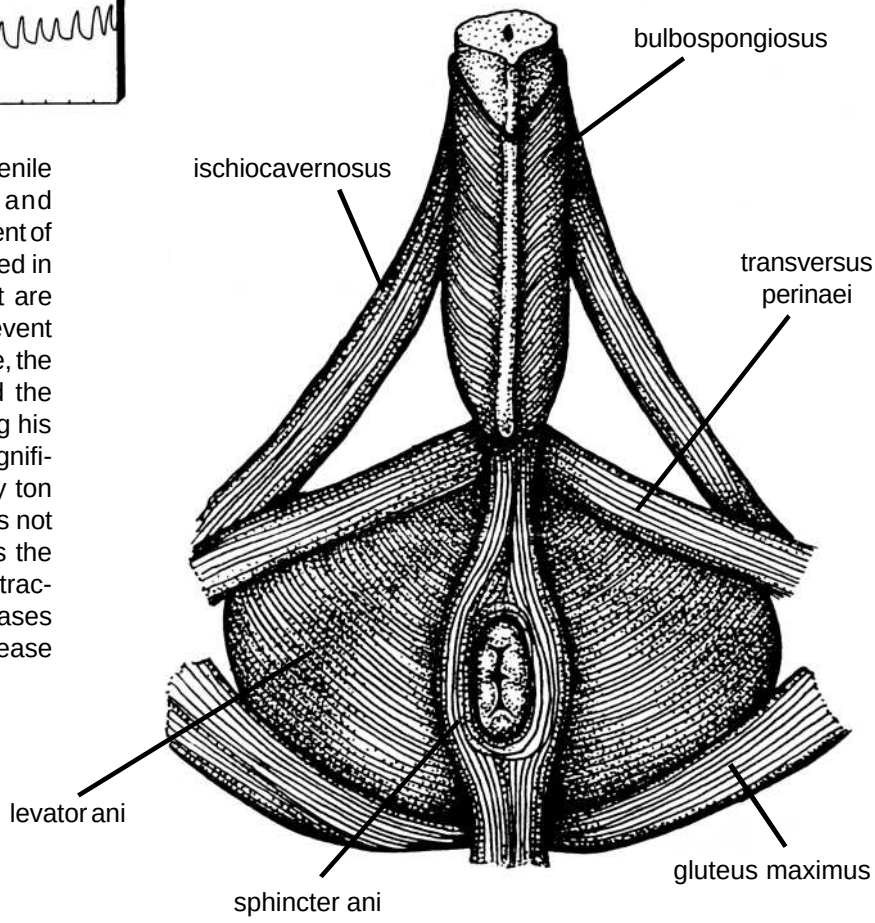


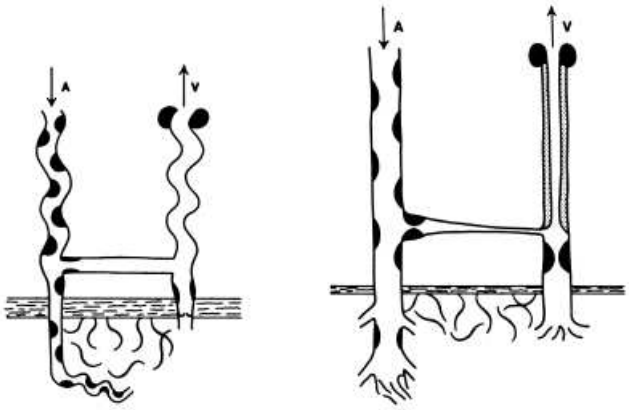
The muscles of the penis





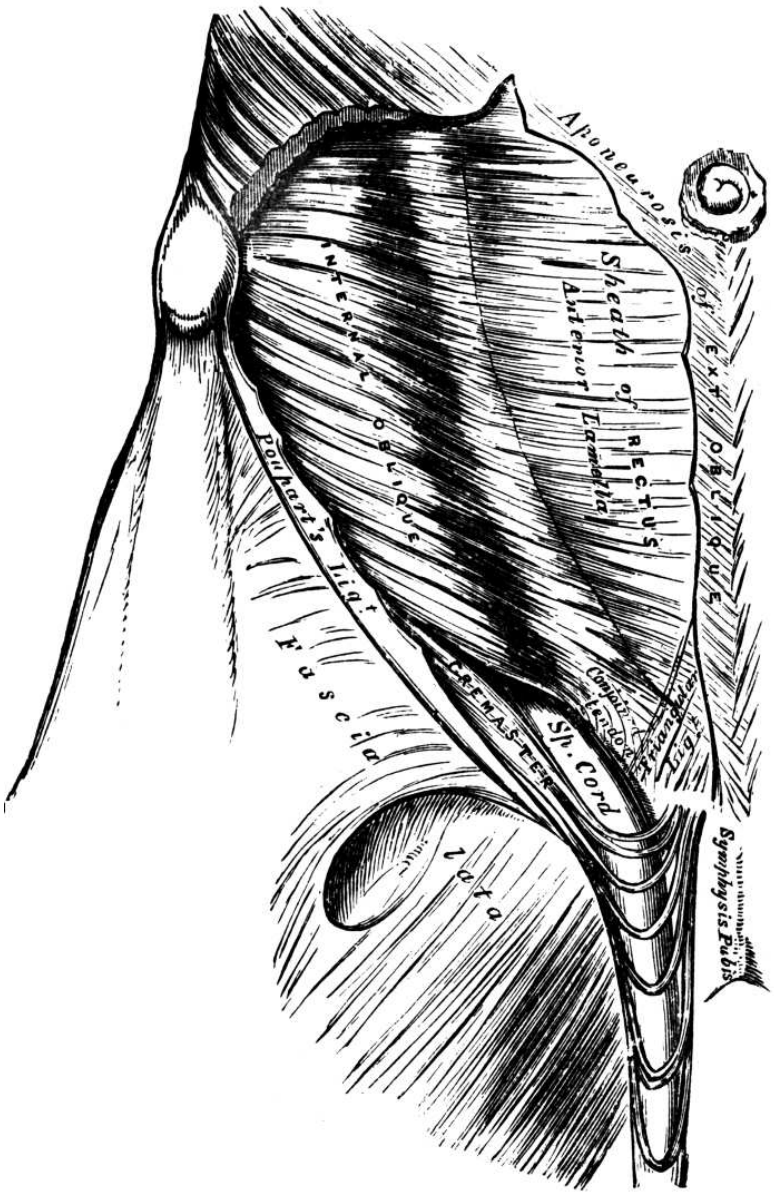
Above: Rhythmic contractions of the penile muscles (bulbospongiosus and ischiocavernosus) during the development of an erection. About one in four men tested in the laboratory show this pattern. Most are aware of these contractions and can prevent them if asked. In the case illustrated here, the subject was unable to stop them and the contractions were also observed during his nocturnal erections. Their functional significance is not known, but some men try ton "pump up" their erection in this way. It is not yet clear whether this helps or hinders the erection. With a full erection such contractions produce transient dramatic increases in intracavernosal pressure which increase the rigidity of the erect penis.





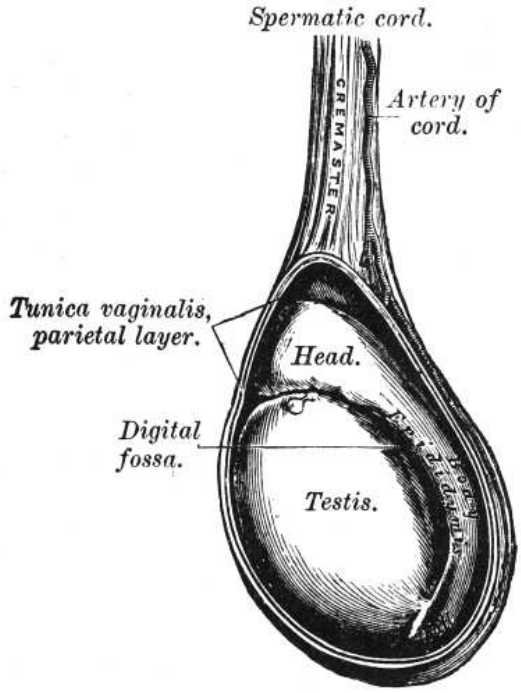
Far left: A schematic presention of the hypothesized direction of blood flow in the flaccid state. A is the tortuous arterial inflow with contracted and protruding pads in the lumen. The blood is supposed to be shunted via the open canal (A-V shunt) into the wide-open vein and to leave through this vein. At the venous outlet (V), a circular sphincter placed under the pelvic arch is relaxed in this state. A modelst amount of blood runs through the tunica albuginea into the cavernous space and the capillary system of the cavernous tissue. The drainage is via the open vein, which is provided with valves preventing flow.

Left: Schematic drawing of cirulatory conditions in the erect penis. The blood flows into the artery (A), now stretched out and with relaxed and flattended Ebner pads in the lumen. The A-V shunt is closed, and the flow of blood continues into the now expanding cavernous space. The return of blood is hampered by closure of the outlet veins, partly by contracted luminal pads and partly by constriction of the wall. The sphincter at the top may also prevent blood from escaping

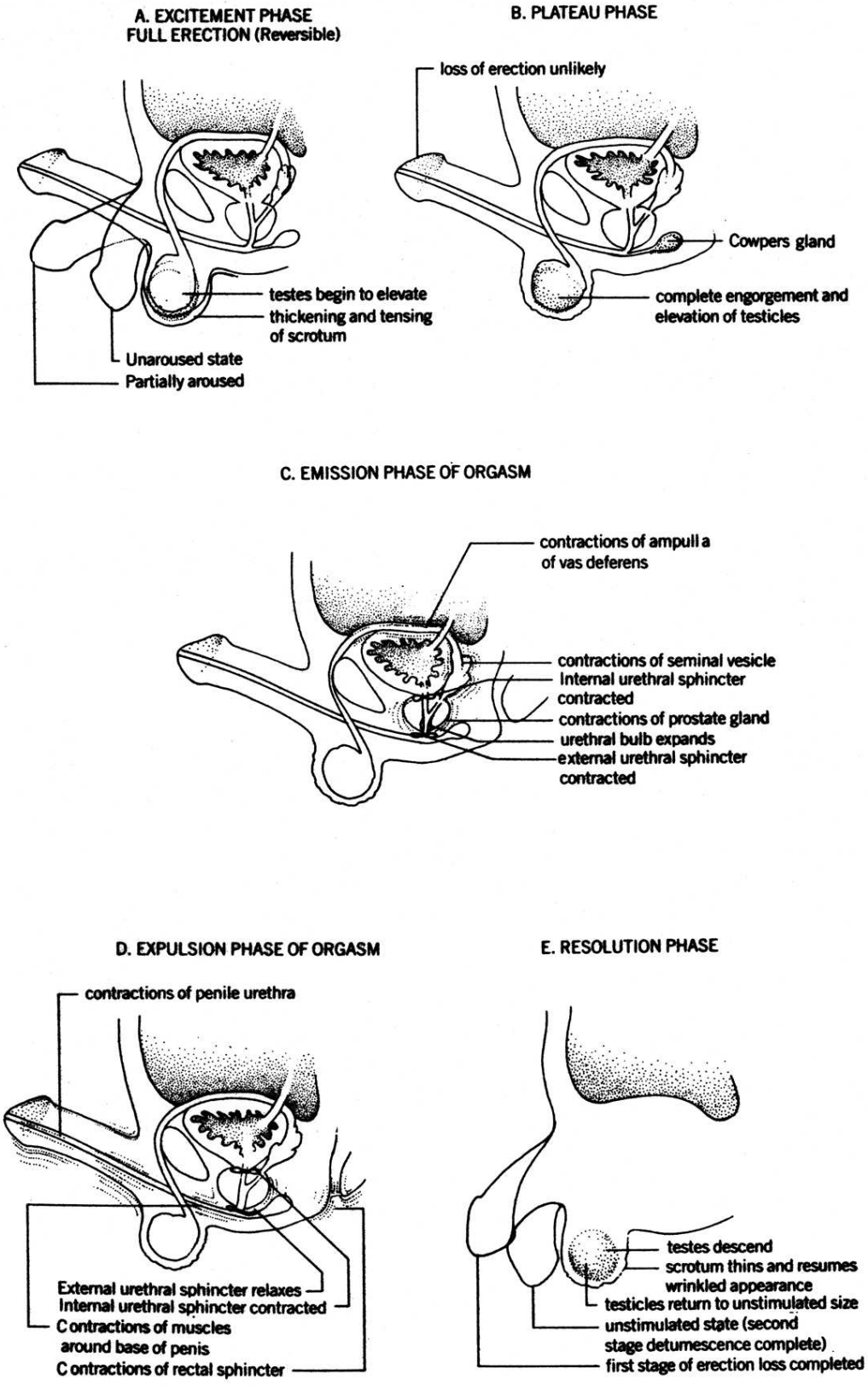


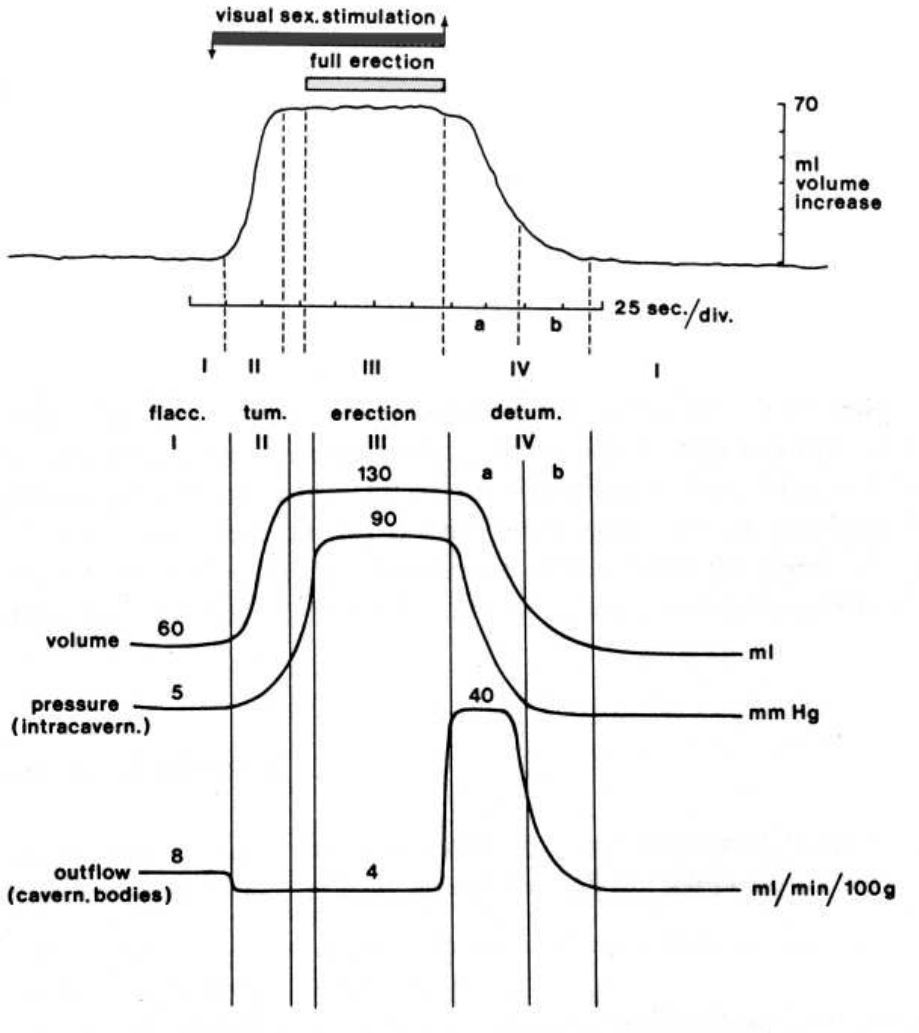
The cremaster muscle is a thin, muscular layer, composed of a number of fasciculi which arise from the inner part of Poupart's ligament, where its fibres are continuous with those of the Internal oblique and also occasionally with the transversalis. It passes along the outer side of the spermatic cord, descends with it through the external abdominal ring upon the front and sides of the cord and forms a series of loops wich differ in thickness and length in different subjects.

The cremaster raises or lowers the scrotum to keep the testes at a constant temperature. During sexual arousal, the cremaster muscle contracts to draw the testes closer to the abdomen, and the smooth muscle of the scrotum contracts too. As a result the testes are held in a more protected position during sexual intercourse.



Male anatomy during the stages of sexual response





The Four Phases of the Erectile Cycle

I. *Resting phase:* constant volume, intracavernous pressure, and blood flow rate

II. *Tumescence phase:* volume increases, and there is a slight increase in intracavernous pressure. The duration of this phase is age-dependent and is influenced by the strength and the reception of the sexual stimulation.

III. *Erection phase:* volume is constant, and the intracavernous pressure has increased to at least 80mm Hg

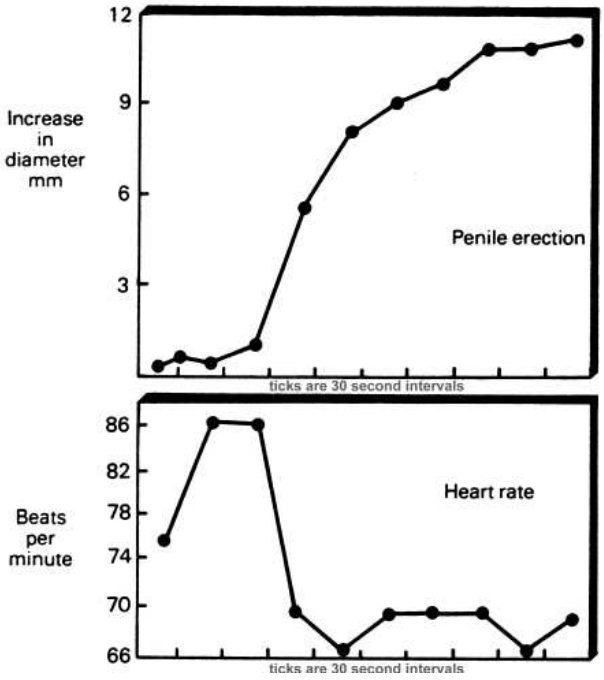
IVa. *Detumescence phase (rapid):* stiffness is lost and volume decreases

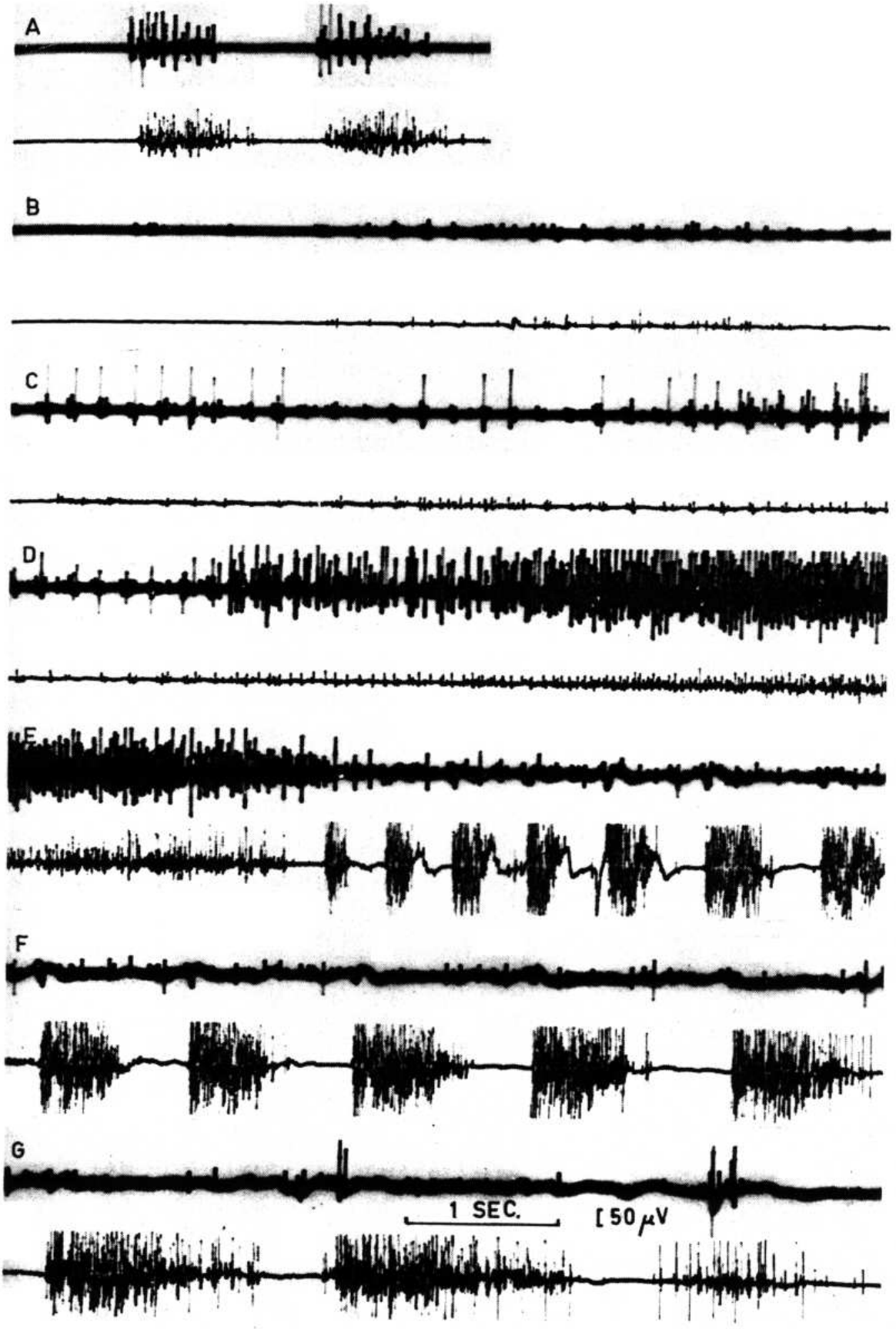
IVb. *Detumescence phase (slow), or restitution phase:* volume returns to basal value.

Very Top: Change of volume of the penis in a 26-year-old normal man exposed to a visual sexual stimulation of 150-second duration (film strip). I-IV indicate the four phases of the penile erectile cycle. The maximum volume is obtained before full erection is achieved. The volume increase of the mobile part of the penis is 70ml.

Top: Theoretical presentation of cirulatory changes in each of four phases of the penile erectile cycle. Volume of the penis, intracavernous pressure, and outflow from cavernous bodies are depicted with average values and are presented to demonstrate their interrelationship. It should be noted that an intermediate phase exists after the maximum volume has occured (II) and the maximum pressure is developed (III). During this period, the pressure is built up to that necessary to create rigidity of the cavernous bodies.

Right: Sexual response (i.e. erection) associated with a decrease in peripheral arousal in a normal male (Bancroft & Mathews 1971)





Electromyographic recording during orgasm and ejaculation. The upper part of each section is a recording from a muscle in the vicinity of the striated urethral sphincter, probably the deep transverse perineal muscle. The lower parts are recordings from the membranous urethral sphincter. **(A)** two voluntary contractions as on attempting to interrupt miturition. **(B-G)** Continuous recording. Orgasm was experienced simultaneously with the steep rise in activity during D and at the start of E. Ejaculation occurred during **E** through **G**. From Kollberg, S., Petersen, I., and Stener, I. (1962) Preliminary results of an electromyographic study of ejaculation. *Acta Chirurgica Scandinavica 123:478-483*