Test of Renal Function

Objectives

At the end of the lecture the student should be able to;

- list the renal function tests
- explain the biochemical basis of renal function tests
- renal function tests in renal disorders

Renal functions

You have to teach me

-Glomerular function ?

-Tubular function?

Major Renal function Tests

1 Urine analysis

2 Serum Markers for renal functions

3 Estimation of GFR

4Tests for Tubular function

Urinalysis (Physical & Chemical analysis)

Physical characteristics

- **Volume -**

  Oliguria , Anuria , Polyuria

- **Appearance -**

  Colour Turbidity

- **Odor -**

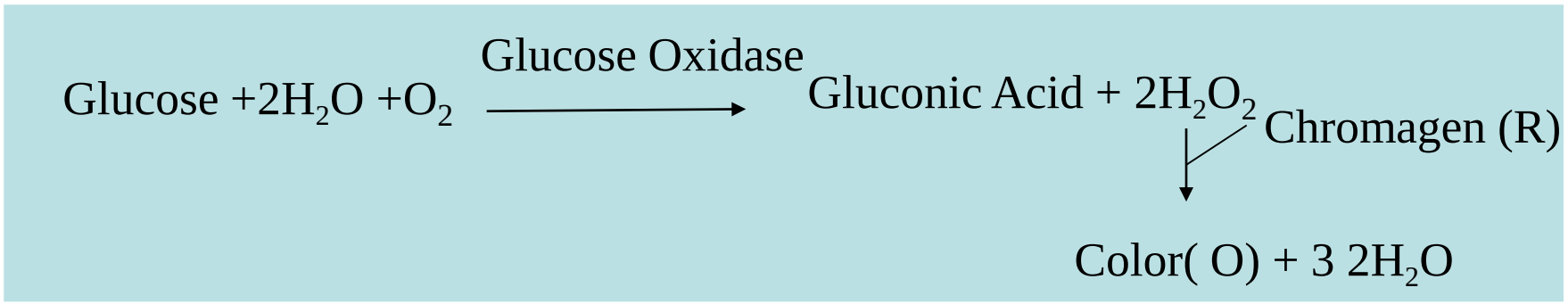
- **Specific gravity -**
- **pH -**

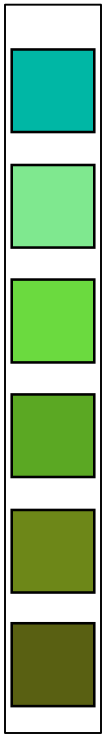
Chemical Analysis

Urine Dipstick

- Glucose
- Bilirubin
- Ketones
- Specific Gravity
- Blood
- pH
- Protein
- Urobilinogen
- Nitrite
- Leukocyte Esterase

Glucose





Negative

Trace (100 mg/dL)

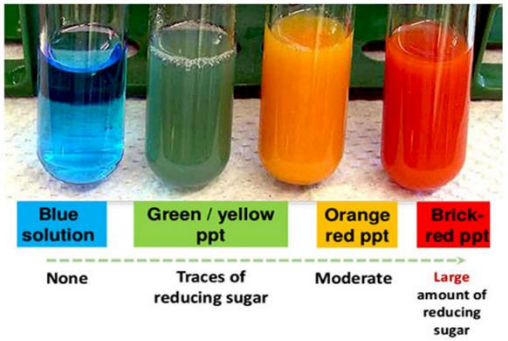
+ (250 mg/dL)

++ (500 mg/dL)

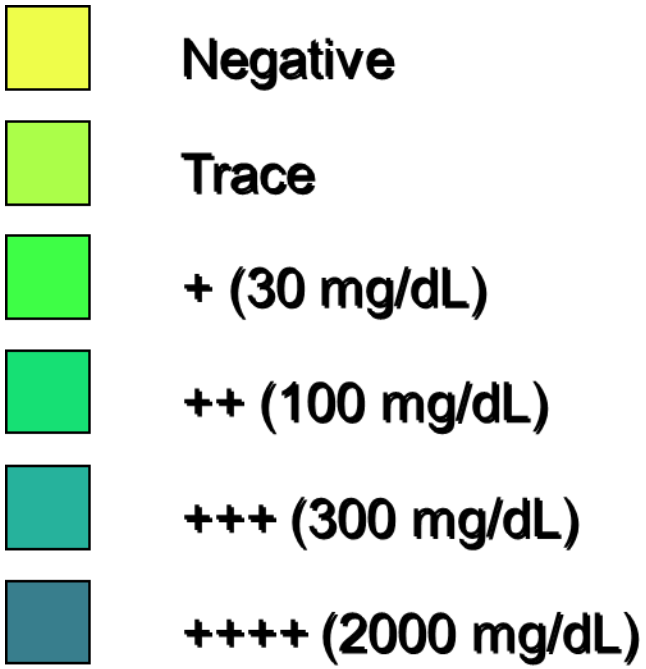
+++ (1000 mg/dL)

++++ (2000+ mg/dL)

BENADICTS TEST



Protein
Renal Function Test



Causes

- Functional
- Renal
- Pre renal
- Post renal

Tests for protein

Protein analysis is carried out to

- ❖ Establish the renal disease
- ❖ Define the nature of the renal disease
- ❖ Define the degree of renal dysfunction
- ❖ Monitor response to treatment

Protein in 24 hr urine collection

Spot sample (1st void sample is the best)

Urinary Protein/Creatinine ratio(PCR)

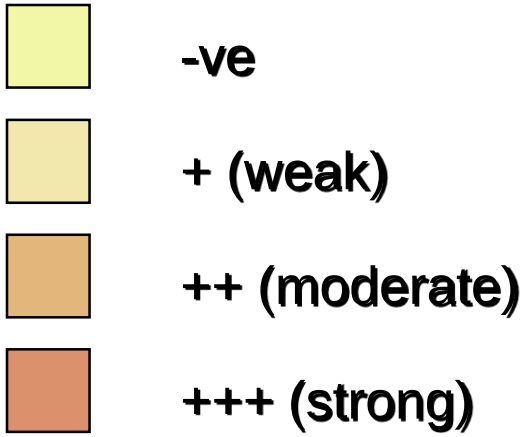
Albumin/creatinine ratio (ACR)

Table 15. Definitions of Proteinuria and Albuminuria

	Urine Collection Method	Normal	Microalbuminuria	Albuminuria or Clinical Proteinuria
Total Protein	24-Hour Excretion (varies with method)	<300 mg/day	NA	>300 mg/day
	Spot Urine Dipstick	<30 mg/dL	NA	>30 mg/dL
	Spot Urine Protein-to-Creatinine Ratio (varies with method)	<200 mg/g	NA	>200 mg/g
Albumin	24-Hour Excretion	<30 mg/day	30–300 mg/day	>300 mg/day
	Spot Urine Albumin-Specific Dipstick	<3 mg/dL	>3 mg/dL	NA
	Spot Urine Albumin-to-Creatinine Ratio (varies by gender[a])	<17 mg/g (men) <25 mg/g (women)	17–250 mg/g (men) 25–355 mg/g (women)	>250 mg/g (men) >355 mg/g (women)

[a] Gender-specific cut-off values are from a single study.[19] Use of the same cut-off value for men and women leads tc higher values of prevalence for women than men. Current recommendations from the American Diabetes Associatior define cut-off values for spot urine albumin-to-creatinine ratio for microalbuminuria and albuminuria as 30 and 30(mg/g, respectively, without regard to gender.[8]

Bilirrubin



-ve

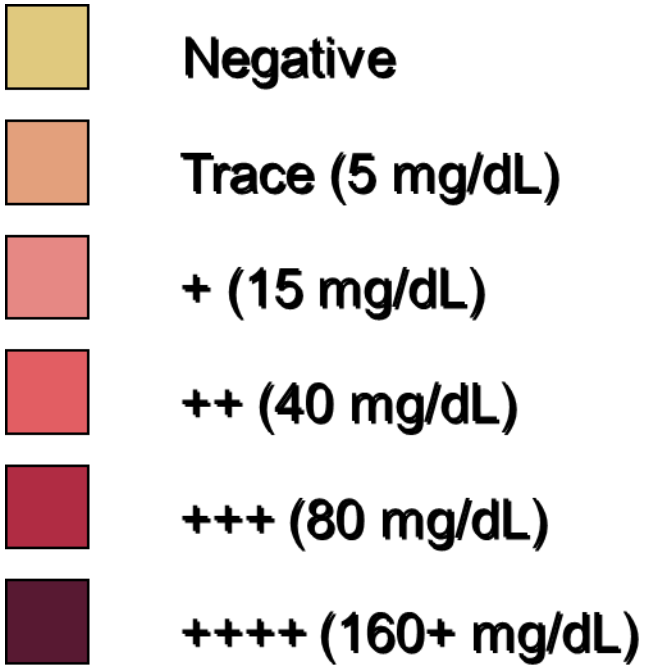
+ (weak)

++ (moderate)

+++ (strong)

Only Direct Bilirubin

Ketones



Negative

Trace (5 mg/dL)

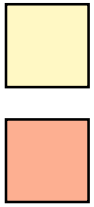
+ (15 mg/dL)

++ (40 mg/dL)

+++ (80 mg/dL)

++++ (160+ mg/dL)

Nitrite



Negative

Positive

Gram negative bacteriuria
Only able to detect bacteria that reduce nitrate to nitrite

Serum Markers for renal functions

Serum Markers for renal functions

- Serum Creatinine
- Serum Urea

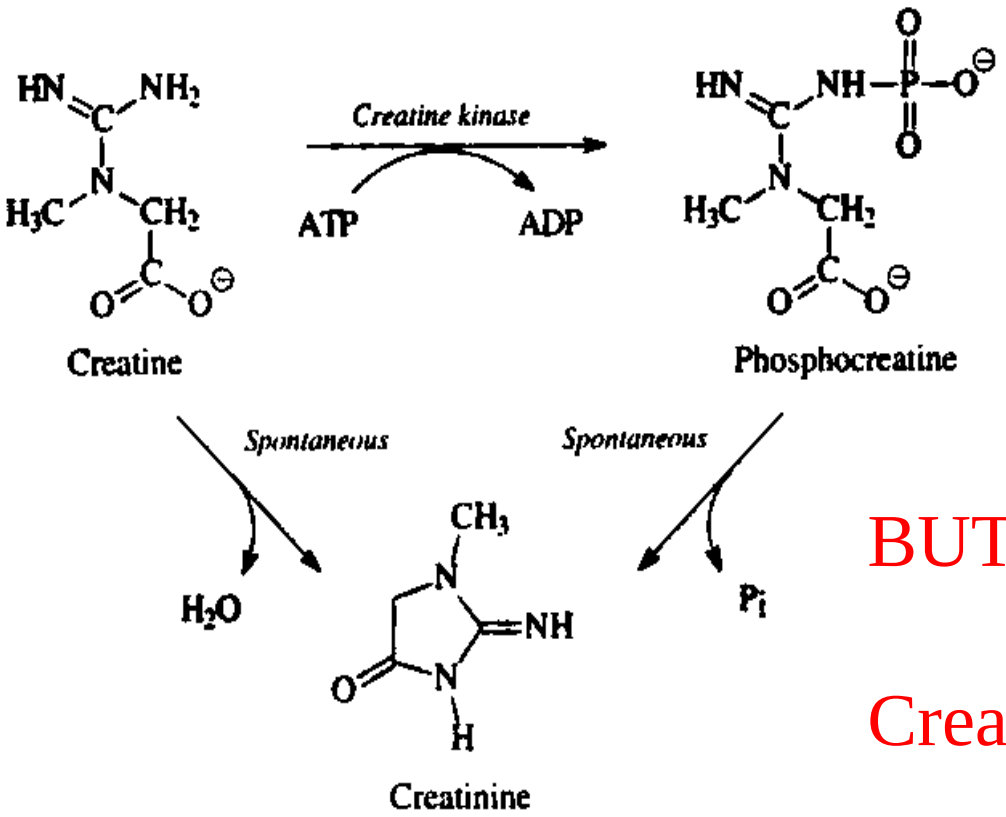
Serum Creatinine

Kidney is the major of excretion
Freely filtered neither reabsorption no secretion

What is ?

Creatinine

1 to 2% of muscle creatinine spontaneously converts to creatinine daily and released into body fluids at a constant rate.



BUT?

Creatinine α muscle mass

Plasma creatinine concentration is inversely related to the GFR

Normal plasma creatinine does not necessarily imply normal renal function

GFR can decrease by 50% before plasma creatinine concentration rises beyond the normal range

Normal levels

men - 0.7 to 1.3 mg/dL

women- 0.6 to 1.1 mg/dL

Blood Urea Nitrogen (BUN)

Urea is filtered freely by the glomeruli

* But ? Reabsorbed and excreted (GFR underestimated)

Increased

-Renal

-Pre renal problems (decreased perfusion of the kidneys increased)

-Post renal (obstruction)

-Non renal (high protein intake ,dehydration, increased protein catabolism, starvation,)

Decreased -low protein intake, liver disease.

normal adults level is 7mg/dl – 20mg/dl

Estimation of glomerular filtration rate

Clearance test

GFR can be estimated by measuring the urinary excretion of a substance that is

- **completely filtered from the blood by the glomeruli**
- **not secreted, reabsorbed or metabolized by the renal tubules**.

Clearance is defined as the (hypothetical) quantity of blood or plasma completely cleared of a substance per unit of time**. (ml/minute)**

$$GFR = \frac{UxV}{P}$$

U= Concentration in urine mg/dl

V= Volume of urine (ml)pass in a minute

P= Concentration in plasma mg/dl

Substances use in clearance test

Inulin

Gold standard

No secretion or absorption in the tubules

But need to infuse in to blood

Not use in clinical practice

Other substances

Cystatin-C good

Urea

Creatinine

Creatinine

Creatinine **clearance is approximately 10% greater than inulin clearance**. (Normal Clearance)

-It is freely filtered by the glomerulus, but also actively secrete by tubular cells in very small amounts

-So creatinine clearance overestimates actual GFR

-The difference is not significant when GFR is normal

➢but when the **GFR is low** (less 10 ml/min),

it is significant

Estimated GFR

Various formula

❖MDRD(Modification of Diet in Renal Disease)

creatinine in mg/dl (MDRD4)

$$eGFR = 186 \times \text{Serum Creatinine}^{-1.154} \times \text{Age}^{-0.203} \times [1.210\ if\ Black] \times [0.742\ if\ Female]$$

Used to stage CKD (not in normal person)

❖CDK-EPI (Chronic Kidney Disease Epidemiology Collaboration)

$$eGFR = 141 \times \min(\text{SCr}/\text{k},1)^{a} \times \max(\text{SCr}/\text{k},1)^{-1.209} \times 0.993^{Age} \times [1.018\ if\ Female] \times [1.159\ if\ Black]$$

Glomerular permeability

Proteinuria.

Micro albumin

Albumin

Protein

Renal tubular function tests

Proximal tubule - tubular handling of sodium, glucose, phosphate, calcium, bicarbonate and amino acids

Distal tubule -urinary acidification and concentration

Tests

1. Urine specific gravity and osmolality
2. Day night urine volume
3. Serum electrolytes
4. Concentration test
5. Dilution test

49 year old man with history of hypertension, diabetes presents with four day history of right sided flank pain radiate to groin and “pink urine.”

Etiology

Supersaturation of urine with solutes

Solubility is affected by urine pH, volume and total excretion

Those factors can often be modified with medications and diet

Risk Factors

-Male sex

-Obesity

-Family History

-H/o stone disease (1/2 will have recurrence)

-Dietary factors

-Lower fluid intake, higher animal protein, higher Vitamin C

Signs/Symptoms

Typical symptoms

1.Sudden onset

Unilateral colicky flank pain radiating to groin (localization of pain evolves as stone migrates)

2.Often with nausea/vomiting

3.Hematuria (microscopic or gross)

Differential Diagnosis

Differential for flank pain with hematuria

-UTI

-Renal Cell Carcinoma

-Ectopic pregnancy

-Dissecting Aortic artery A with renal artery involvement

Types of Stones

In order of prevalence

- Calcium Oxalate
- Calcium Phosphate
- Struvite
- Uric Acid
- Cysteine

Urinalysis:

may show

Hematuria (90% sensitive)

Signs of infection

Crystals

Elevated pH (urea-splitting bugs?) or low pH (RTA?)

Metabolic workup: Consider only if recurrent

Imaging

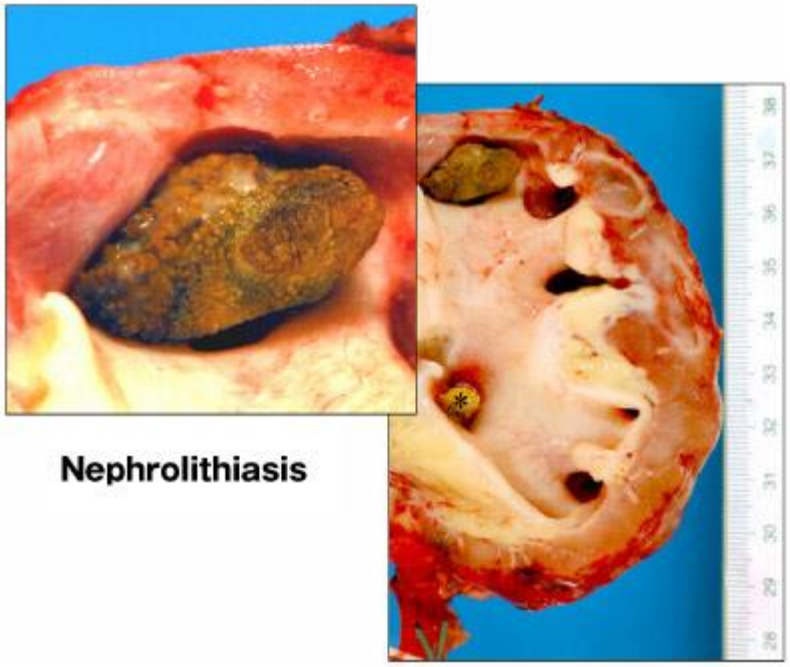
Non-Contrast helical CT

Ultrasound:

KUB: Will miss radiolucent uric acid stones, small stones, stones with overlying bony structures.

Basic chemical inredient	Occurrence	Macroscopic view	Neorenal efficiency
Calcium oxalate monohydrate	39.5%		++
Calcium oxalate dihydrate	20.6%		++
Uric acid	15.1%		+++
Calcium phosphate	0.1%		+++
Magnesium ammonium phosphate	23.3%		+++
Calcium hydrogen phosphate	0.1%		+++
Cystine	1.2%		+
Xanthine	0.1%		+

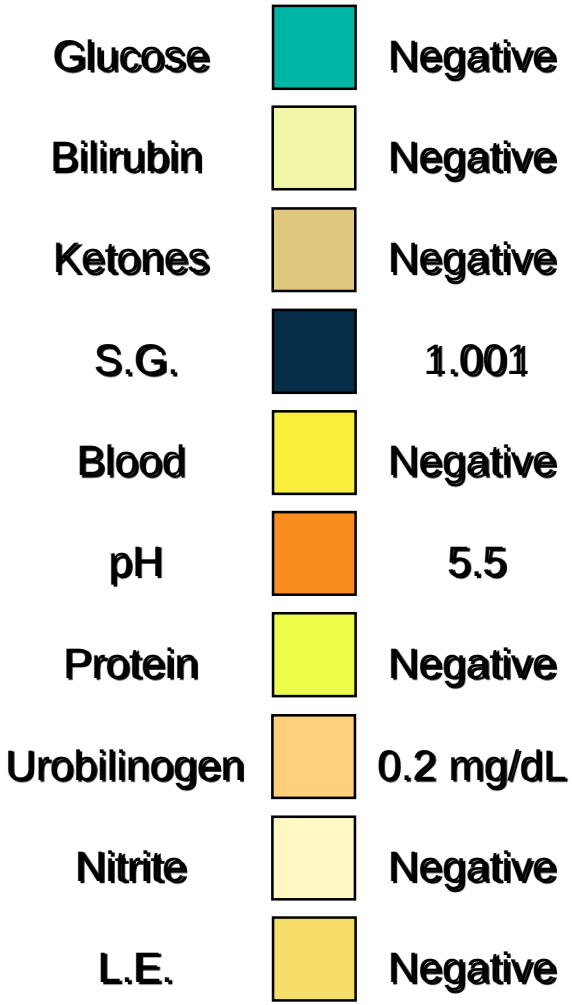
Urinary Stones



Nephrolithiasis

Activity

Case 1



A 35-year old man undergoing routine pre employment medical check up.

Physical characteristics: Clear.
Microscopic: Not performed.

Questions:

- What is your differential diagnosis?

Case 2

Glucose	Negative
Bilirubin	+++
Ketones	Negative
S.G.	1.020
Blood	Negative
pH	5.5
Protein	Negative
Urobilinogen	0.2 mg/dL
Nitrite	Negative
L.E.	Negative

A 42-year old woman presents with “dark urine”

Physical characteristics: Red-brown.
Microscopic: Not performed.

Questions:

- What is your differential diagnosis?
- - How would you rule it out?
- What tests would you order next?

Case 3

Glucose		Negative
Bilirubin		Negative
Ketones		Negative
S.G.		1.030
Blood		+++
pH		6.5
Protein		Trace
Urobilinogen		1.0 mg/dL
Nitrite		Negative
L.E.		+++

A 42-year old man presents painful urination

Physical characteristics: dark red, turbid
Microscopic: leukocytes = 30 per HPF
RBCs = >100 per HPF
Bacteria = >100 per HPF

Questions:
- What is your suspected diagnosis?
- What would you do next?
- Comment on of the nitrite test?

Case 4

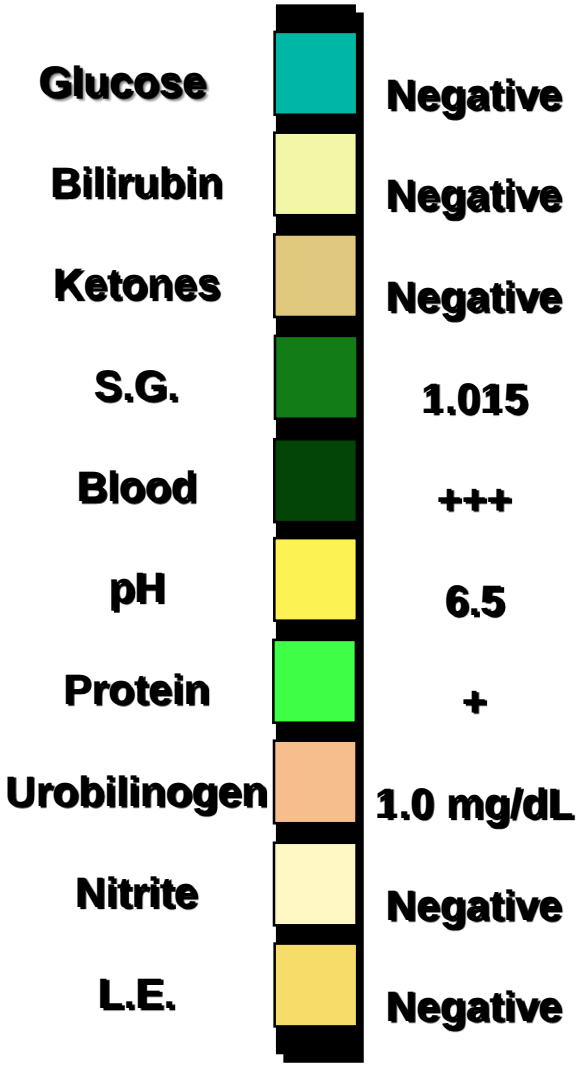
Glucose		++
Bilirubin		Negative
Ketones		Trace
S.G.		1.015
Blood		Negative
pH		6.0
Protein		Negative
Urobilinogen		1.0 mg/dL
Nitrite		Negative
L.E.		Negative

A 27-year old woman presents with severe abdominal pain.

Physical characteristics: clear-yellow.
Microscopic: Not performed.

Questions:
- What is the most likely diagnosis?
- What do you make of the ketone result?

Case 5

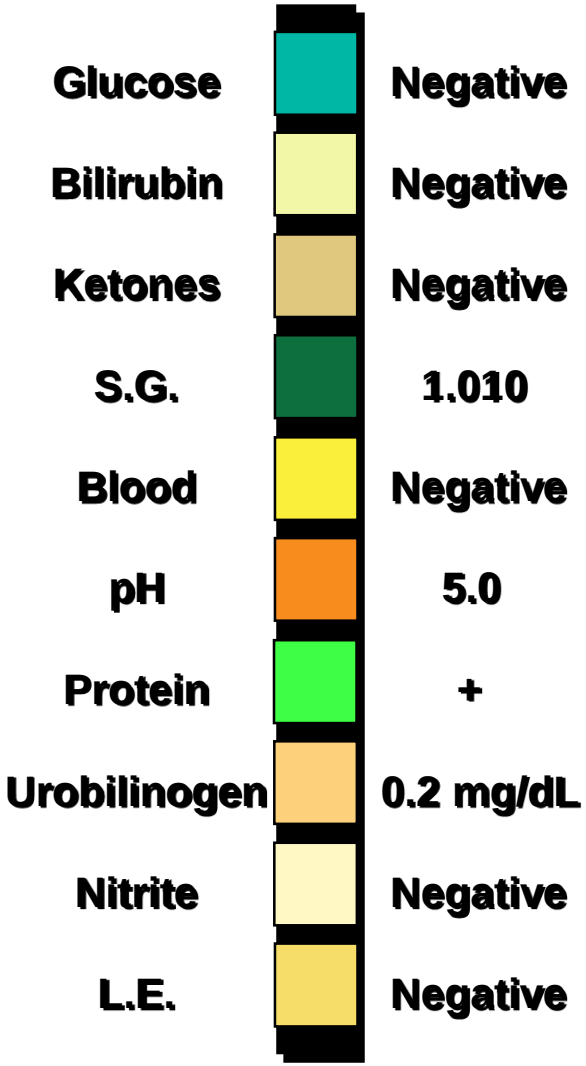


8-year old boy presents with discolored urine

Physical characteristics: Red, turbid.
Microscopic: erythrocytes = >100 per HPF (almost all dysmorphic)
Red cell casts present.

- What is the most likely diagnosis in this case?
- Does the presence of red cell casts help you in any way?
- If the erythrocytes were not dysmorphic would that change *your diagnosis?*

Case 6



22-year old man presenting for a routine physical required for admission to medical school

Physical characteristics: Yellow
Microscopic: Not performed

- What is your differential diagnosis?
- Would you order a microscopic analysis on this sample?
- What would you do next to confirm the diagnosis?