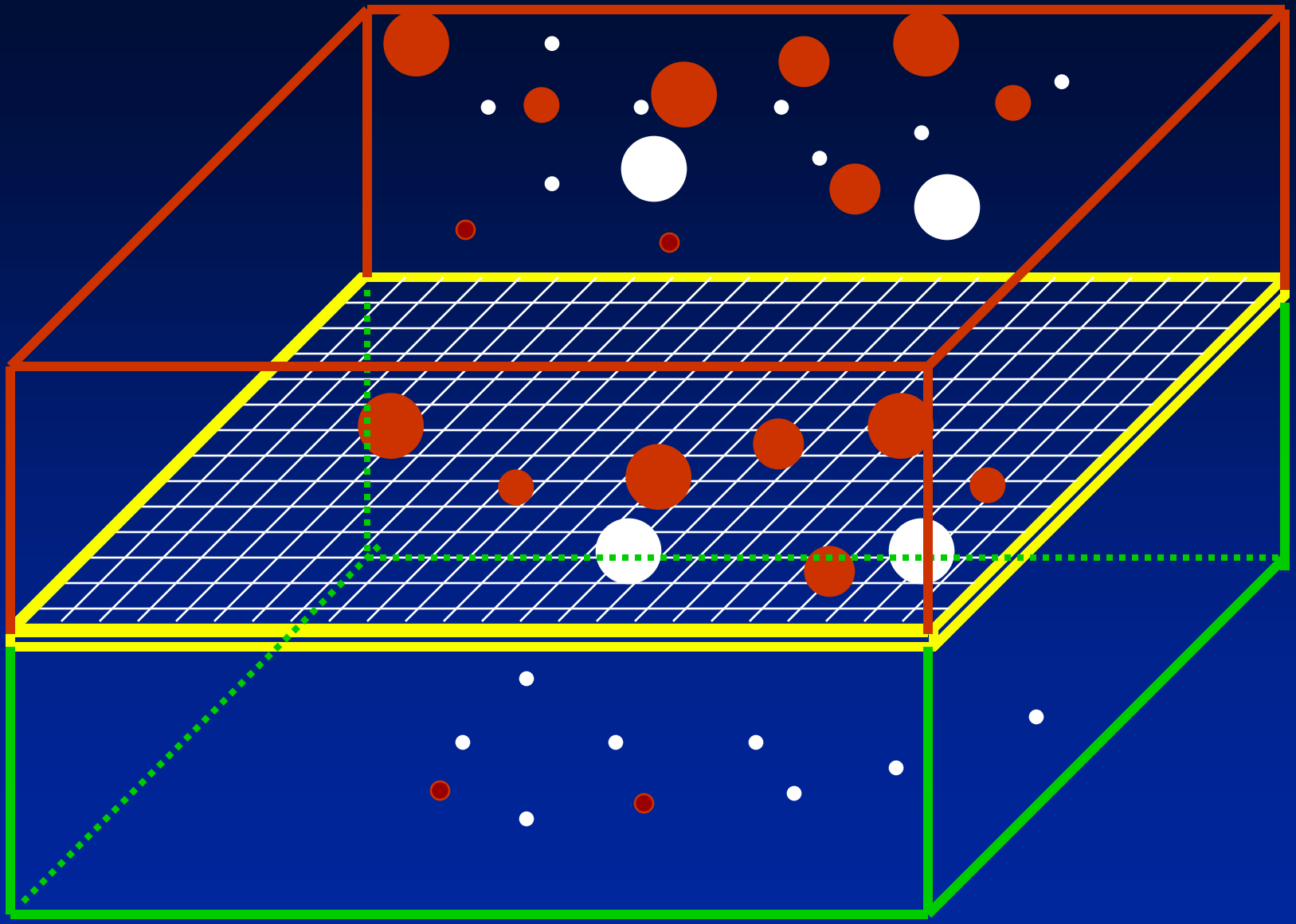
Screening for Disease



Goal of Epidemiology

- Study the natural course of disease
- Determine the extent of disease in a population
- Identify patterns and trends
- Identify causes of disease
- Evaluate preventions and treatment

Test Validity

"Accuracy"; does the test accurately distinguish between healthy and diseased people?

Probability of correct test:

1) Sensitivity: probability that a diseased person will test +

2) Specificity: probability that a non-diseased person will test -

Probability of disease:

3) Predictive value (+): if someone has a + test, what is the probability that they actually *have* the disease?

4) Predictive value (-): if someone has a - test, what is the probability that they *don't* have the disease?

Criterion of Positivity

What test results are considered "positive"? "negative"?

- **Criterion of Positivity - test value at which the screening test outcome is considered positive**

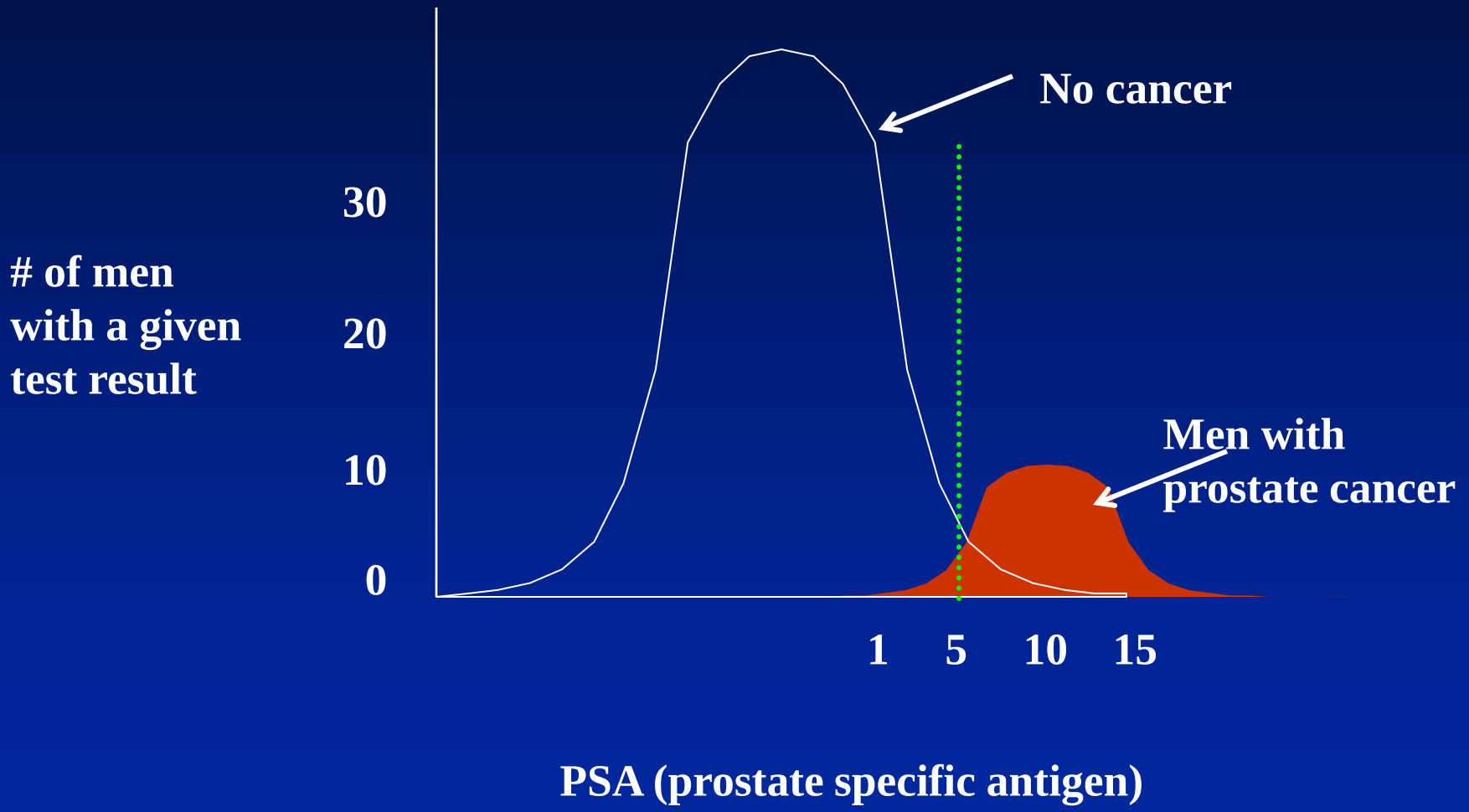
Test Result

Clearly Negative **Grey Zone** **Clearly Positive**

----------??????????????----------

- **Criterion of positivity affects sensitivity and specificity**
- **Must trade off between the two.**

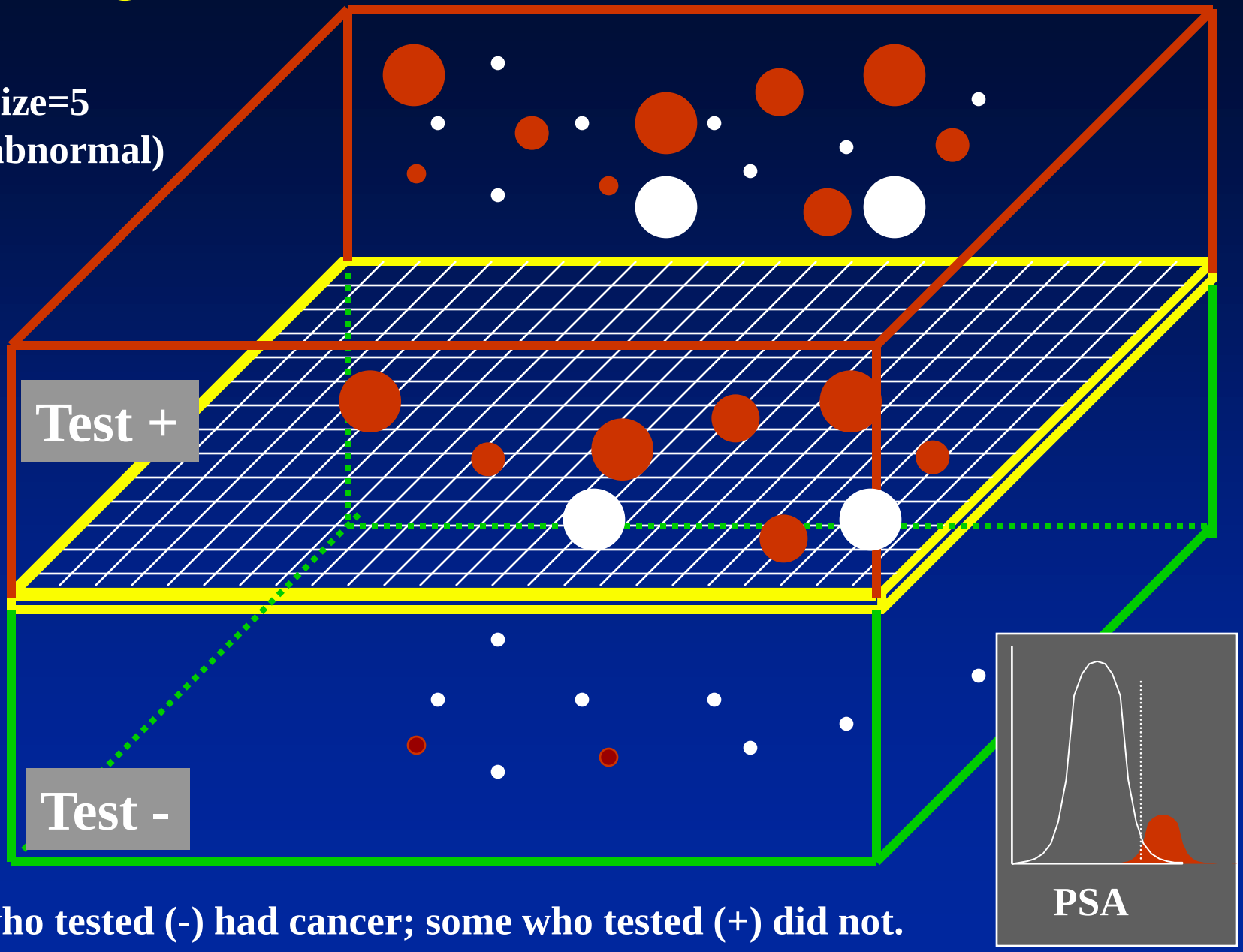
Hypothetical Distribution of PSA Test Results in Men With and Without Prostate Cancer



It is decided that >5 is abnormal.

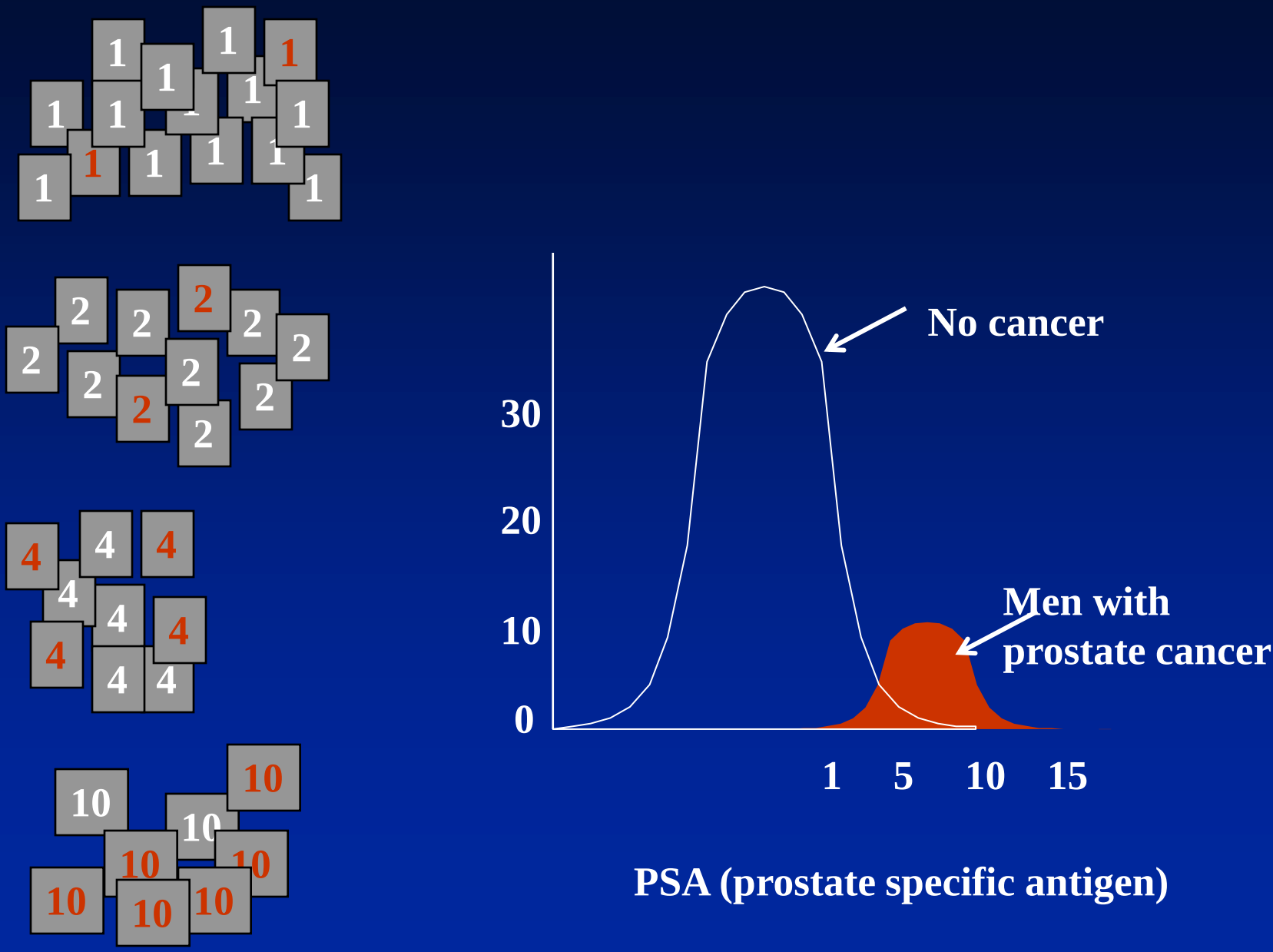
Screening

Mesh size=5
(>5 is abnormal)



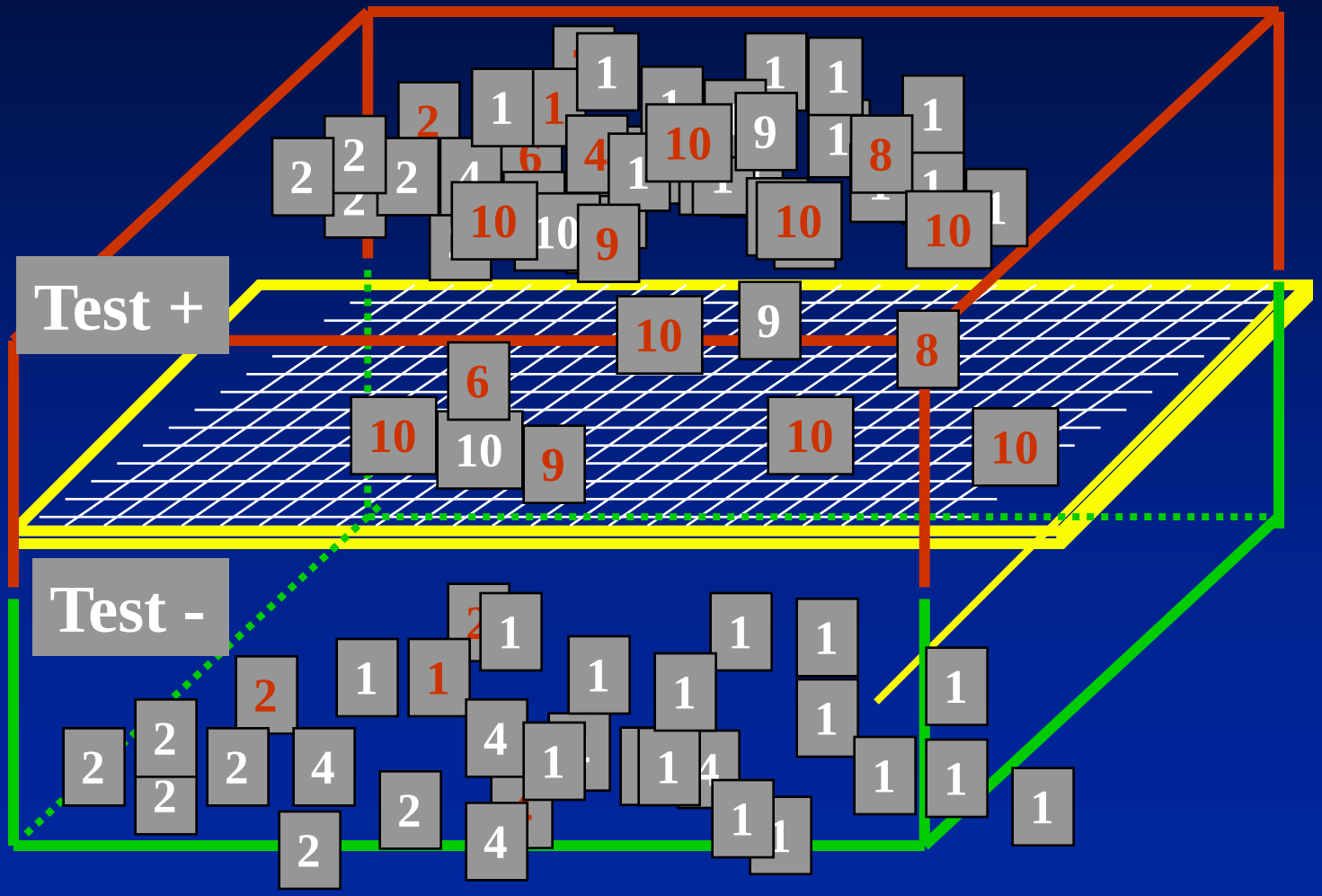
Some who tested (-) had cancer; some who tested (+) did not.

Men with a Variety of PSA Test Results



Sensitivity: Of those who were diseased, what % had a + screening test?

Specificity: Of those who were NOT diseased, what % screened (-)?

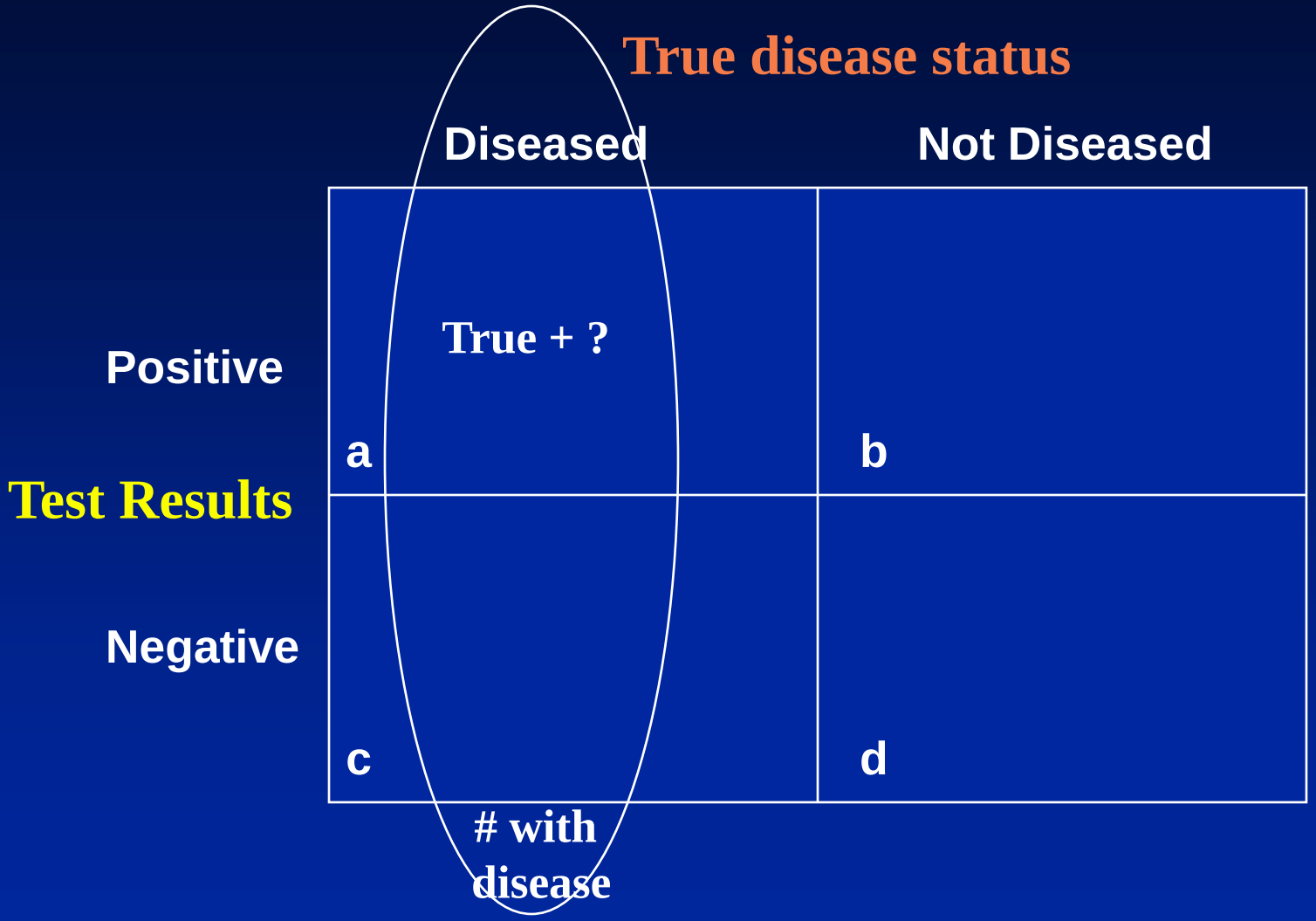


Some who tested (-) had cancer; some who tested (+) did not.

A Different Type of 2x2 Table

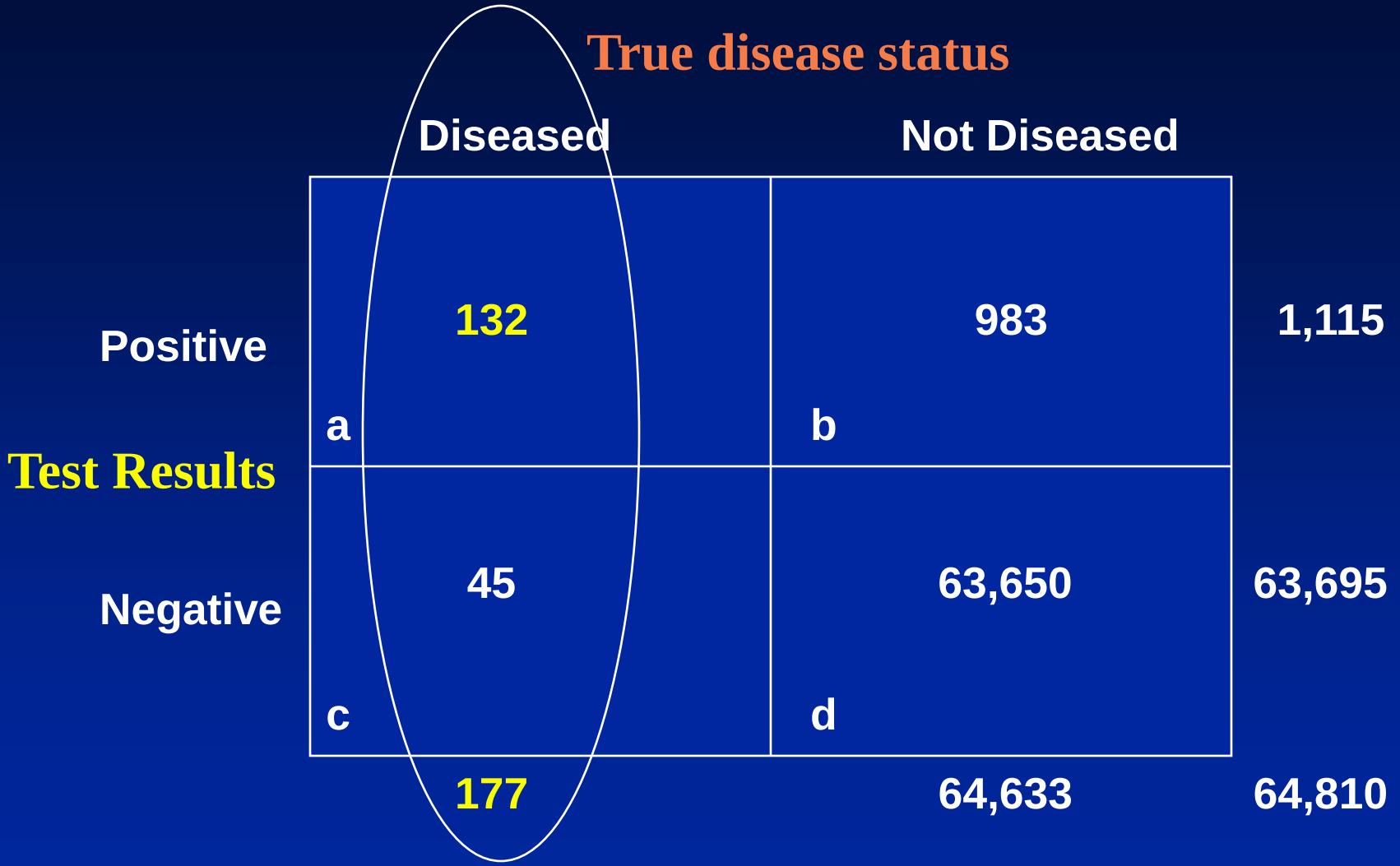
Test Results	True disease status: Diseased	True disease status: Not Diseased
Positive	a	b
Negative	c	d

Sensitivity: Of the people who really had disease, how frequently did the test correctly identify the problem?



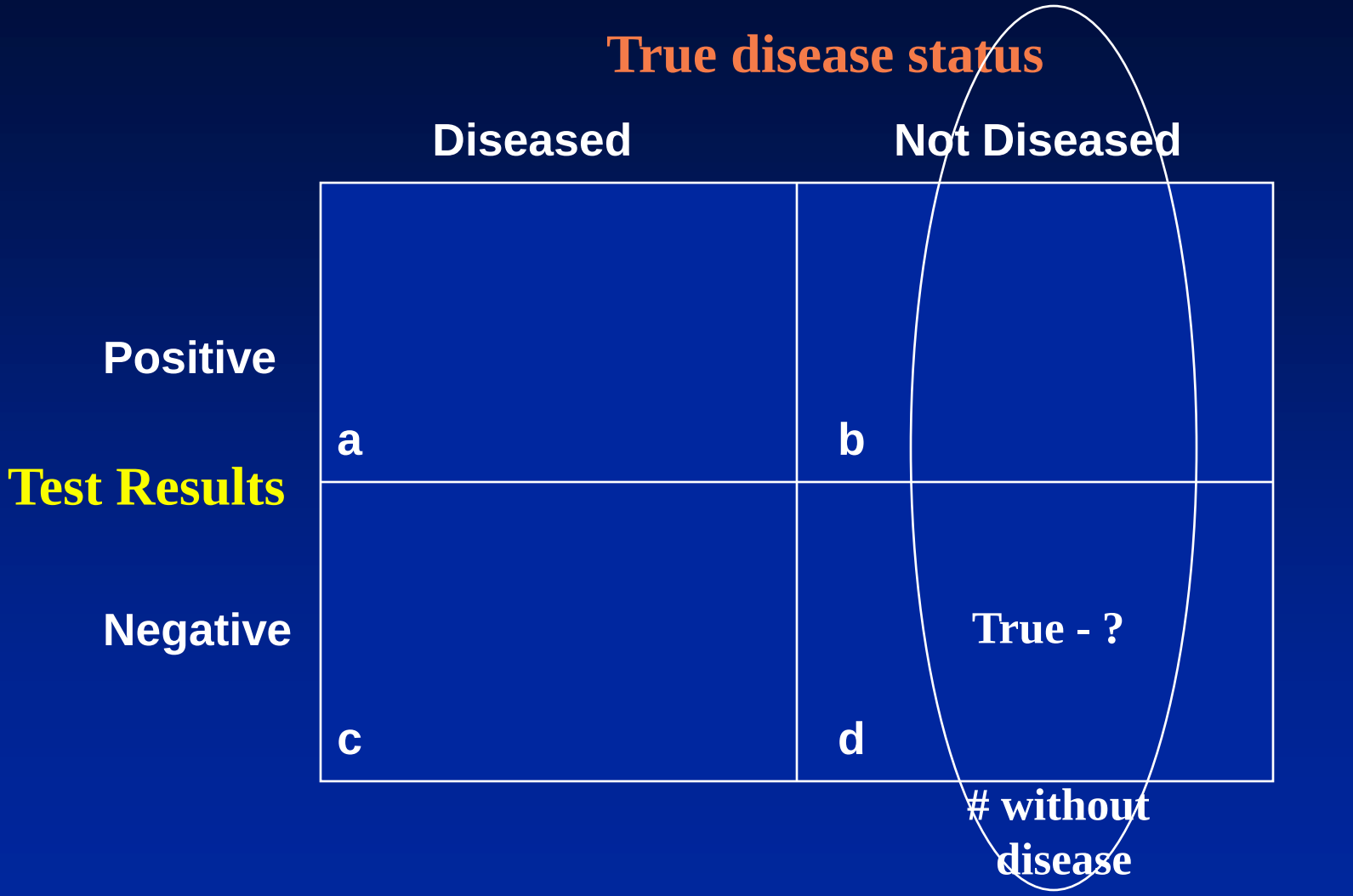
Among those with disease, what % had a + test?

Sensitivity - probability that people ***with*** the disease will have a **positive** test, i.e., "true positive (TP)".

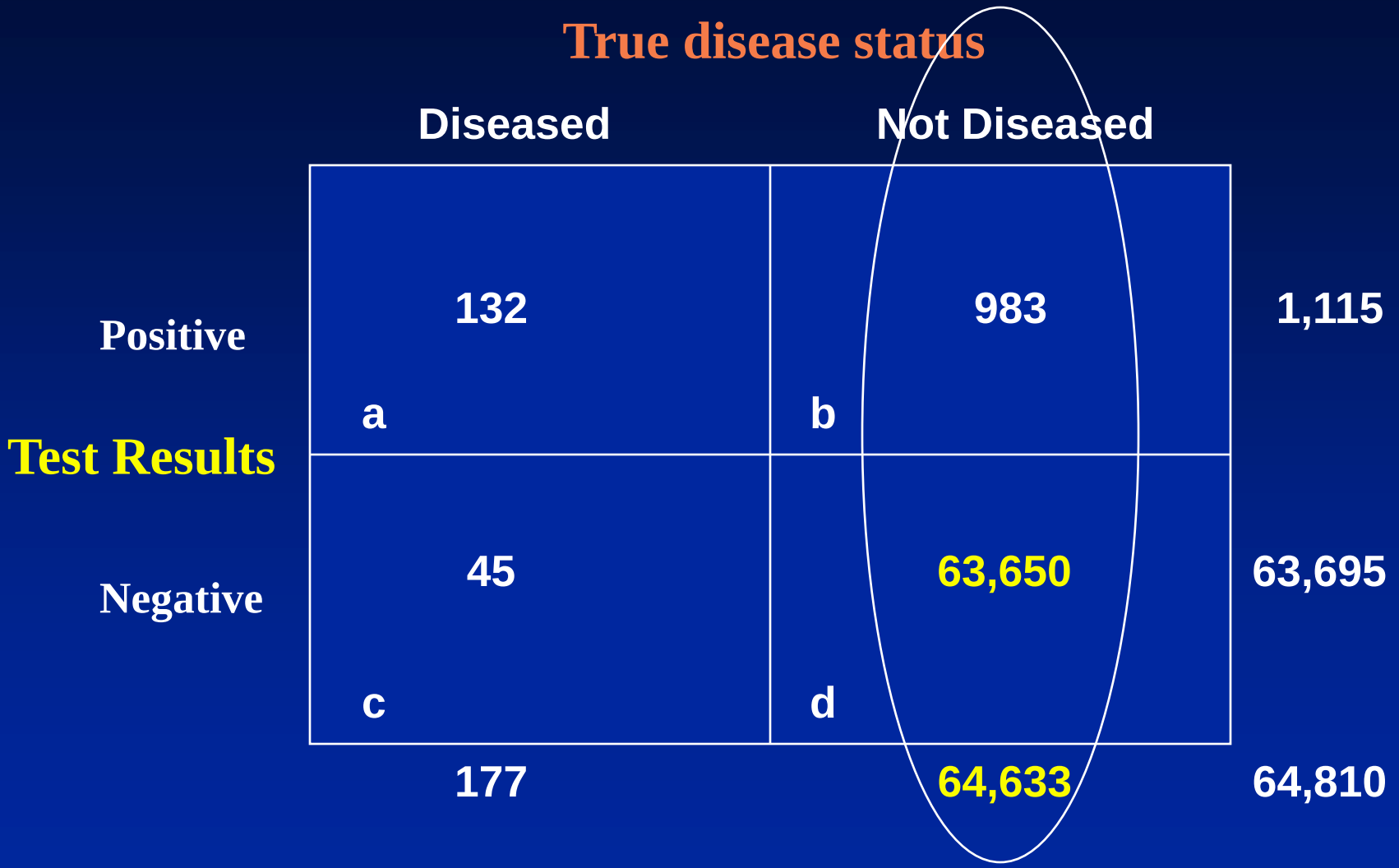


$$\text{Sensitivity} = \frac{a}{a+c} = \frac{132}{177} = 74.6\%$$

Specificity: Of the people who were normal, how frequently did the test correctly inform us that they were OK?



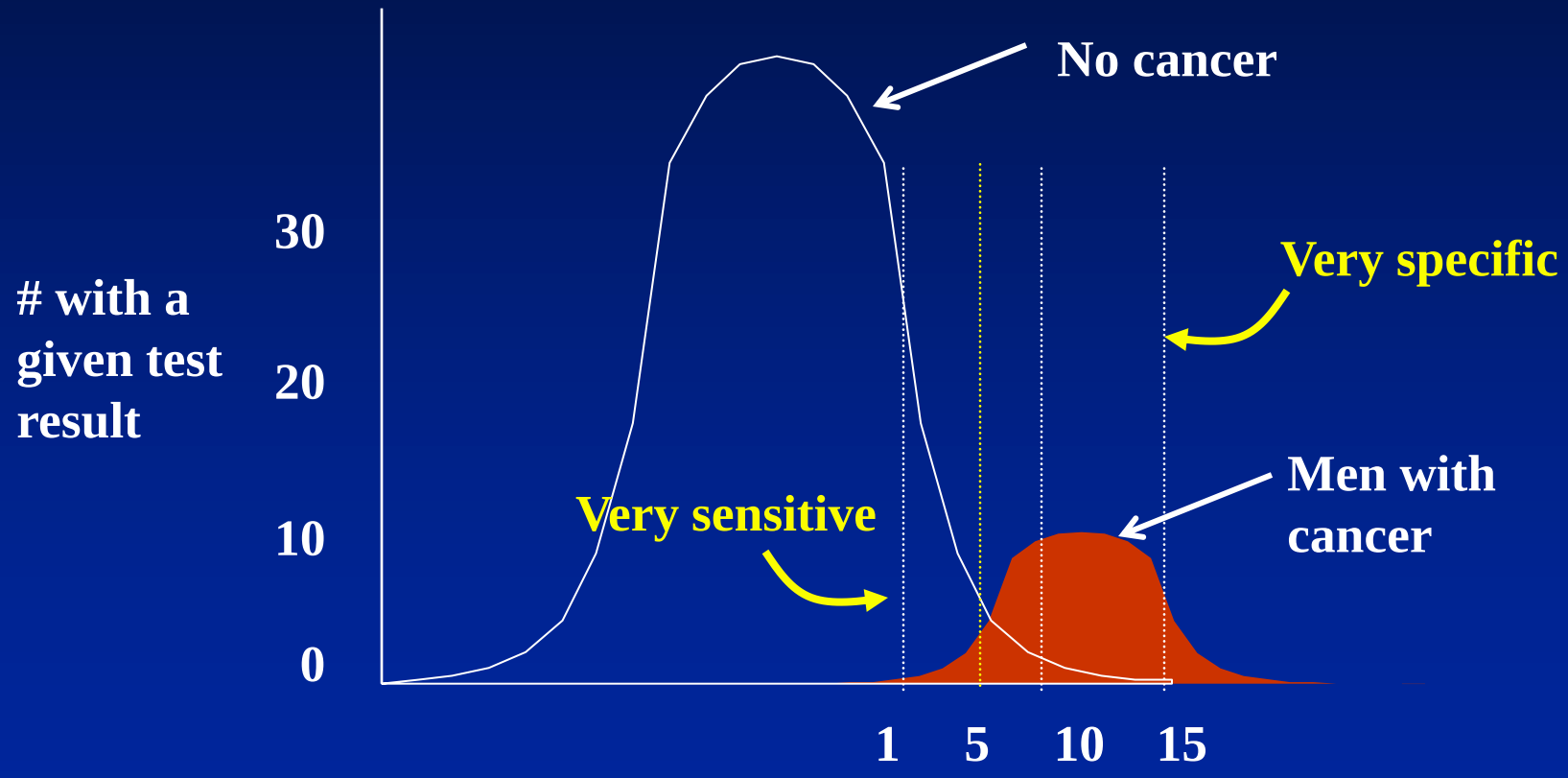
Specificity - probability that people with*out* the disease will have a **negative** test, i.e., "true negative (TN)".



$$\text{Specificity} = \frac{d}{b+d} = \frac{63{,}650}{64{,}633} = 98.5\%$$

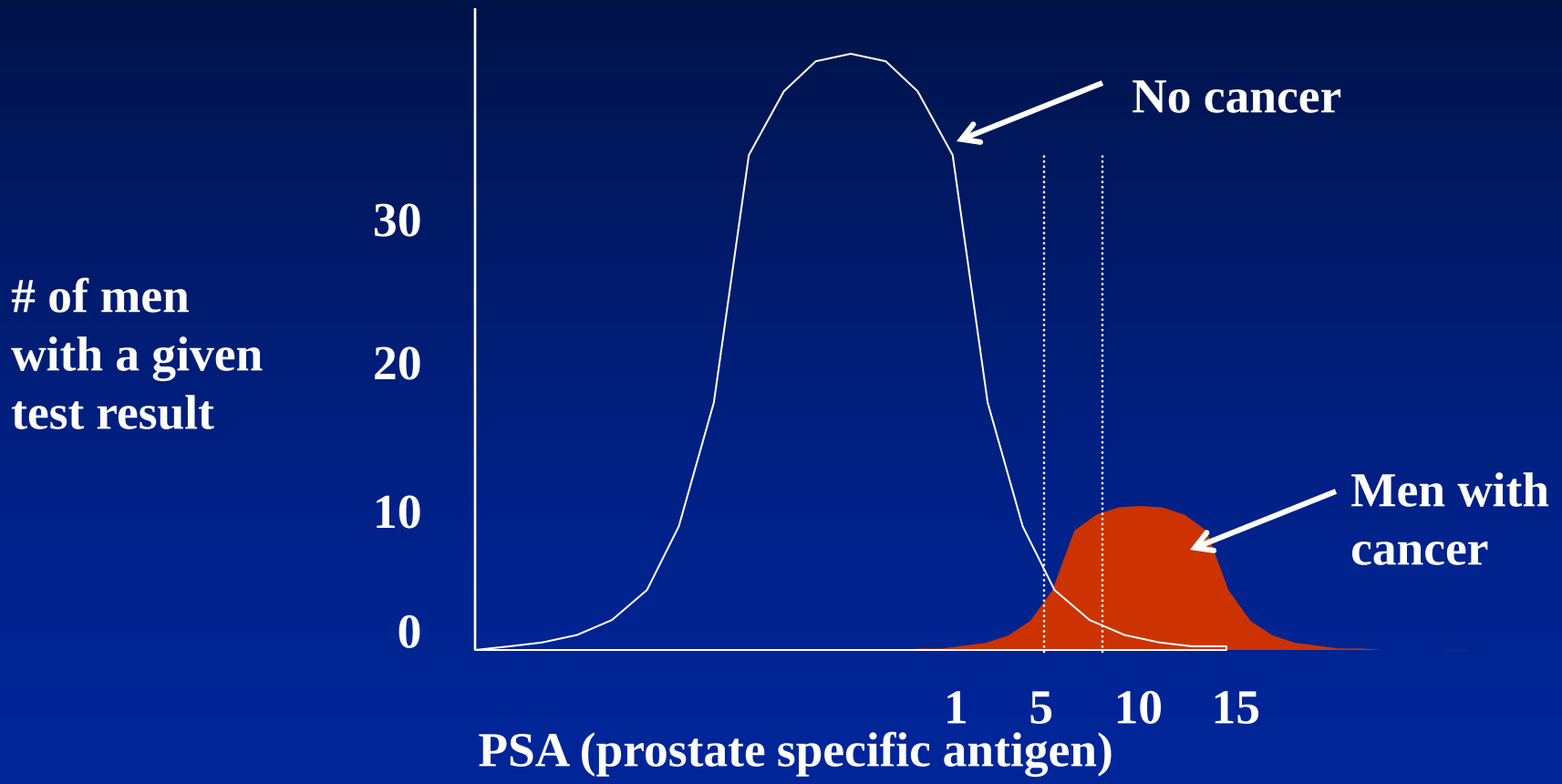
The Trade-Off: Relationship Between Sensitivity & Specificity

Ideal is to have a test that is exquisitely sensitive & highly specific, but this frequently isn't the case.

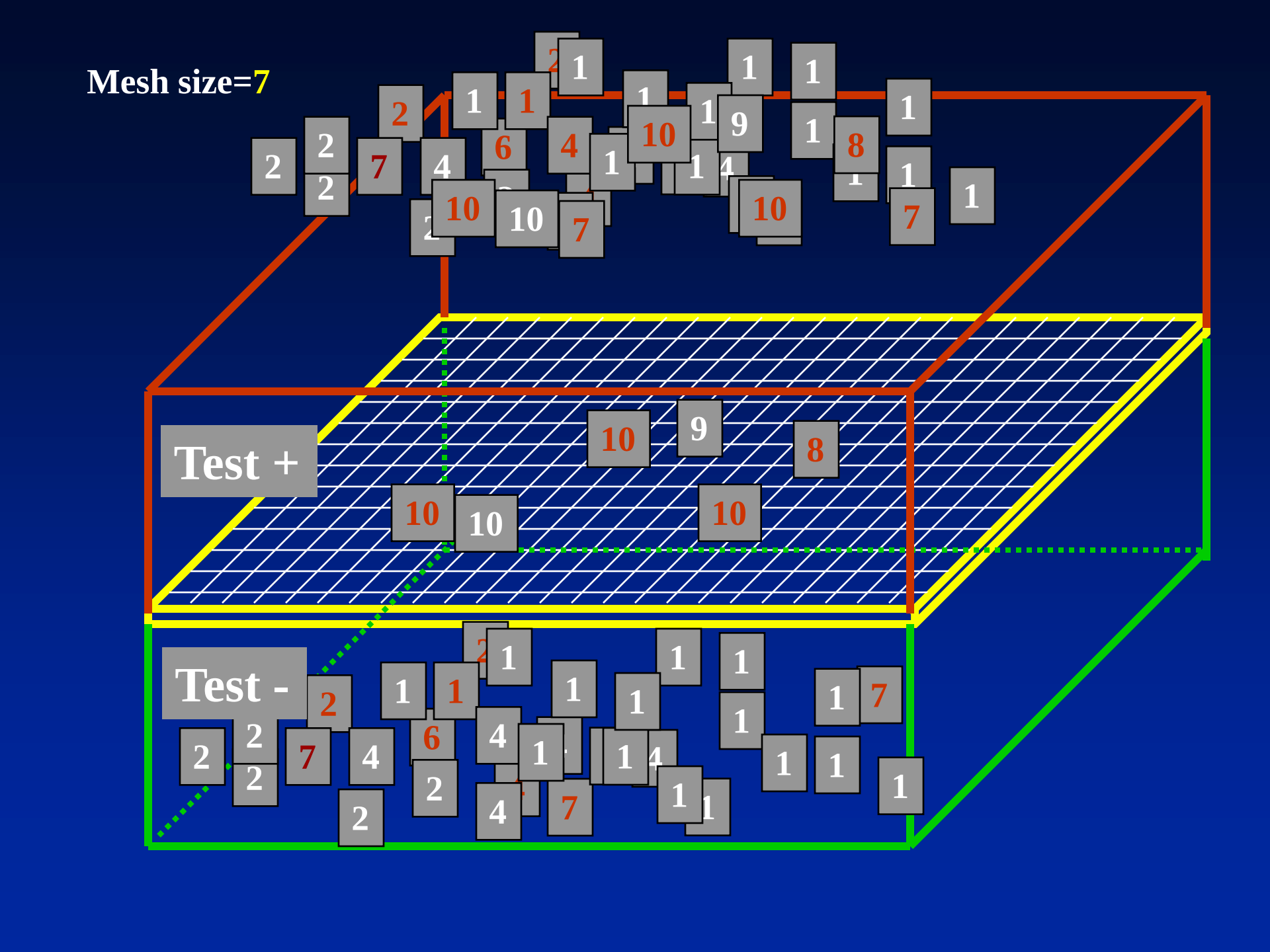


When PSA values for men with prostate cancer overlap those of men without cancer, what do you use as the criterion for "abnormal"?

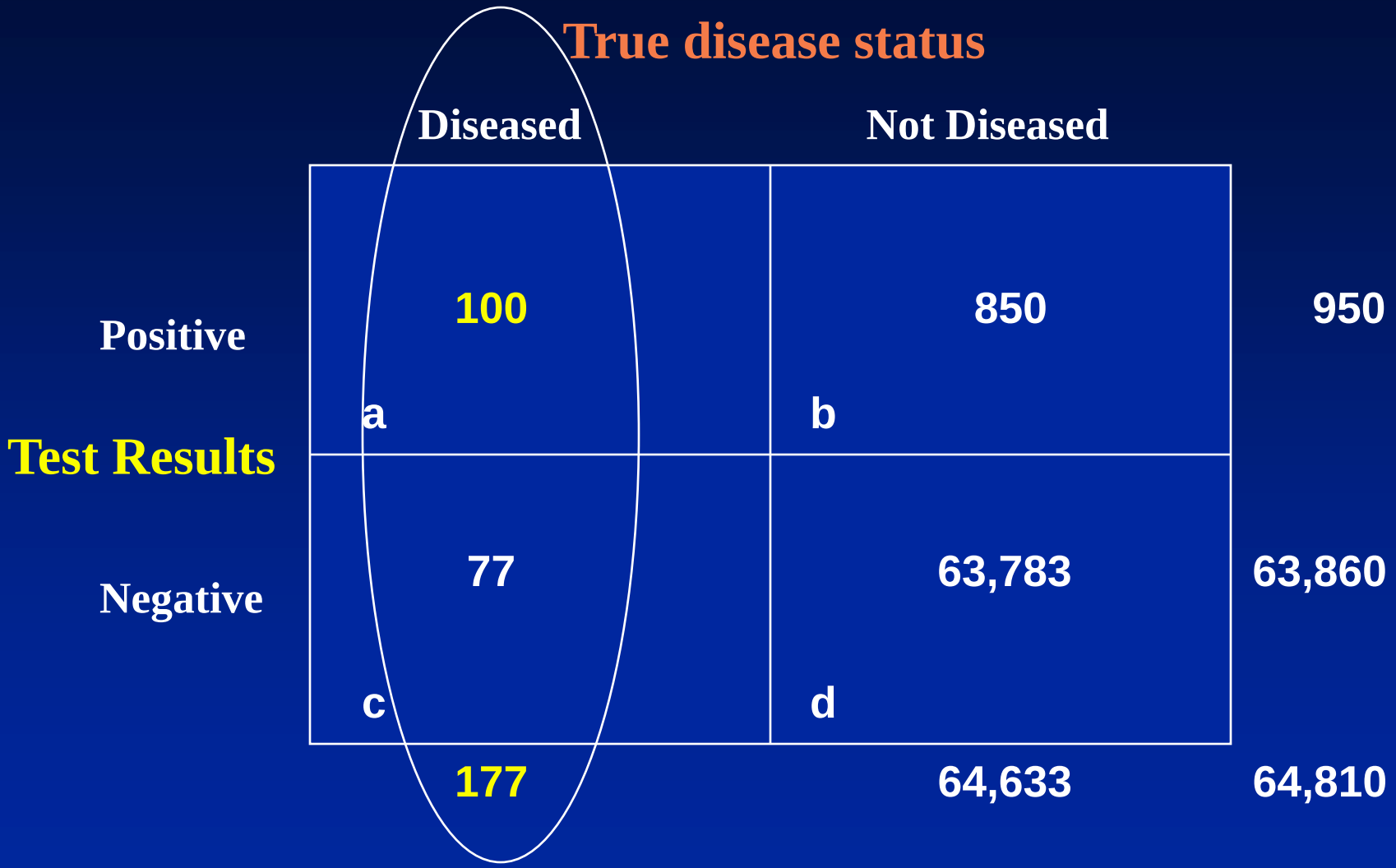
Hypothetical Distribution of PSA Test Results in Men With and Without Prostate Cancer



If we change the criterion from 5 to 7, fewer normal men will be misclassified as +, but more men with cancer will be misclassified as normal.

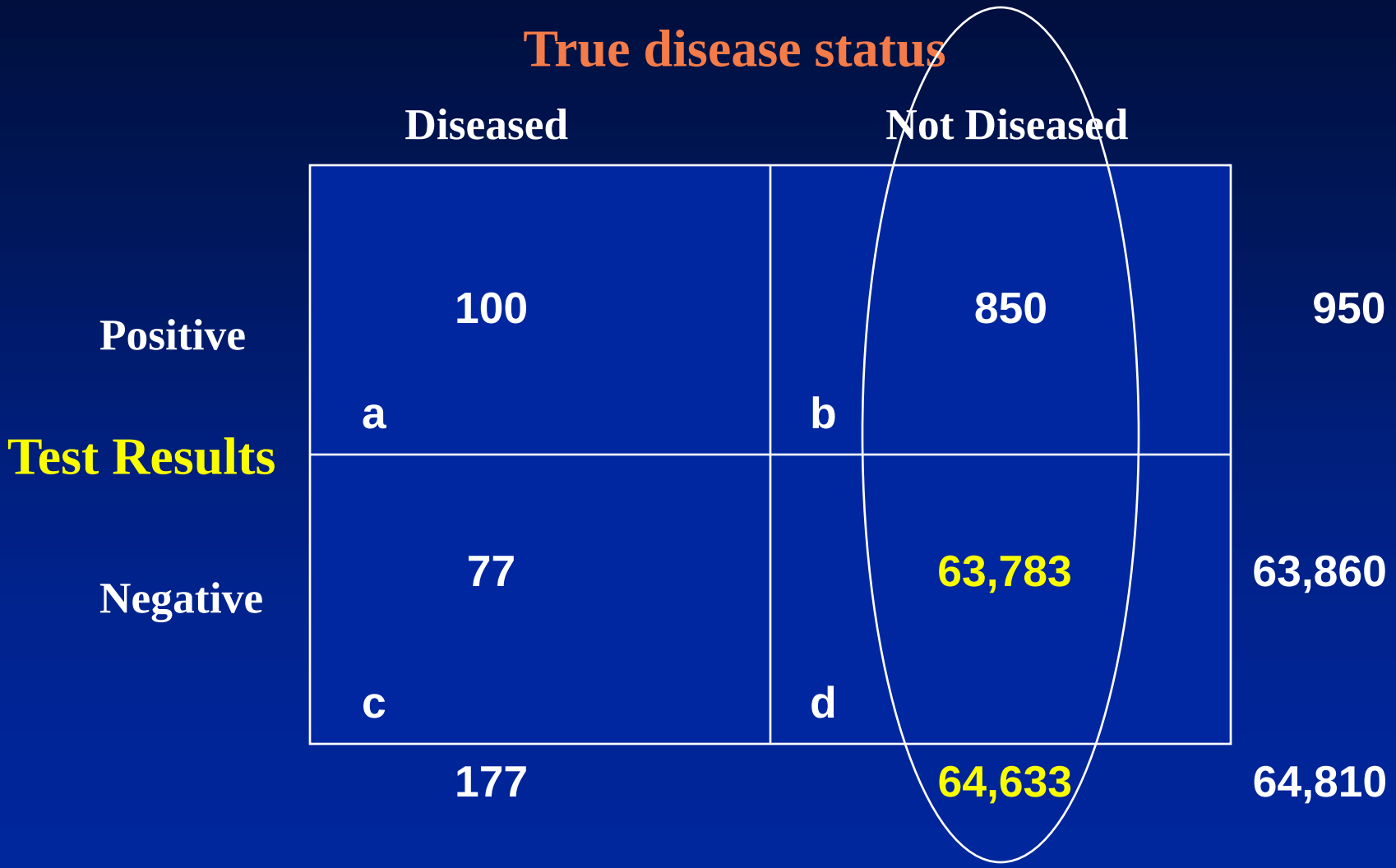

Mesh size=7
Test +
Test -

Sensitivity - probability that people **with** the disease will have a **positive** test, i.e., "true positive (TP)".



Sensitivity = $\frac{a}{a+c} = \frac{100}{177}$ = 56.5% (it was 74.6% with mesh size=5)

Specificity - probability that people with*out* the disease will have a **negative** test, i.e., "true negative (TN)".



Specificity = $\frac{d}{b+d} = \frac{63,783}{64,633}$ = 98.7% (slightly more specific)

When thinking about

Predictive Value of a Test, ...

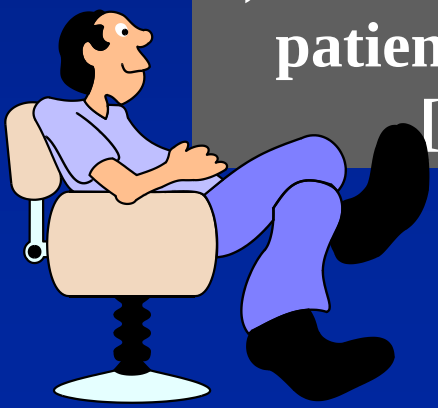
… imagine you are a physician discussing the results of a screening test with a patient.

\+ 1) If the test was ***positive***, how likely is it that the patient really ***has*** the disease?

[How ***worried*** should you be?]

\- 2) If the test was ***negative***, how likely is it that the patient really ***does NOT*** have the disease?

[How ***reassured*** should you be?]



Positive Predictive Value (predictive value +)

proportion of people with positive test results who have the disease

True disease status

Test Results	Positive	Negative	
Positive	132 (a)	983 (b)	1,115
Negative	45 (c)	63,650 (d)	63,695
	177	64,633	64,810

$$\text{Predictive value +} = \frac{a}{a+b} = \frac{132}{1{,}115} = 11.8\%$$

Negative Predictive Value (predictive value -)

proportion of people with negative test results who do *not* have the disease

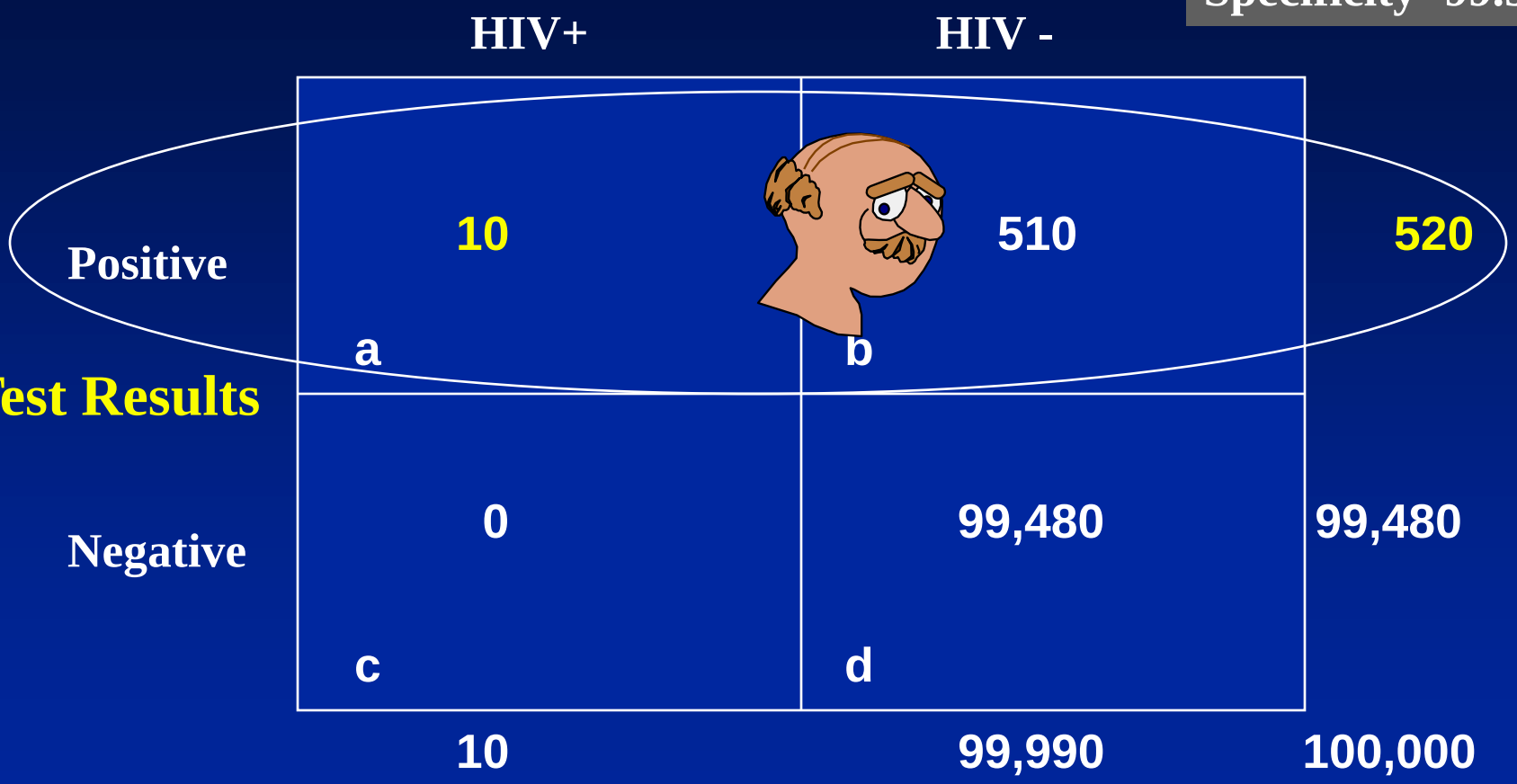
True disease status

Test Results	Positive	Negative	
Positive	132 (a)	983 (b)	1,115
Negative	45 (c)	63,650 (d)	63,695
	177	64,633	64,810

$$\text{Predictive value} - = \frac{d}{c+d} = \frac{63{,}650}{63{,}695} = 99.9\%$$

Positive Predictive Value (predictive value +) is *VERY* much influenced by the prevalence of disease in the population being screened

Sensitivity=100%
Specificity=99.5%

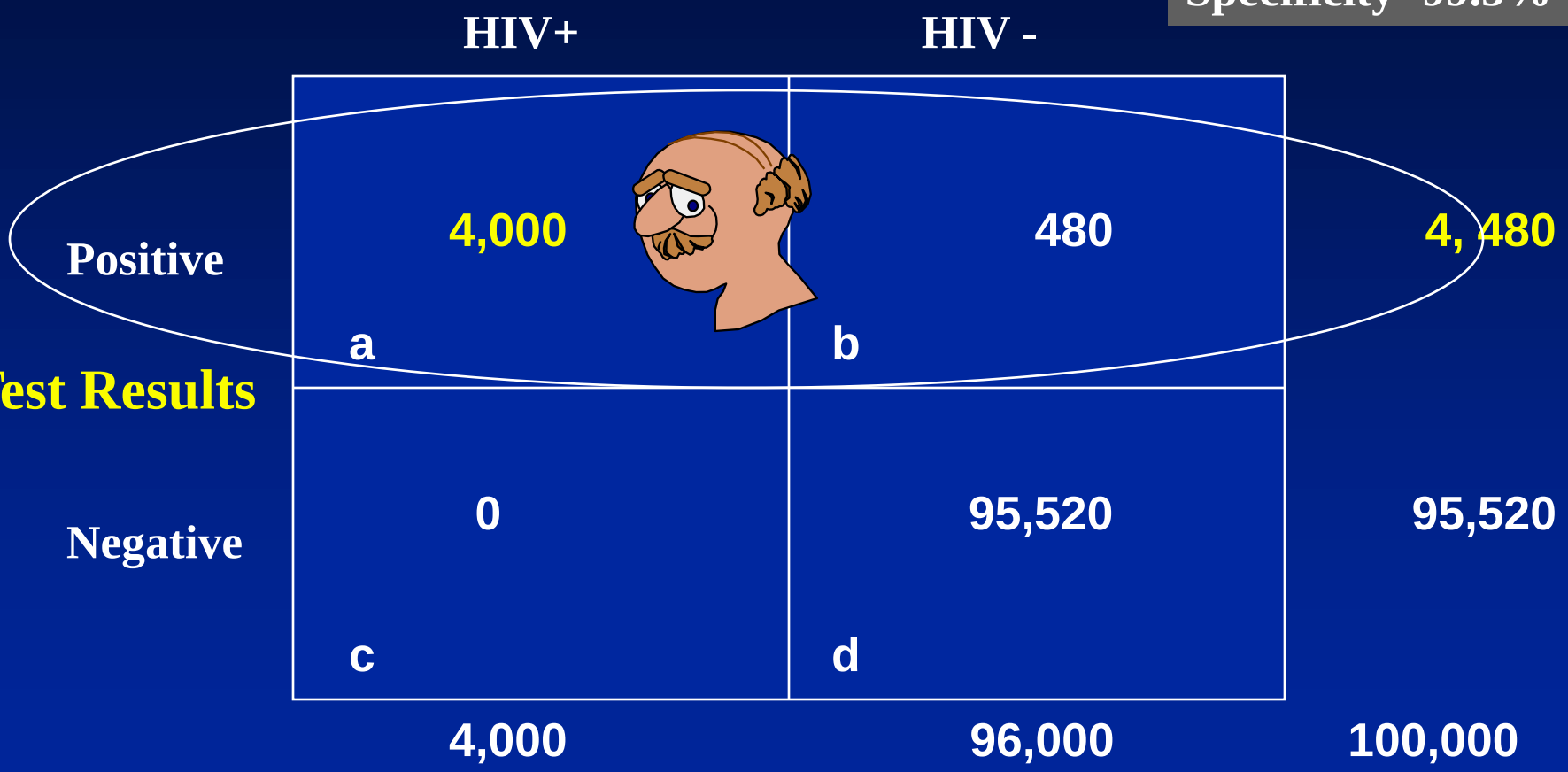


Predictive value + = $\frac{a}{a+b} = \frac{10}{520} = 1.9\%$

Prevalence in female blood donors=0.01%

Positive Predictive Value (predictive value +) is *VERY* much influenced by the prevalence of disease in the population being screened

Sensitivity=100%
Specificity=99.5%

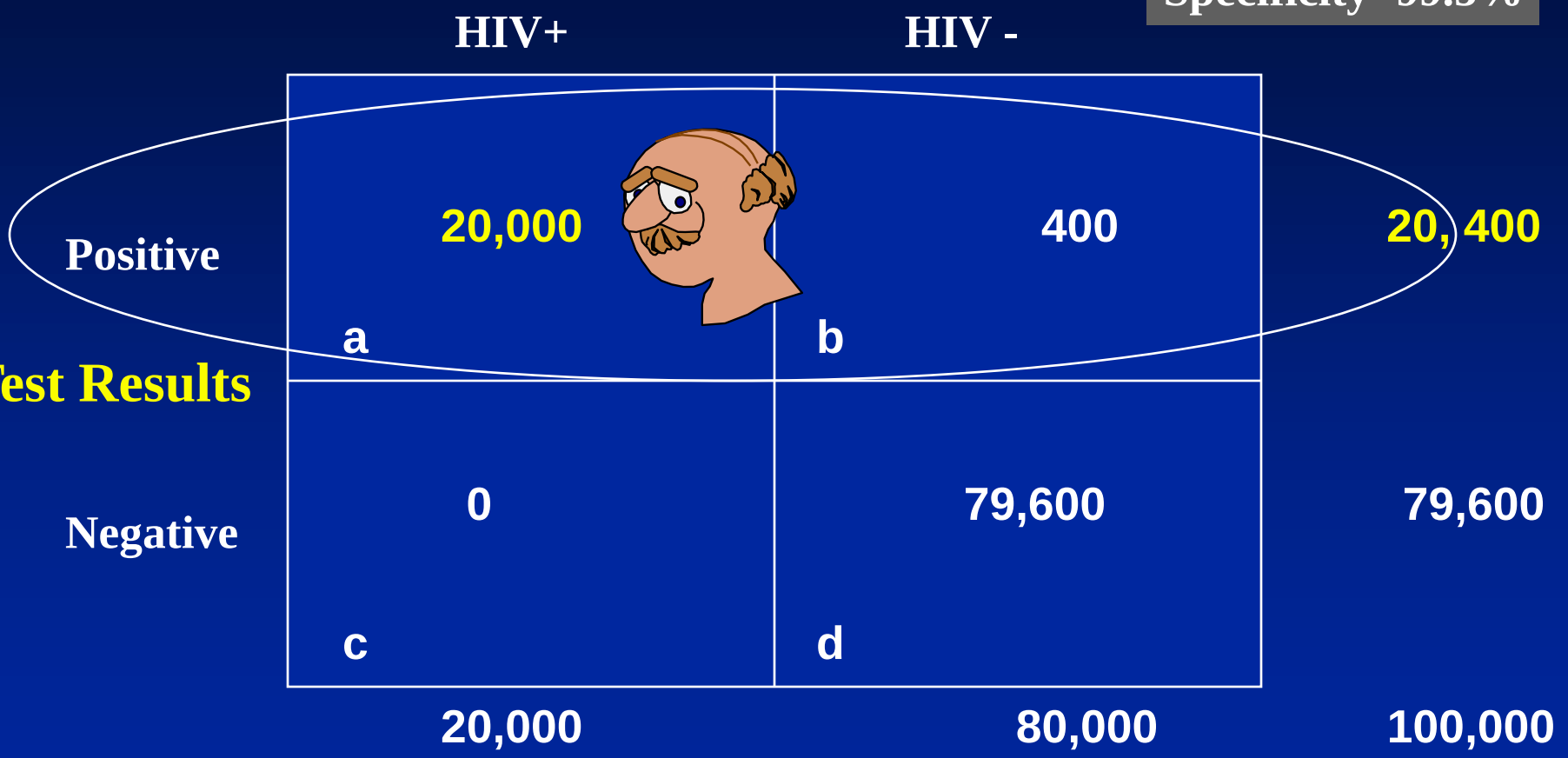


Predictive value + = $\frac{a}{a+b} = \frac{4{,}000}{4{,}480} = 83.3\%$

Prevalence in males at an STD clinic=4%

Positive Predictive Value (predictive value +) is *VERY* much influenced by the prevalence of disease in the population being screened

Sensitivity=100%
Specificity=99.5%



Predictive value + = $\frac{a}{a+b} = \frac{20,000}{20,400} = 98\%$

Prevalence in IV drug users=20%