RENAL PHYSIOLOGY

COUNTER CURRENT MECHANISM

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COUNTER CURRENT MECHANISM

- KIDNEYS HAVE
  - MECHANISMS FOR EXCRETING EXCESS WATER
  - MECHANISMS FOR EXCRETING EXCESS SOLUTES

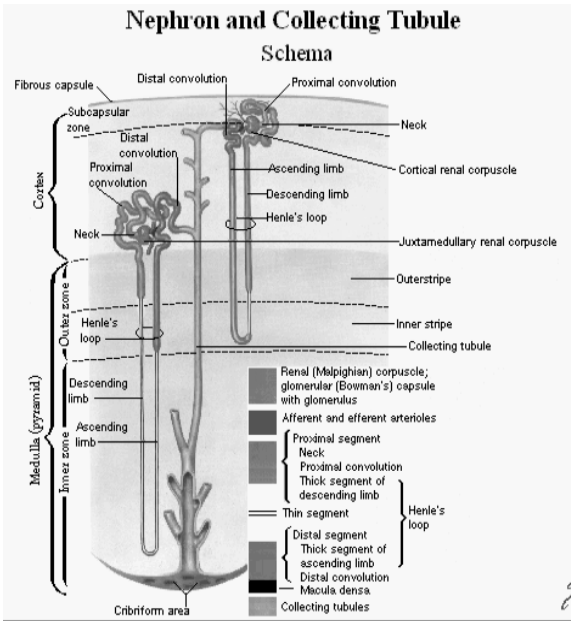
Obligatory Urine Volume $\frac{600\ \text{mOsm/day}}{1200\ \text{mOsm/L}} = 0.5\ \text{L/day}$

NEPHRON TYPES

- **Superficial (cortical) [85 %]**
  - **Capable of forming dilute urine**
- **Juxtamedullary [15-25 %]**
  - **Capable of forming concentrated (> 300 mOsm/kg) urine**

NEPHRON TYPES
Cortical and Juxtamedullary Nephrons

1-2 % Blood Flows Through Juxta Medullary Nephrons



NEPHRON TYPES

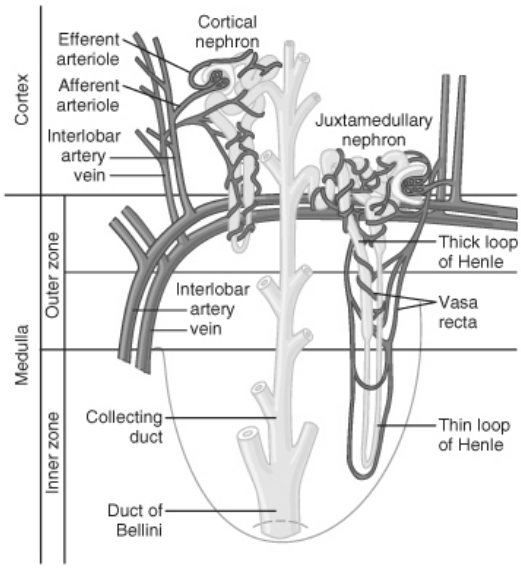
- Cortical Nephrons have
  - Peritubular Capillaries
- Juxtamedullary Nephron have
  - Vasa Recta

EXCRETION LIMITS

- At least 600 mmol must be excreted each day
  - minimum volume = 600/1200 = 0.5 L
  - maximum volume = 20 L

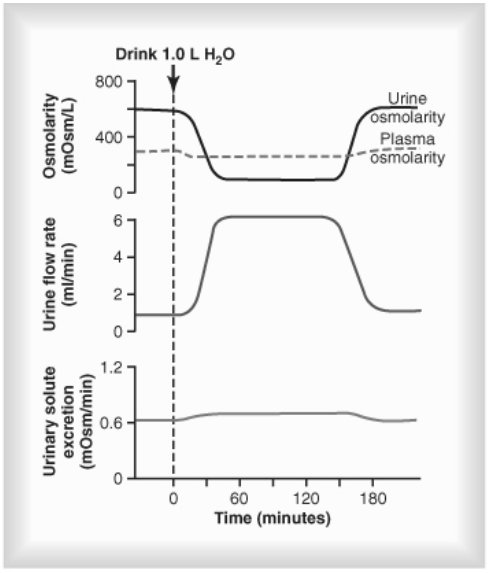
NEPHRON TYPES
Cortical and Juxtamedullary Nephrons

1-2 % Blood Flows Through Juxta Medullary Nephrons



COUNTER CURRENT MECHANISM

- **LOOPS OF HENLE OF JUXTA MEDULLARY NEPHRONS establish hyperosmolality of interstitium of medulla. They are called COUNTER CURRENT MULTIPLIERS**
- **VASA RECTA maintain hyperosmolality established by counter current multipliers. They are called COUNTER CURRENT EXCHANGERS**



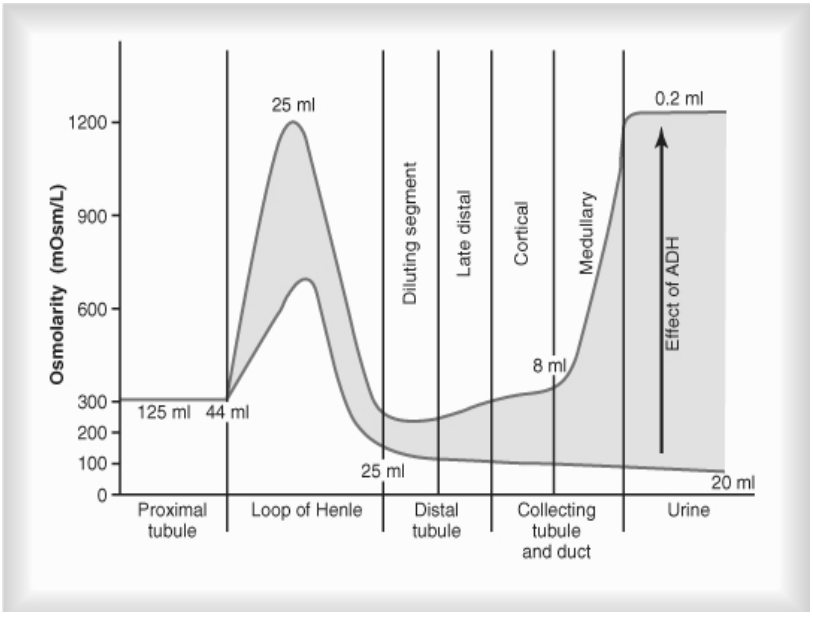
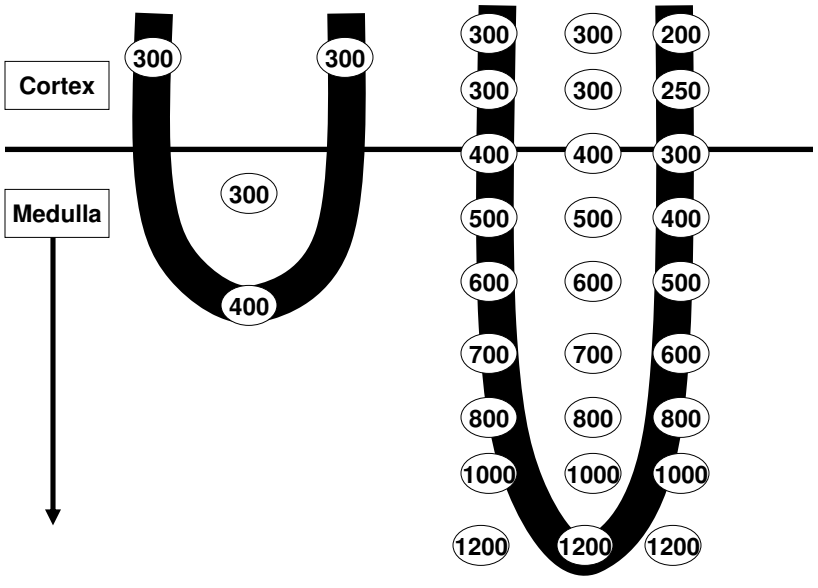


Table 28–1

Summary of Tubule Characteristics—Urine Concentration

	Active NaCl Transport	Permeability		
		H_2O	NaCl	Urea
Proximal tubule	++	++	+	+
Thin descending limb	0	++	+	+
Thin ascending limb	0	0	+	+
Thick ascending limb	++	0	0	0
Distal tubule	+	+ADH	0	0
Cortical collecting tubule	+	+ADH	0	0
Inner medullary collecting duct	+	+ADH	0	++ADH

0, minimal level of active transport or permeability; +, moderate level of active transport or permeability; ++, high level of active transport or permeability; +ADH, permeability to water or urea is increased by ADH.

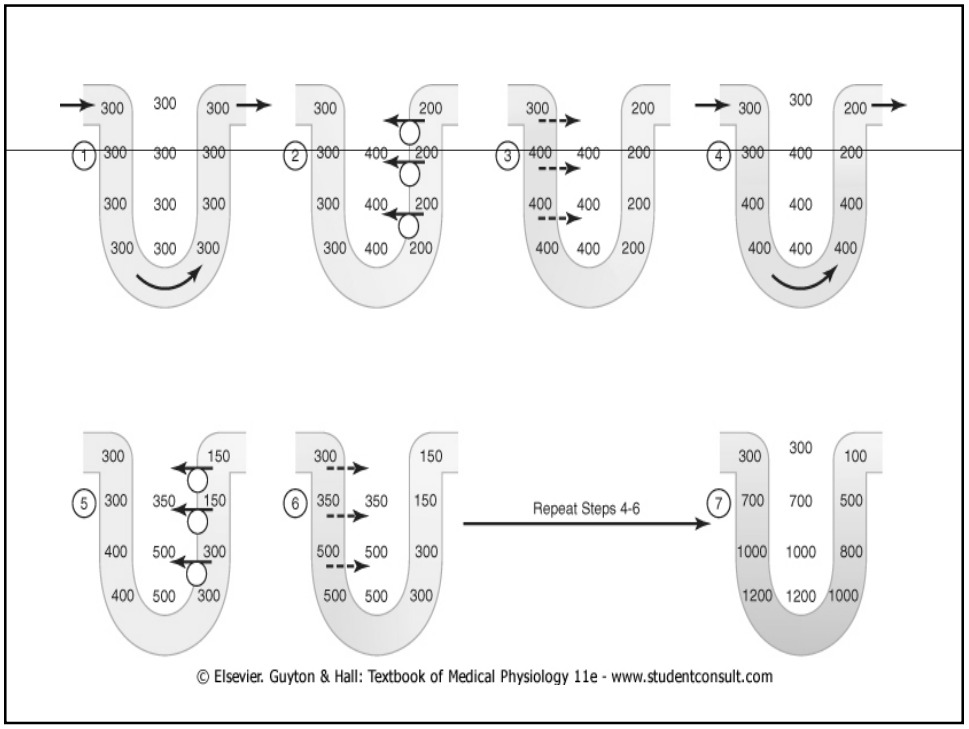


LOOP OF HENLE

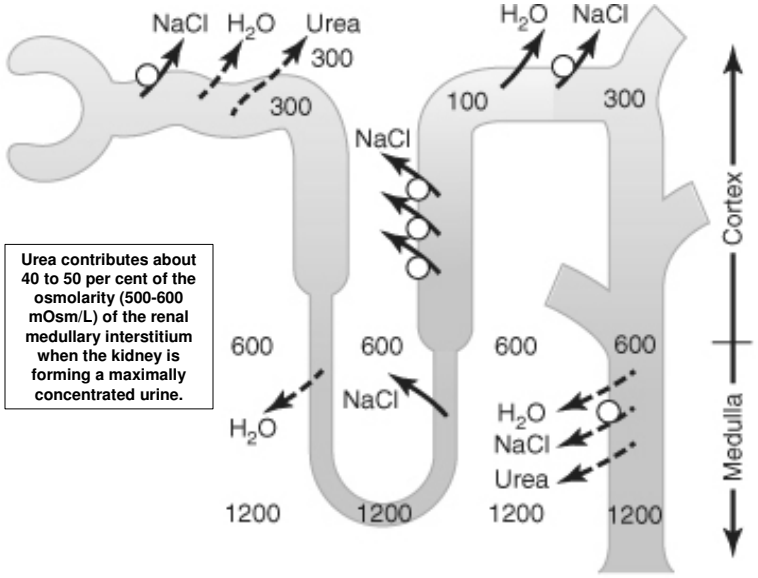
Descending Loop	Ascending Loop
highly permeable to water	impermeable to water
impermeable to Na^+	permeable to Na^+ (mediated by $Na^+/K^+/2Cl^-$ apical carrier - inhibited by furosemide (Lasix))
water exit promoted	Na^+/K^+-ATPase actively pumps out sodium of cell into interstitium

Buildup of solute concentration into the renal medulla

1. **Active transport of sodium ions and co-transport of potassium, chloride, and other ions out of the thick portion of the ascending limb of the loop of Henle into the medullary interstitium**
2. **Active transport of ions from the collecting ducts into the medullary interstitium**
3. **Facilitated diffusion of large amounts of urea from the inner medullary collecting ducts into the medullary interstitium**
4. **Diffusion of only small amounts of water from the medullary tubules into the medullary interstitium,far less than the reabsorption of solutes into the medullary interstitium**



Role of DCT & CT in Excreting a Concentrated Urine

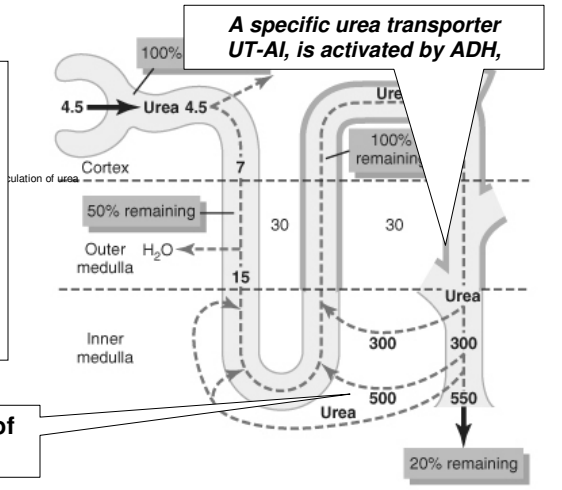


owever, urea

Urea contributes about 40 to 50 per cent of the osmolarity (500-600 mOsm/L) of the renal medullary interstitium when the kidney is forming a maximally concentrated urine.

ROLE OF UREA IN MAKING A HYPEROSMOTIC RENAL MEDULLARY INTERSTITIUM AND CONCENTRATED URINE

About 40 to 50 % of the osmolarity (500-600 mOsm/L) of the renal medullary interstitium when the kidney is forming a maximally concentrated urine.



r. Guyton & Hall: Textbook of Medical Physiology 11e - www.studentcor

two special features of the renal medullary blood flow

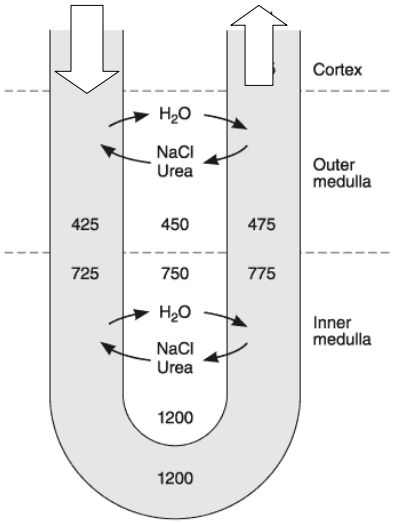
- **The medullary blood flow is low, accounting for less than 5 per cent of the total renal blood flow. This sluggish blood flow is sufficient to supply the metabolic needs of the tissues but helps to minimize solute loss from the medullary interstitium.**
- **The vasa recta serve as countercurrent exchangers, minimizing washout of solutes from the medullary interstitium.**

COUNTER CURRENT EXCHANGERS

- Sluggish blood flow (1-2 %)
- Close proximity
- High permeability

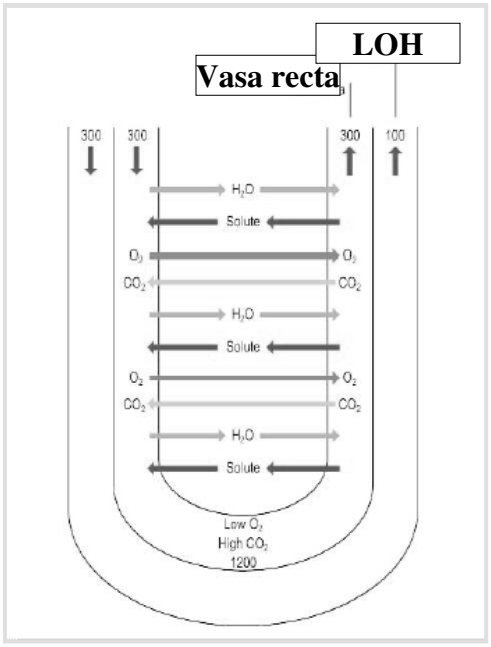
COUNTER CURRENT EXCHANGERS

A PASSIVE PROCESS

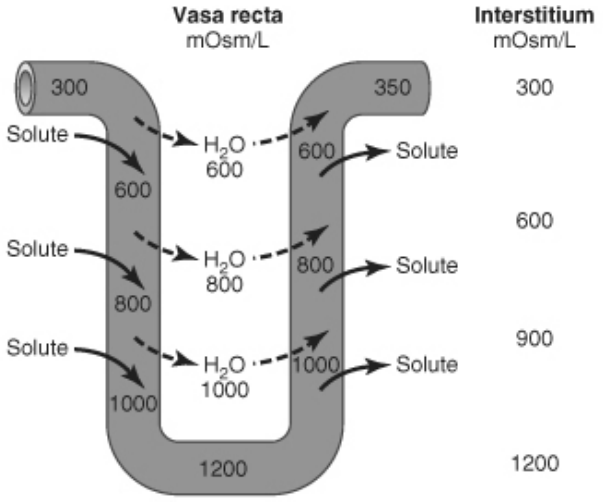


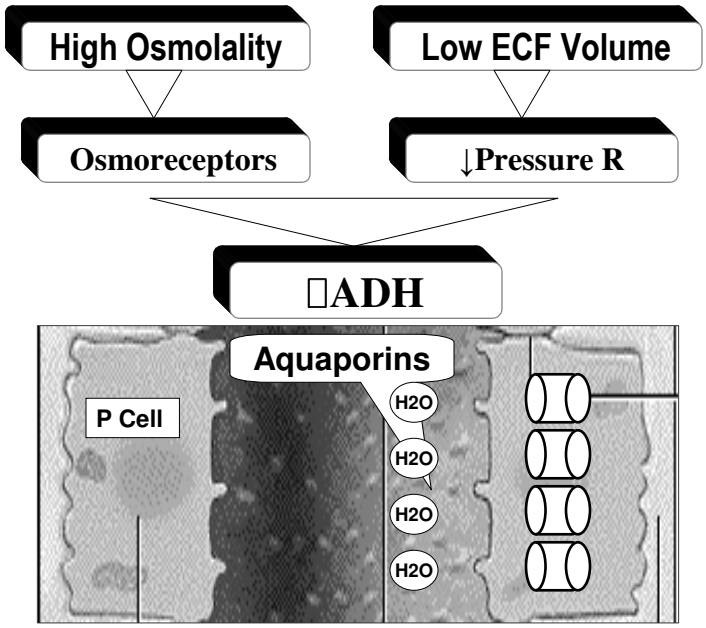
COUNTER CURRENT EXCHANGERS

COUNTER CURRENT MULTIPLIERS



COUNTER CURRENT EXCHANGERS





DISORDERS OF URINARY CONCENTRATING ABILITY

- **Failure to Produce ADH: "Central" Diabetes Insipidus.**
- **Inability of the Kidneys to Respond to ADH: "Nephrogenic" Diabetes Insipidus.**

DISORDERS OF URINARY CONCENTRATING ABILITY

- **Inappropriate secretion of ADH (SIADH)**

RENAL PHYSIOLOGY
MICTURITION

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MICTURITION

It is the process by which the urinary bladder empties when it becomes filled

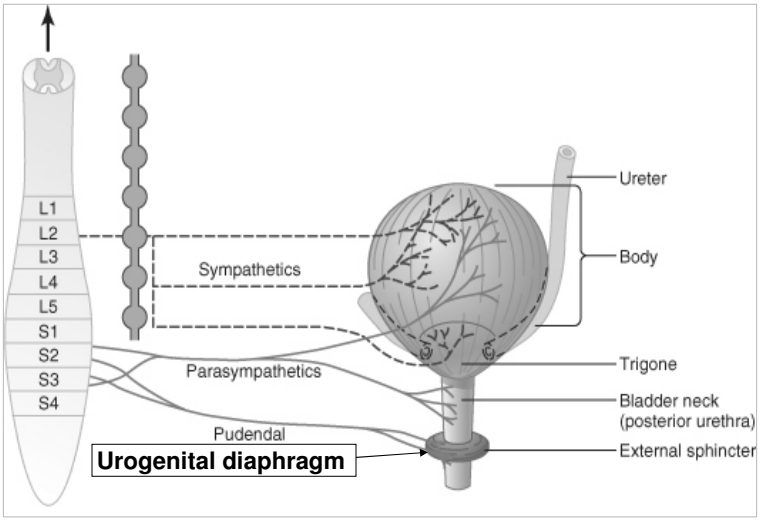
- **Filling of bladder.**
- **Micturition reflex.**
- **Voluntary control.**

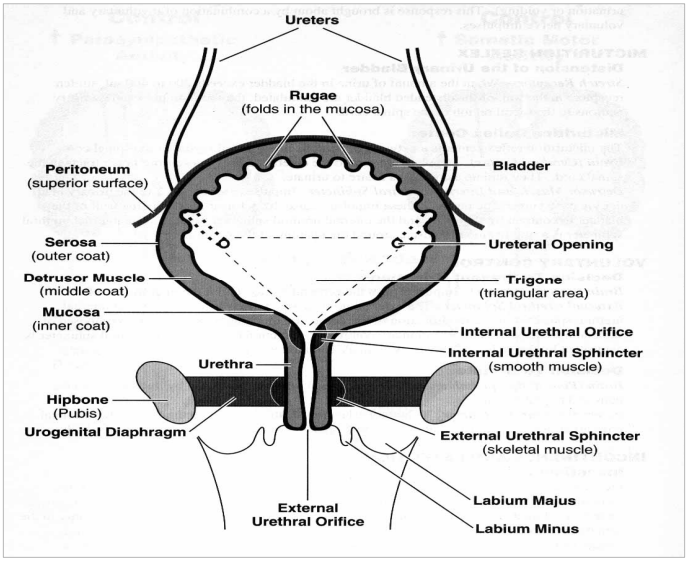
Physiologic Anatomy and Nervous Connections of the Bladder

- **Composed of**
  1. **Body**
  2. **Neck……..post urethra (stretch receptors)**
- **External sphincter.**
- **Pelvic diaphragm.**

A reservoir … adult … 250-400ml
DETRUSOR MUSCLE … pr can rise upto 40-60 mmHg.
Mucosa… RUGAE …TRIGONE

Nervous Connections of the Bladder





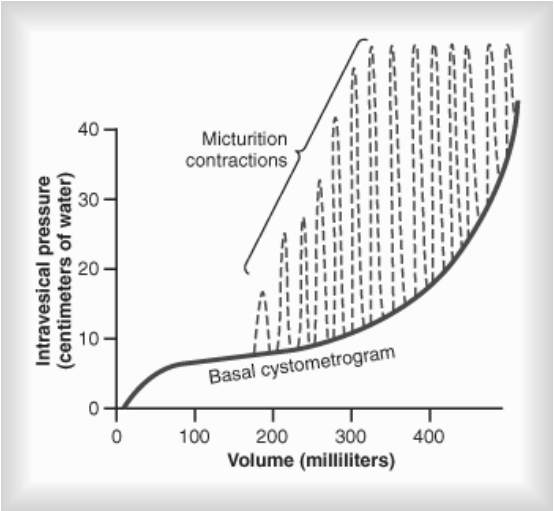
Nerve Supply

- **PELVIC NERVES** from sacral plexus mainly S2 and S3…both sensory and motor.The motor nerves transmitted in the pelvic nerves are **parasympathetic fibers**
- **PUDENDAL NERVE** contain skeletal motor fibers transmitted through the to the external bladder sphincter
- **SYMPATHETIC INNERVATION** from the sympathetic chain through the hypogastric nerves (L-2). Stimulate mainly the blood vessels and have little to do with bladder contraction. Some sensory nerve fibers for fullness and pain.

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.

CYSTOMETROGRAM



MICTURITION REFLEX

Micturition Reflex

- **Completely AUTONOMIC SPINAL REFLEX.**
- **When bladder only partially filled..relax spontaneously after a fraction of a min, Detrusor muscle contraction stops … pr falls to baseline.**
- **As bladder fills more… reflexes increase in frequency and intensity.**
- **Positive feedback mechanism.**

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