Physiology of micturition

This is something to understand well so you can then simplify for your clients or patients

Learning Objectives:

- Identify and describe the Functional Anatomy of Urinary Bladder
- Describe the mechanism of filling and emptying of the urinary bladder
- Cystometrogram
- Appreciate neurogenic control of the mechanism of micturition and its disorders.

Urinary Bladder

Anatomical consideration:

- **Body: Wall of bladder contain smooth muscle in different arrangement (detrusor muscle), contraction → emptying of bladder during micturition.**
- **Neck**

- **2 sphincters:**

-internal urethral sphincters (IUS) in either side of urethra, made of smooth muscle.

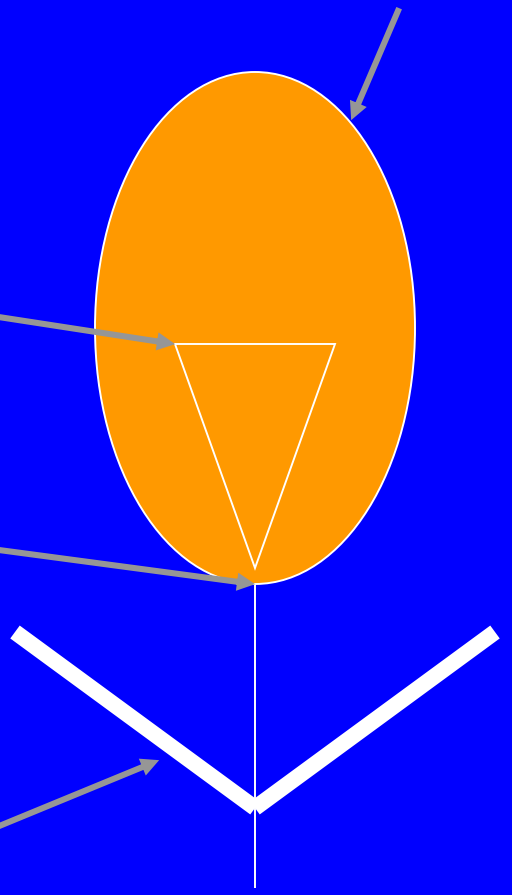
-External urethral sphincter (EUS), made of skeletal muscle.

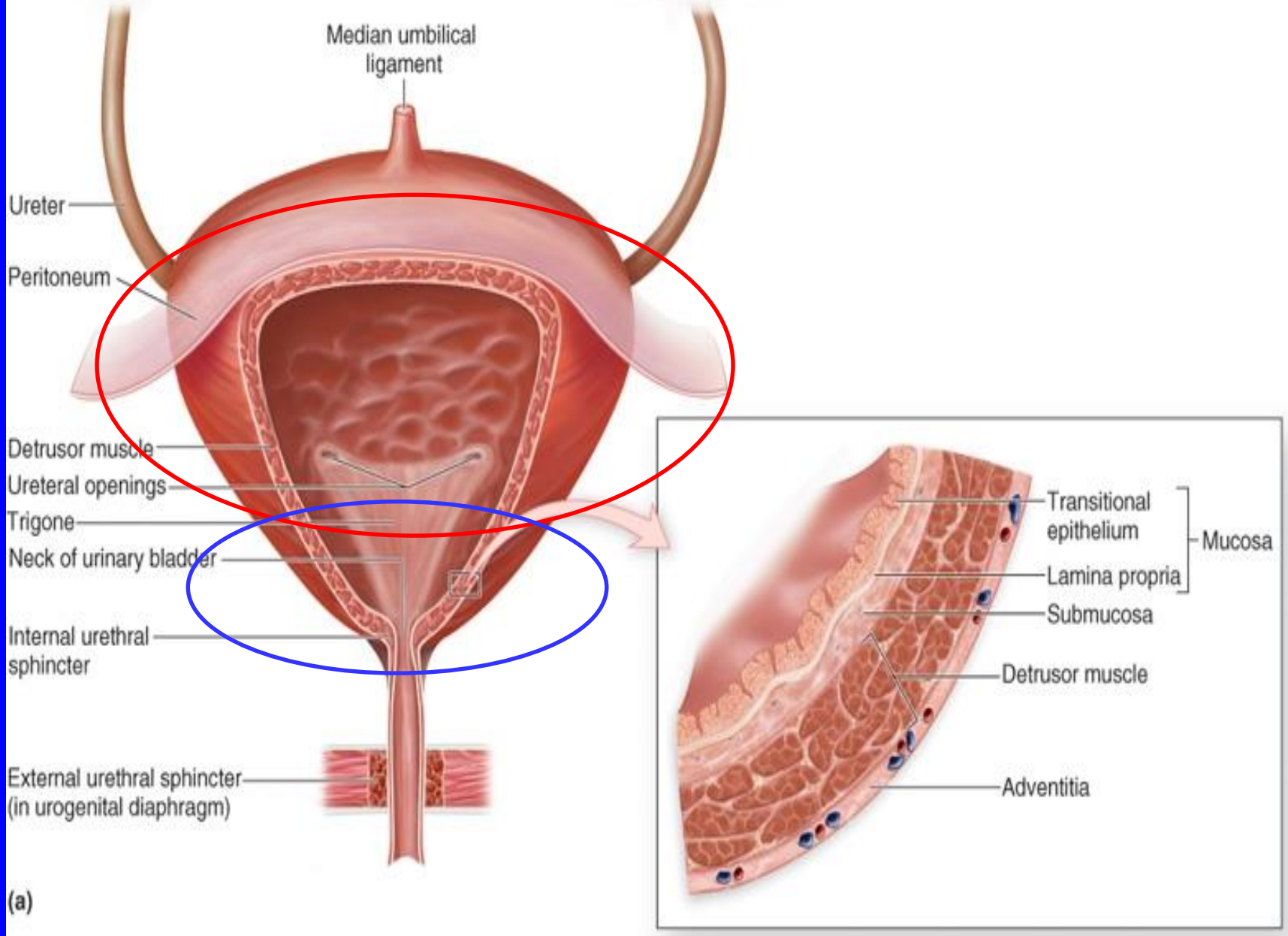
Detrusor – smooth muscle of the bladder wall

Trigone – smooth muscle at bladder base

Internal sphincter – smooth muscle at the bladder neck

External urethral sphincter – skeletal muscle





Innervations of UB

Nerve Supply to the Bladder

A.Sympathetic nerve (Hypogastric n)

B. Pelvic nerve (Parasympathetic)

C. Pudendal nerve (Somatic N)

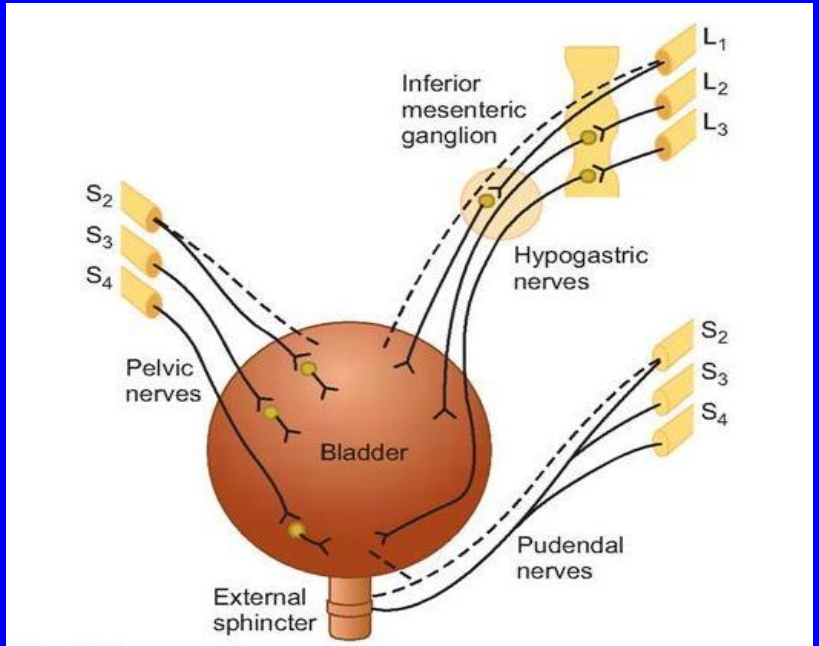


FIGURE 38–20 **Innervation of the bladder.** Dashed lines indicate sensory nerves. Parasympathetic innervation is shown at the left, sympathetic at the upper right, and somatic at the lower right.

INNERVATION OF THE BLADDER

	Nerves	Characteristic	Function
1	Pelvic nerves (parasympathetic fibers) S-2 and S-3	Both sensory and motor nerve fibers	Contraction of bladder The sensory fibers detect the degree of stretch in the bladder wall
2	Pudendal Nerve	somatic nerve	Fibers that innervate and control the voluntary skeletal muscle of the sphincter
3	Hypogastric Nerves	sympathetic innervation (L2)	Stimulate mainly the blood vessels and have little to do with bladder contraction. Sensory nerve fibers of the sympathetic nerves also mediate the sensation of fullness and pain.

Autonomic Innervations of the bladder

	Parasympathetic Supply	Sympathetic Supply
Nerve	Pelvic nerve	Hypogastric Nerve
Efferents:		
Origin:	-LHCs of the S 2,3, and 4.	- L1,2, and 3.
Supply:	-Body and neck of the bladder.	- Bladder neck.
Functions	a) Contraction of bladder wall. b) Relaxation of the bladder neck → stimulation of the detrusor ms of the body causes longitudinal layers to open the bladder neck.	a) Contraction of bladder neck, specially the middle layer→ facilitate the storage of urine. b) Relaxation of the bladder wall.
Afferents:	a) Carry input from stretch receptors in the bladder neck.. b) Detect bladder fullness. c) Carry pain and temperature sensation.	a) Transmit pain sensation b) Detect bladder fullness

- **Sympathetic supply to the bladder cause storage of urine.**
- **Parasympathetic supply leads to the Passage of urine.**

Somatic Innervations of the bladder

The Pudendal nerves (AHCs of S 2,3,and 4)

- Its efferent fibers arise as the **parasympathetic nerves** from the 2nd, 3rd and 4th sacral segments of the spinal cord but from the AHCs.
- They supply and control the activity of the external urethral sphincter

Micturition

Definition: Micturition is the process of emptying the urinary bladder through the urethra .

- **Filling of bladder.**
- **Micturition reflex.**
- **Voluntary control.**

Micturition Reflex

Two processes are involved:

(1)The bladder fills progressively until the tension in its wall is above a threshold level, and then

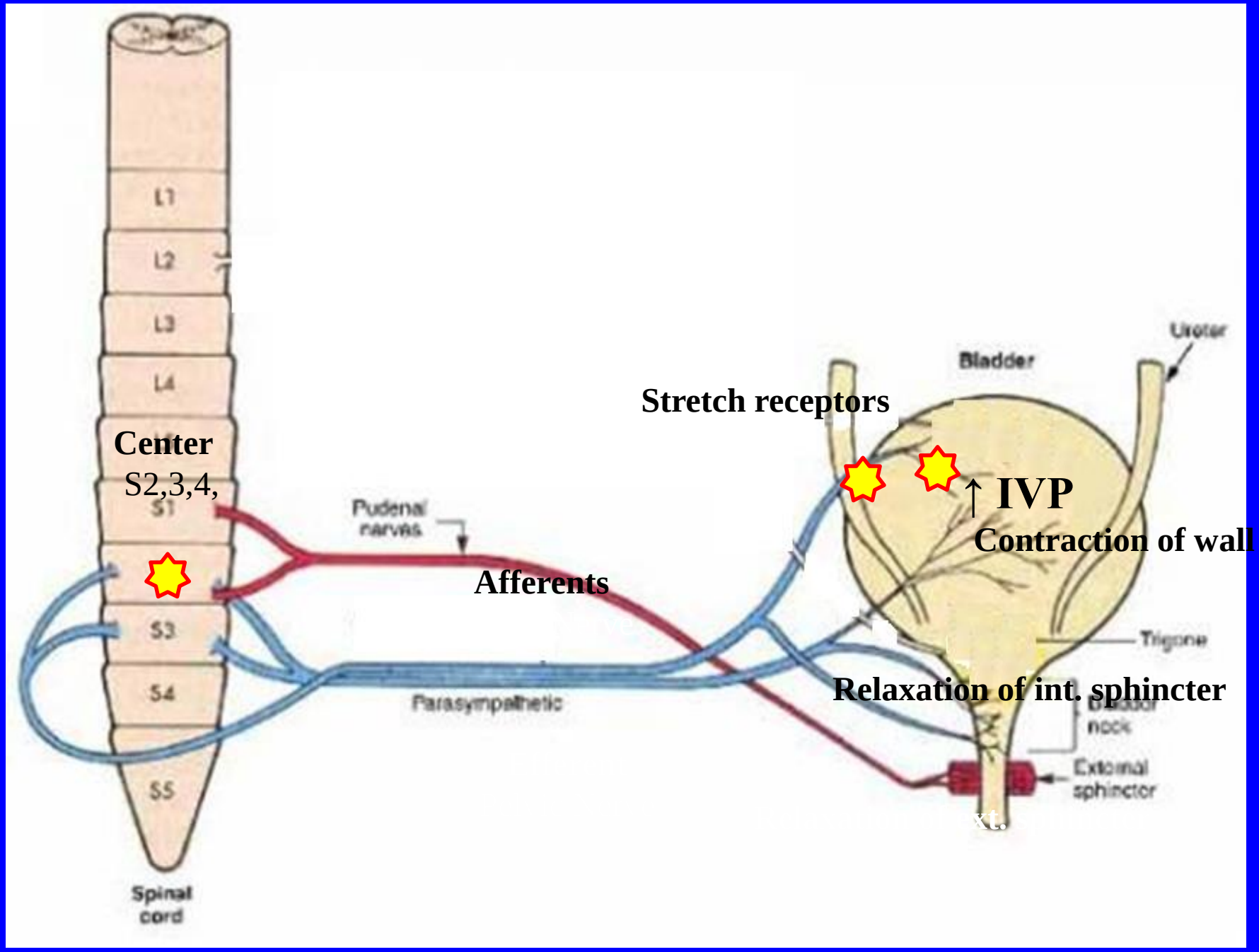
(2)A nervous reflex called the micturition reflex occurs that empties the bladder → at 150-200mls of urine volume

The micturition reflex is an autonomic spinal cord reflex: however, it can be inhibited or facilitated by centers in the brainstem and cerebral cortex.

Micturition Reflexes

- **Center**: sacral segments 2, 3 & 4.
- **Receptors**: stretch (receptor) in the wall of bladder.
- **Afferent & efferent**: pelvic nerve.
- **Response**:

1. Contraction of detrusor muscle (body).
2. Relaxation of **internal sphincter of urethra.**
3. Relaxation of **external urethral sphincter** via the pudendal nerve which is somatic nerve originating from AHC of sacral segment 2, 3, & 4.


L1
L2
L3
L4
S1
S3
S4
S5
Spinal cord
Pudenal nerves
Parasympathetic
Ureter
Bladder
Trigone
Bladder neck
External sphincter
Center
S2,3,4,
Stretch receptors
↑ IVP
Contraction of wall
Afferents
Relaxation of int. sphincter

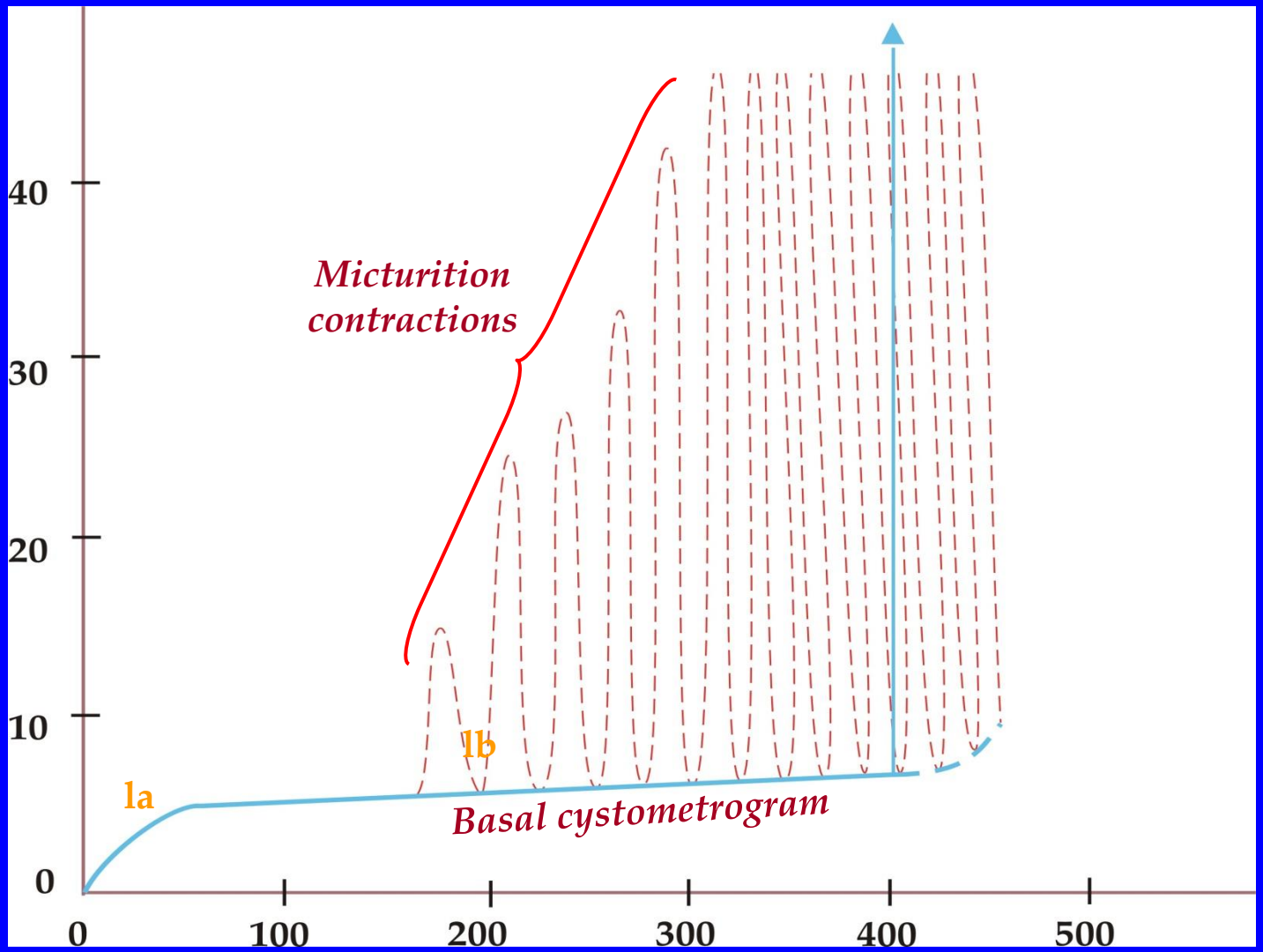
Cystometry

Study the relationship between intravesical volume and pressure.

Done by inserting catheter and emptying the bladder, then recording the pressure while bladder filled at 50ml increment of water.

This plot is known as the cystometrogram.

Cystometrogram



Guyton 312-313

Plot has 3 components (segments):

Ia – initial slight rise in pressure when the first increment in volume are produced

Ib – a long, nearly flat segment as further increments are produced (conscious level to void at about 150mL)

II – a sudden, sharp rise in pressure as the micturition reflex is triggered (sense of fullness and urge to void at about 400mL)

Laplace Law

The flatness of segment Ib is a manifestation of the law of Laplace, which states that the pressure in the spherical viscus equal to twice the wall tension divided the radius.

$$P = 2T / r$$

Sensations from the U.B at different urine volumes:

- At a urine volume of **150 –300 ml** ⇒ the first urge to void urine.
- From **300 –400 ml** ⇒ sense of fullness of the bladder.
- From **400 –600 ml** ⇒ sense of discomfort.
- From **600 –700 ml** ⇒ sense of pain.
- **Micturition reflexes** start to appear at the first stage. They are progressively intensified in the subsequent stages up to stage 4. Micturition reflexes can be voluntarily suppressed.
- At about 700 ml ⇒ break point ⇒ micturition can not be suppressed.

Control of Micturition reflex

It is a complete autonomic spinal reflex to get urine outside the body, that is facilitated or inhibited by higher brain centers.

Voluntary Control of Micturition

Higher Centers Control Micturition

- **1) Cerebral cortex:** Motor cortex exerts a voluntary control of micturition either stimulation or inhibition.
- **2) Hypothalamus:** There is facilitatory area in the hypothalamus.
- **3) Midbrain:** Inhibition.
- **4) Pons:** facilitation

Mechanism of voluntary control of micturition:

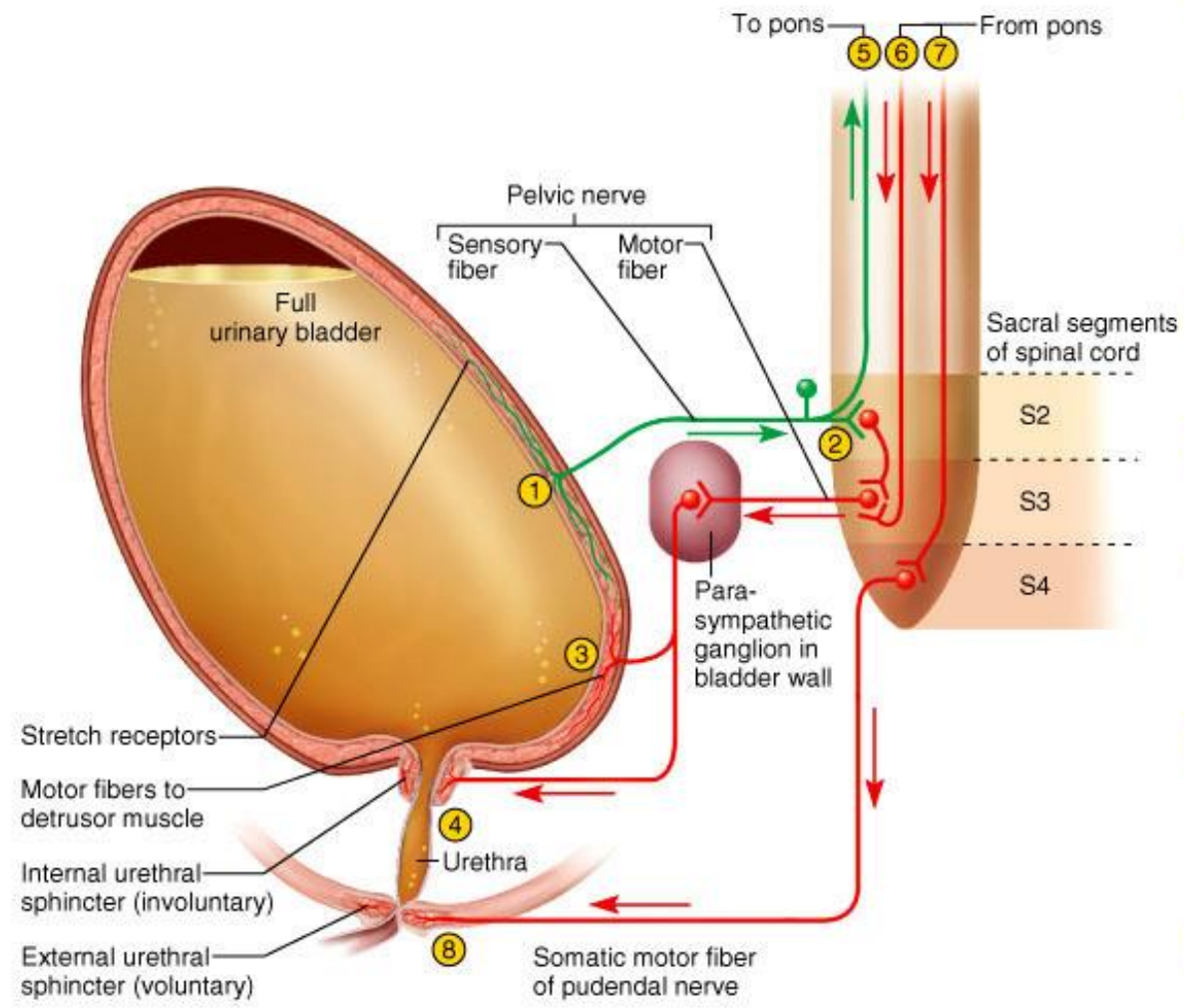
- Filling of the bladder beyond **300 –400 ml** causes stretching of sensory stretch receptors.
- These sensory signals stimulate sacral segment, which is consciously appreciated by higher centers.

If the condition is favourable

- The cortical centers facilitate micturition by discharging signals that leads to:
  - Stimulation of sacral micturition center.
  - Inhibition of pudendal nerves ⇒ relaxation of external urethral sphincter.
  - Contraction of anterior abdominal muscle & diaphragm to increase intra-abdominal pressure ⇒ the intra-vesical pressure is increased. This intensifies the micturition reflex.

If the conditions are unfavorable

- The higher centers will inhibit the micturition reflex by:
  - Inhibition of sacral micturition center.
  - Stimulation of pudendal nerves ⇒ contraction of external urethral sphincter.



1. Stretch receptors detect filling of bladder, transmit afferent signals to spinal cord.
2. Signals return to bladder from spinal cord segments S2 and S3 via parasympathetic fibers in pelvic nerve.
3. Efferent signals excite detrusor muscle.
4. Efferent signals relax internal urethral sphincter. Urine is involuntarily voided if not inhibited by brain.
5. For voluntary control, micturition center in pons receives signals from stretch receptors.
6. If it is timely to urinate, pons returns signals to spinal interneurons that excite detrusor and relax internal urethral sphincter. Urine is voided.
7. If it is untimely to urinate, signals from pons excite spinal interneurons that keep external urethral sphincter contracted. Urine is retained in bladder.
8. If it is timely to urinate, signals from pons cease and external urethral sphincter relaxes. Urine is voided.

1) APs generated by stretch receptors

2) reflex arc generates APs that

3) stimulate smooth muscle lining bladder

4) relax internal urethral sphincter (IUS)

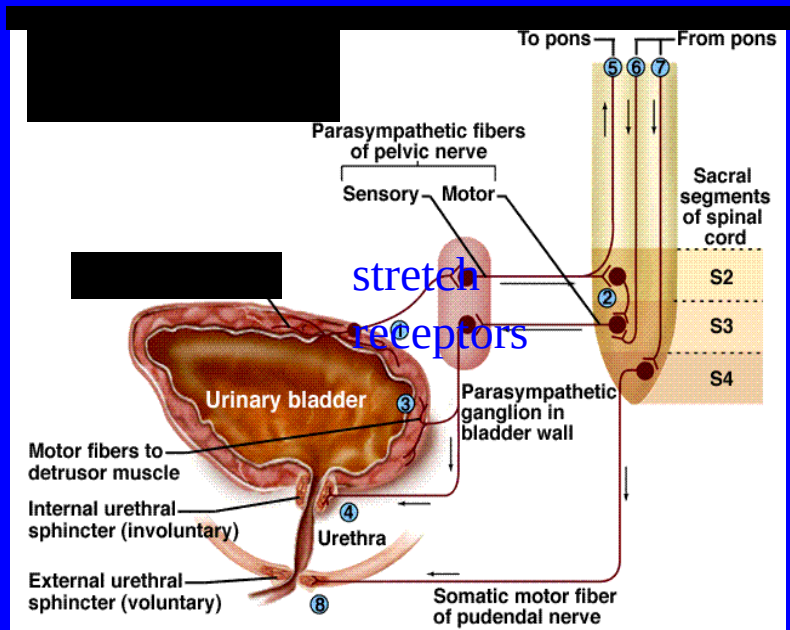
5) stretch receptors also send APs to Pons

6) if it is o.k. to urinate

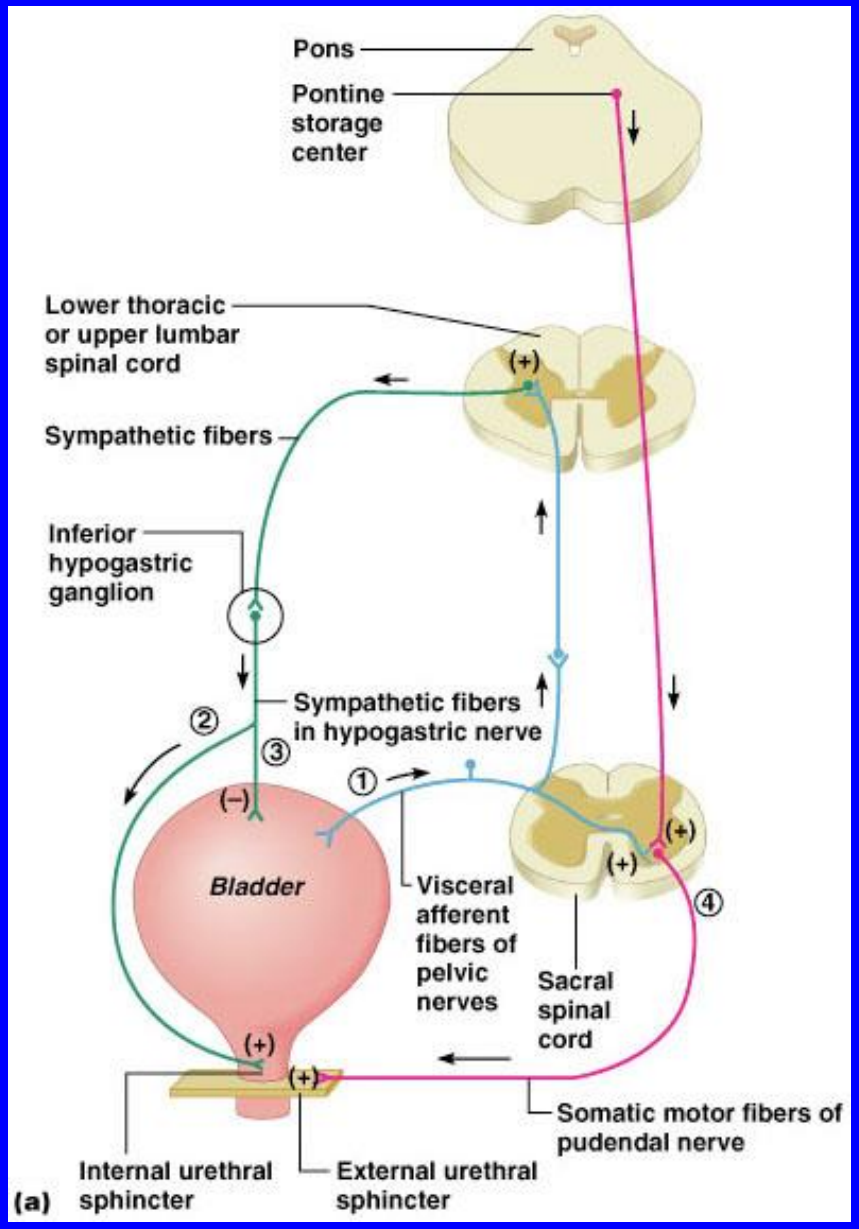
- –APs from Pons excite smooth muscle of bladder and relax IUS
- –relax external urethral sphincter

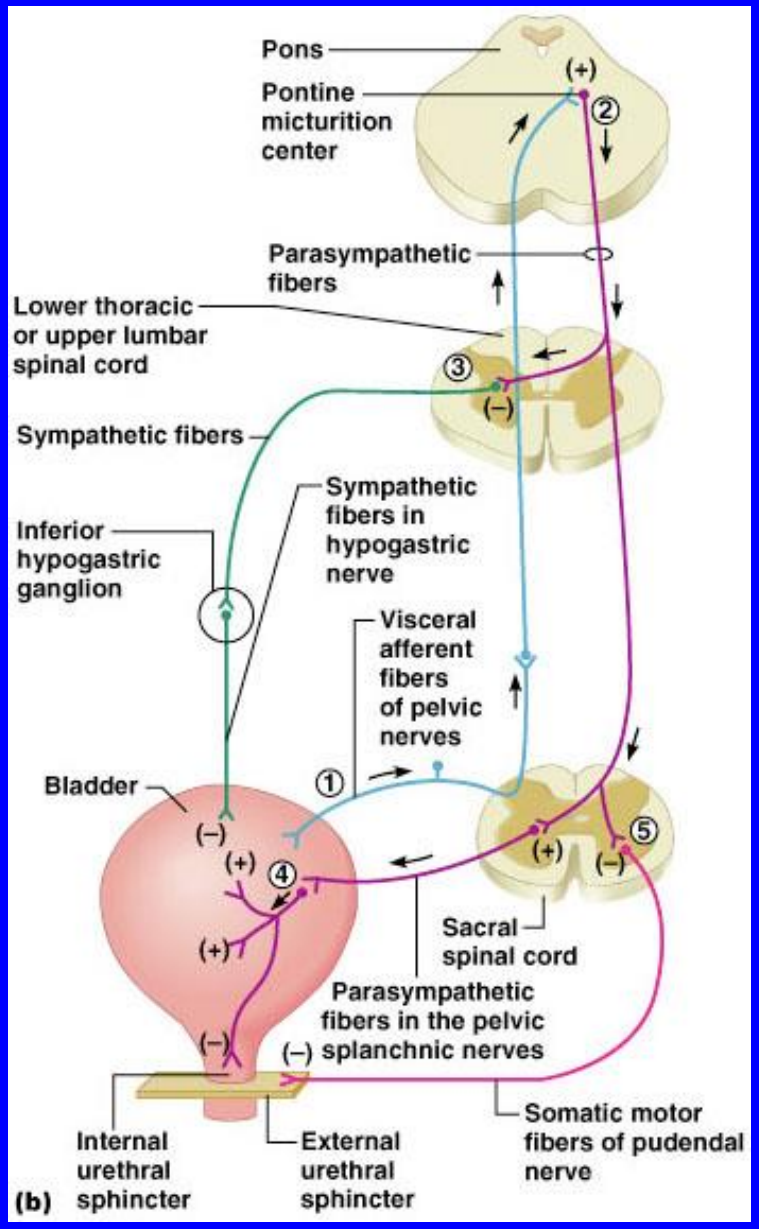
7) if not o.k.

- –APs from Pons keep external urethral sphincter contracted

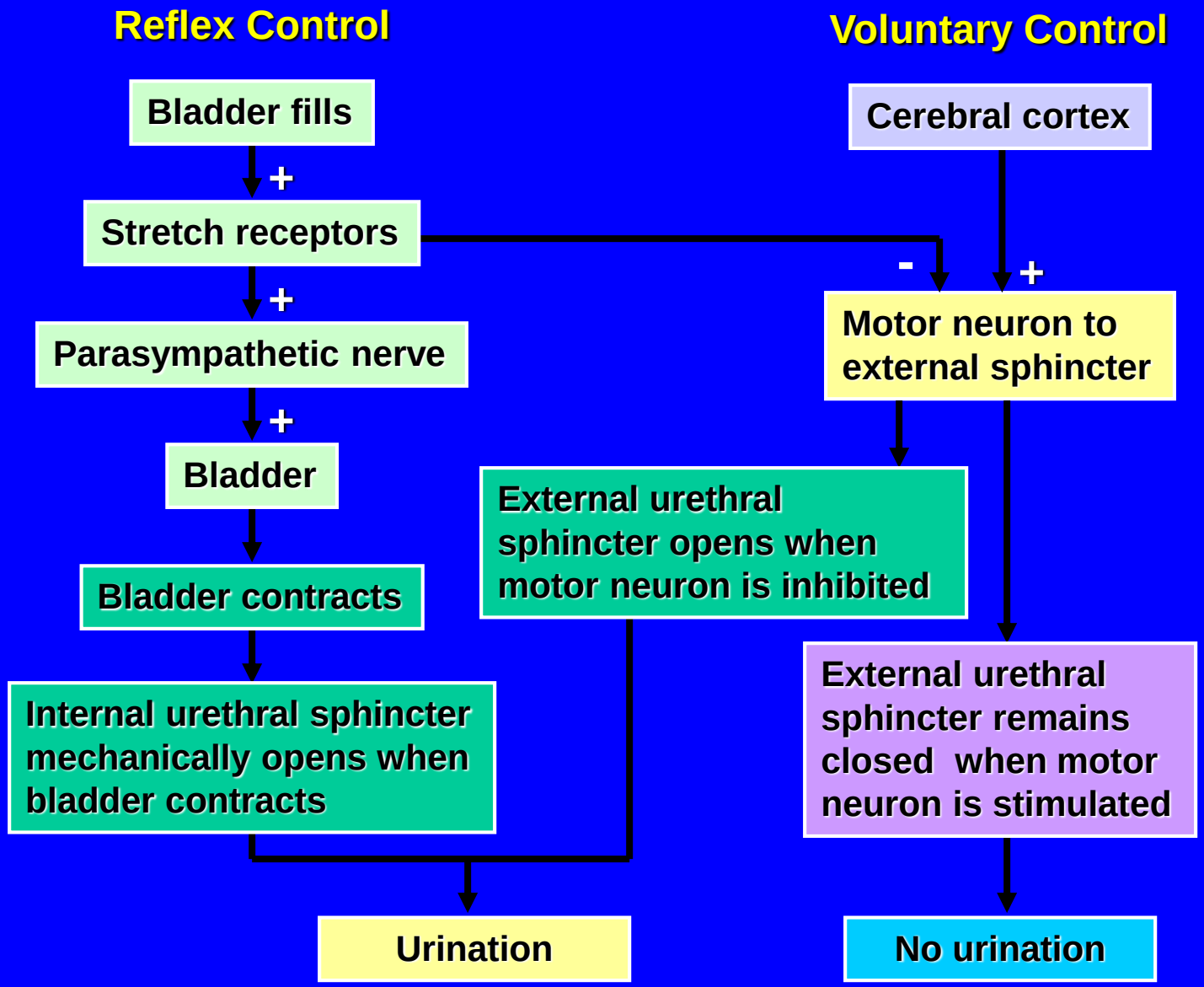


Micturition (Voiding or Urination)



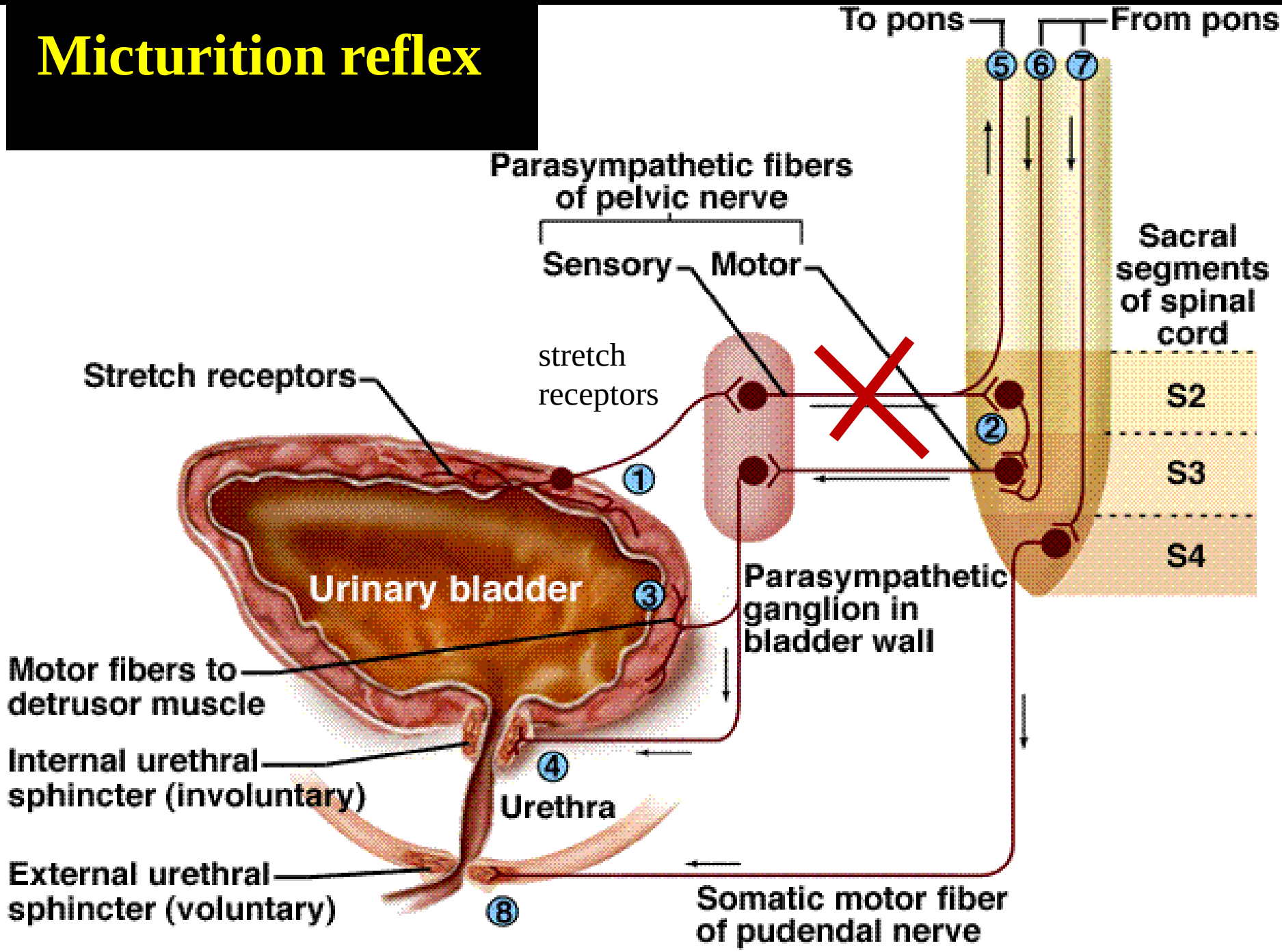


Reflex and Voluntary Control of Micturition



Disturbances of micturition

Micturition reflex

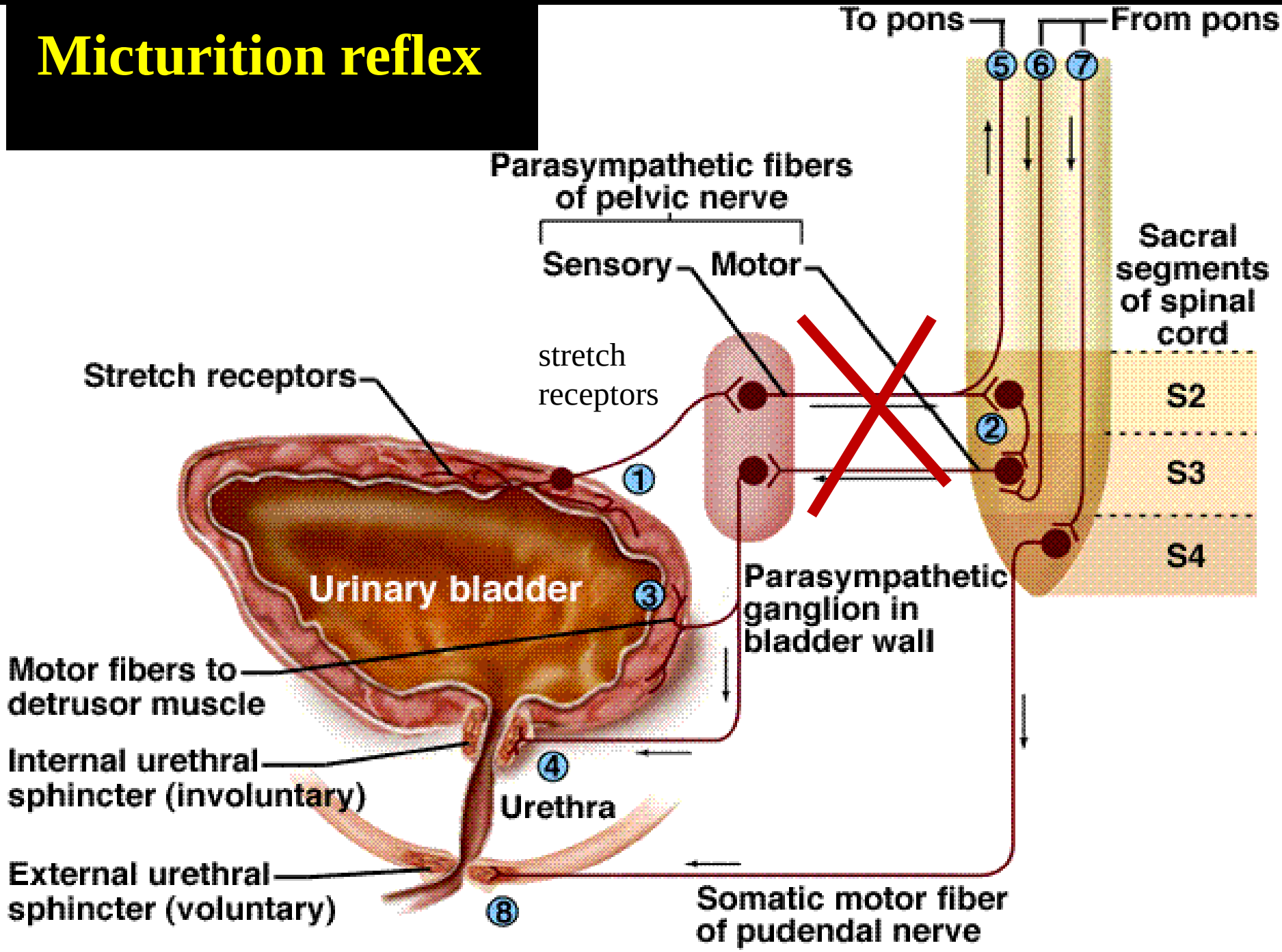


Disturbances of micturition

- **Denervation of the afferent supply e.g.in tabes dorsalis (tabetic bladder):**
- **Characterized by:**
  - Loss of the U.B. sensations & reflex micturition.
  - Some intrinsic responses of the smooth muscle are retained.
  - The bladder becomes distended, thin walled & hypotonic(atonic bladder).
  - There is retention with overflow i.e. dribbling of urine when the bladder becomes over filled.

Notes: Tabes dorsalis is a late manifestation of untreated syphilis and is characterized by a triad of clinical symptoms namely gait unsteadiness, lightning pains and urinary incontinence. It occurs due to a slow and progressive degeneration of nerve cells and fibers in spinal cord. It is one of the forms of tertiary syphilis or neurosyphilis.

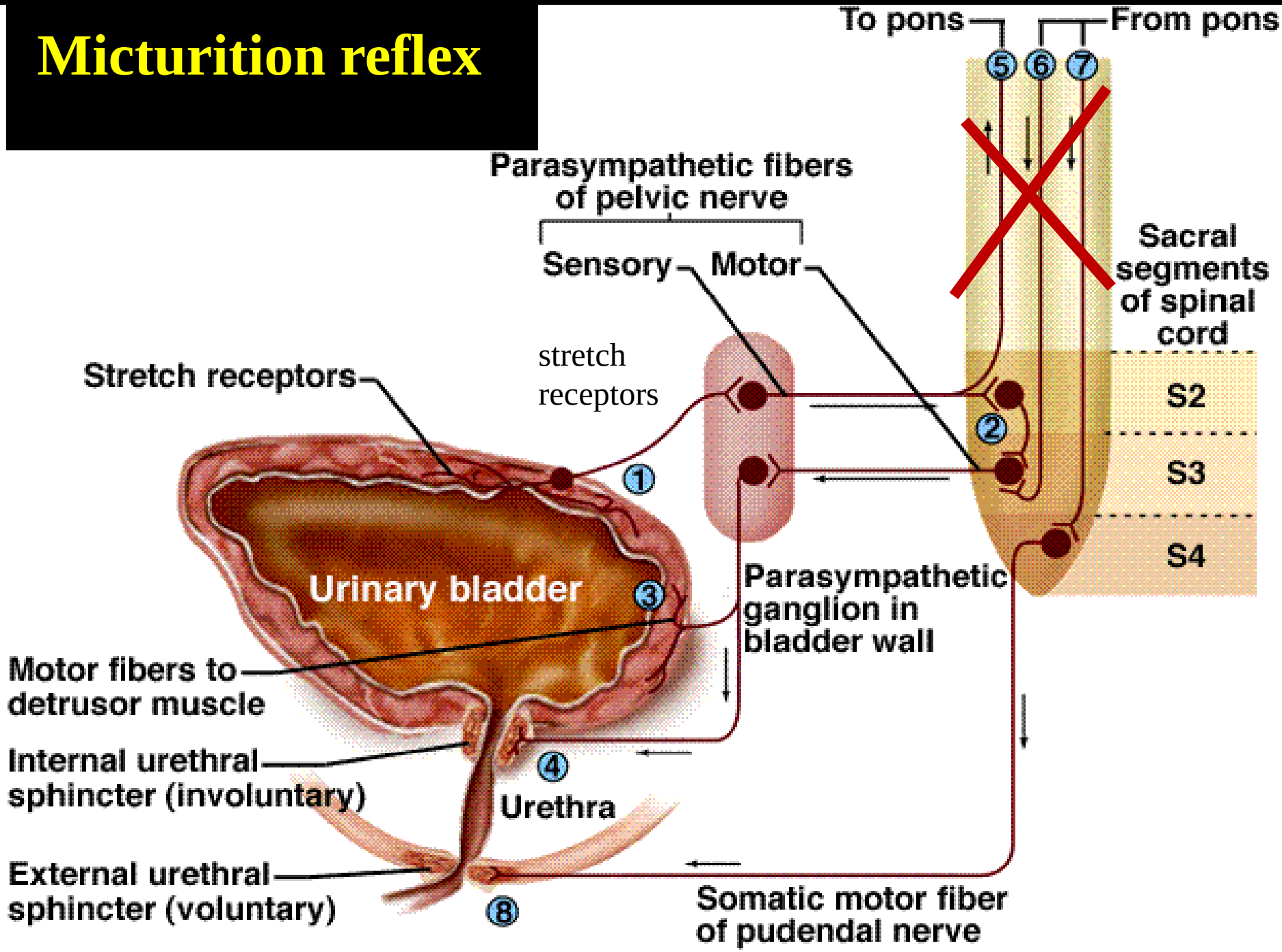
Micturition reflex



Disturbances of micturition

- **Denervation of the afferent & efferent supply e.g. tumour, injury to cauda equina.**
- **Characterized by:**
  - Reflexes are abolished.
  - Intrinsic responses of the smooth muscles are increased.
  - The bladder is hypertonic.
- This is due to denervation hypersensitivity because:
  - ↓ degradation of acetyl choline by process of reuptake.
  - ↓ cholinesterase in the tissue
  - ↑ number of cholinergic receptors.
- This condition is associated with uncontrolled periodic micturition about 25 – 100 ml at a time

Micturition reflex



ABNORMALITIES OF MICTURITION

	ATONIC BLADDER	AUTOMATIC BLADDER
Lesion	Sensory nerve fibers from the bladder to the spinal cord are destroyed Crush injury to the sacral region of the spinal cord *and tabes dorsalis*	Spinal Cord Damage Above the Sacral Region resulting in Spinal shock
Feature	Bladder fills to capacity and overflows a few drops at a time through the urethra. This is called *overflow incontinence*.	return of excitability of micturition reflex until typical micturition reflexes returns & then, periodic (but unannounced) bladder emptying occurs which may be controlled by scratching or tickling

Notes:

Uninhibited Neurogenic Bladder Caused by Lack of Inhibitory Signals from the Brain. Therefore, facilitative impulses passing continually down the cord keep the sacral centers so excitable that even a small quantity of urine elicits an uncontrollable micturition reflex, thereby promoting frequent urination.

Essential functions and anatomy
The bladder has two functions – storage and voiding. Afferent pathways (T12–S4) respond to pressure within the bladder and sensation from the genitalia. As the bladder distends, continence is maintained by suppression of parasympathetic and reciprocal activation of sympathetic outflow. Both are under some voluntary control. Voiding takes place by parasympathetic activation of the detrusor, and relaxation of the internal sphincter (Table 21.18).
Cortical awareness of bladder fullness is located in the post-central gyrus, parasagittally, while initiation of micturition is in the pre-central gyrus. Voluntary control of micturition is located in the frontal cortex, parasagittally.
Neurological disorders of micturition

Notes cont …

Urogenital tract disease is dealt with largely by urologists. Incontinence is common and easy to recognize; neurological causes are sometimes not obvious. These are:

Cortical:

- Post-central lesions cause loss of sense of bladder fullness.
- Pre-central lesions cause difficulty initiating micturition.
- Frontal lesions cause socially inappropriate micturition.

Spinal cord. Bilateral UMN lesions (pyramidal tracts) cause urinary frequency and incontinence. The bladder is small and hypertonic, i.e. sensitive to small changes in intravesical pressure. Frontal lesions can also cause a hypertonic bladder.

LMN. Sacral lesions (conus medullaris, sacral root and pelvic nerve – bilateral) cause a flaccid, atonic bladder that overflows (cauda equina, p. 1177), often unexpectedly.

Management. Assessment of both urological causes (e.g. calculi, prostatism, gynaecological problems) and potential neurological causes of incontinence is necessary. Intermittent self-catheterization is used by many patients, with for example spinal cord lesions.