LABS: WHAT THEY MEAN AND
DIFFERENTIATING BETWEEN "MEH" AND "OH SHIT"

Complete Blood Count (CBC)

WBC (white blood cells) 4-11
MEH < 20 < OSR
- total white count
- high means infection or inflammation generally
- white count >20 is specific for a rampant infection or one that has been allowed to go on without treatment or has not responded to treatment
- white count >35 is almost always due to C.diff or leukemia (where bone marrow creates magnitudes more white blood cells than are needed)

RBC (red blood cells) 4.7-6.1
- total # of red blood cells
- low is anemia
- high when you produce more RBCs in an effort to increase O2-carrying ability (chronic lung disease, high altitude)

Hgb (hemoglobin) 12.5-17.5
OSR < 7 < MEH
- amount of hemoglobin in a given quantity of RBCs
- low is anemia
- being acutely low can signify blood loss
- being chronically low is more likely a deficiency issue
- Hgb <7 usually requires transfusion
- Hgb <5 can affect a person's ability to oxygenate, resulting in weakness and confusion

Hct (hematocrit) 37-51%
- % of blood volume that is RBCs
- in anemia, it goes down with Hgb
- is the second part of "H&H"

MCV (mean corpuscular volume) 80-94
- average size of RBCs
- low is "microcytic"; high is "macrocytic"
- in chronic anemia, blood cells will become larger in an attempt to hold more Hgb

MCH (mean corpuscular hemoglobin) 27-31
- measure of amount of Hgb in given amount of RBCs

MCHC (mean corp. hgb concentration) 33-37

RDW (RBC distribution width) 11.6-14.8
- measures difference in sizes of smallest to largest RBCs; wide range implies deficiencies

Plt (platelets) 150-400
- total platelet count
- low is thrombocytopenia
- thrombocytopenia can be caused by decreased bone marrow function (aplastic anemia or leukemia) or other types of anemia (sickle cell)
- high is thrombocythemia
- thrombocythemia can occur after a splenectomy, where large amount of platelets are usually stored, or with chronic inflammation

(White Count) Differential

NEUTROPHILS (54-60% of WBCs)
- first responders to site of inflammation
- will get very high (85-90%) immediately after an injury
- high means bacterial infection

LYMPHOCYTES (25-33% of WBCs)
- high means viral infection
- B-lymphocytes produce antibodies
- T-lymphocytes act in cell-mediated response

EOSINOPHILS (1-3% of WBCs)
- high in allergic reactions and parasitic infections

BASOPHILS (<1% of WBCs)
- circulate in blood
- are "mast cells" when they are found in tissue
- high in allergic reactions, some cancers

MONOCYTES (3-9% of WBCs)
- circulate in blood
- are macrophages when they are found in tissue

Introduction:

It is important to realize that most lab values cannot merely be divided into normal and abnormal ranges. The normal range of any given lab test is determined by where the majority of people lie; this of course means that some patients will normally live outside of this range. Beyond that, there are many abnormal lab values that, while abnormal for any person, do not require specific treatment if they are sufficiently close to the normal range. I will therefore present the following ranges outside the normal limits: MEH (abnormal but not particularly notable) and OSR (the "oh shit" range).

Hgb is an example of a lab value that is best examined in the context of recent prior values. A Hgb of 10 in a patient who always has a Hgb of 10 is much less concerning than a Hgb of 11 in a person who had a Hgb of 14 a week ago. The cause of the second patient's acute blood loss needs to be identified.

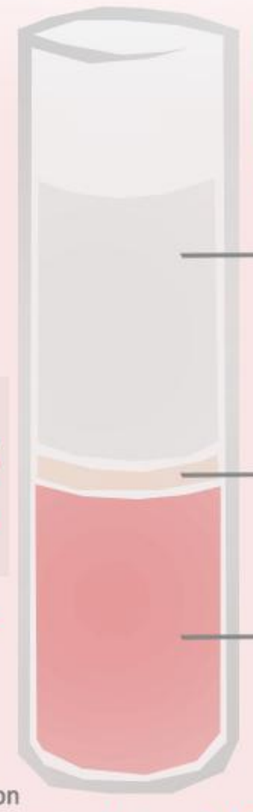
Caveat:

This does not mean that every lab has an abnormal range ambling slowly from negligible to serious. For some labs, such as bands or a urine pregnancy, every abnormality is an "oh shit" abnormality.

Reasons for high Hgb:
- dehydration (all other cell values will be high as blood concentration increases relative to total blood volume)
- smoking
- high altitude
- kidney tumor (erythropoietin)

TROPONIN 0.05 < MEH < 0.1 < OSR

Troponins are proteins used by skeletal and cardiac muscle. Troponin-I is only found in cardiac muscle. High levels in the blood signify some sort of damage to the myocardium, be it from dehydration or demand (strenuous exercise or heart failure). An especially high level is specific for acute MI.



Normal Blood Volume

PLASMA
- 54% of blood volume
- water
- electrolytes
- proteins and glucose
- much of this volume is reported in the metabolic panel (BMP/CMP)

WHITE BLOOD CELLS (& PLATELETS)
- 1% of blood volume
- volume is directly reported as white count (WBC) and platelet count (Plt)

RED BLOOD CELLS
- 45% of blood volume
- carry hemoglobin (Hgb)
- volume is directly reported as hematocrit (Hct)

Comprehensive Metabolic Panel (CMP)

GLUCOSE 70-100
OSR < 60 - 350 < OSR
- moderate hyperglycemia is normal in diabetics (100-350)
- very high can mean DKA (>350)
- hypoglycemia can lead to altered mental status, stroke-like symptoms

BUN (blood urea nitrogen) 8-25
- metabolite of dietary protein
- should be removed by kidneys
- will be high when kidneys are under-performing

CREATININE 0.6-1.2
1.2 < MEH < 2.0 < OSR
- product of muscle creatine catabolism
- should be removed by kidneys
- will be high when kidneys are under-performing
- small elevation is likely due to dehydration
- >1.5x normal level is concerning

GFR (glomerular filtration rate) >60 mL/min
OSR < 30 < MEH < 60
- mL of urine kidneys create in 1 minute
- a mild decrease may not be eligible for contrast or certain medications
- serious decrease signifies kidney disease or failure

SODIUM (Na) 135-145
OSR < 130 < MEH < 150 < OSR
- moderate hyponatremia causes weakness, confusion
- cerebral edema at <115
- moderate hypernatremia causes confusion, muscle twitching
- seizures at >160

POTASSIUM (K) 3.5-4.8
- hypokalemia normally due to diarrhea, vomiting, diuretics (Lasix)
- severe hypoK can cause paresthesias, impairment of muscle function
- severe hyperK can cause arrhythmias (peaked T-waves)

CALCIUM (Ca) 8.9-10.3
- hypoCa caused by hypoparathyroidism
- reduced calcium lowers threshold for depolarization
- "CATs go numb": convulsions, arrhythmia, tetany, numbness

CO2 22-32
- hypercapnia is caused by hypoventilation, lung disease; CO2 is not being expelled

ALK PHOS - elevated in liver disease/obstruction 32-91

AST 5-50
ALT 17-63
} 250 < OSR
when elevated together, called transaminitis
mild elevation can be viral, related to obstruction
severe elevation due to liver failure from cirrhosis or hepatitis

Arterial Blood Gases (ABGs)

The ABG gives you insight to the acid/base balance of the blood. From the ABG you can see the pH of arterial blood, the partial pressures of CO2 and O2, and the HCO3 (bicarb) concentration. pH is important, but just as important is knowing what to do with that information and figuring out where a pH derangement is coming from.

Normal ranges:

pH	7.35-7.45
pCO2	35-45
HCO3	21-27
pO2	80-100
SaO2	95-100%

A pH <7.35 indicates acidemia, and a pH >7.45 indicates alkalemia. CO2 is (basically) an acid, and HCO3 is a base, so when one of these is too high or low, it causes the pH to be correspondingly high or low. The body deals with a deranged pH caused by one of these variables by changing the other variable to match. Amount of CO2 is changed by respiration; HCO3 concentration is changed by binding/separating from a H+ ion or by increasing/decreasing its reabsorption in the kidneys.

Acidemia can be caused by increased CO2 or by a low HCO3. Alkalemia is caused by decreased CO2 or by a high HCO3. In each case the body will attempt to compensate as follows:

Initial Problem:	Initial pH:	Compensation:	New pH:
Resp. Acidosis	↑CO2	↓pH	↑HCO3	↑pH
Resp. Alkalosis	↓CO2	↑pH	↓HCO3	↓pH
Metab. Acidosis	↓HCO3	↓pH	↓CO2	↑pH
Metab. Alkalosis	↑HCO3	↑pH	↑CO2	↓pH

Though the body will do its best to compensate and bring the pH back to normal, it will never normalize pH all the way. The important thing to know is if the patient is compensating well (pH is at least close to normal, say 7.25-7.5), or if they are undercompensating. Patients with chronic disease, such as lung disease that causes chronic respiratory acidosis, can compensate with increased HCO3 for years. A newly hyper-ventilating patient may quickly become alkalemic and then critically ill, because it takes hours to days to bring down the HCO3 enough to bring pH back up.

Final notes on ABGs:

pO2 is not the same as O2 sat. The "p" refers to the partial pressure, which is an amount, and not a percent. SaO2 is the O2 saturation, which explains why (just like when measured by pulse ox) the normal range is 95-100%.

The OSR for acidemia is somewhere around <7.1. The OSR for alkalemia is somewhere around >7.5. it is more difficult to determine an OSR for the other sections of the ABG because the body is so good at throwing CO2 and HCO3 out of whack in an attempt to save itself. So generally you should just think of decompensation in any acid/base disorder as the OSR.

Some differentials include the percentage of neutrophils which are immature; these baby neutrophils are called bands. They are recruited to join the immune response when the more mature neutrophils are not expected to be able to handle an infection on their own. The normal range of bands is 0-5%. Anything above this signifies a patient has a very bad infection. The band count can be elevated even before the total white count is, which makes it a very good tool to help predict how sick a patient might become without prompt treatment.

You will sometimes hear an elevated percentage of bands referred to as a "left shift". If you placed bands and segs (mature neutrophils) on a graph and examined the difference between a normal distribution in a healthy person and someone with bandemia (high bands), you would see that the average age of neutrophils in the sick person shifts toward immaturity, or to the left.