BIOE 310
Exams available to reserve within 4 days:
Exam 1 first date 2021-03-18
“Mitochondrial Eve” lived in Africa between 100,000 and 150,000 years ago (or 240,000?)

“Adam” and “Eve” are both out of Africa

- “Mitochondrial Eve” lived in Africa between 100,000 and 150,000 years ago (or 240,000?)
- “Y-chromosome Adam” also lived in Africa between 120,000 and 160,000 years ago
Mitochondrial Eve (maternally transmitted ancestry)
Y-chromosome Adam (paternally transmitted ancestry)
lived ~200,000 years ago.

When lived the latest common ancestor
shared by all of us based on nuclear DNA?

A. 1 million years ago
B. 200,000 years ago
C. 3400 years ago
D. 660 years ago
E. Yesterday, I really have no clue

Get your i-clickers
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Last common ancestor in nuclear (non Y-chr) DNA is another matter

• Unlike Mito or Y-chromosome, **nuclear DNA gets mixed with every generation**
  – Each of us gets 50% of nuclear DNA from the father & 50% from the mother
  – Each of us has 2 parents, 4 grandparents, 8 great-grand parents ...

• If one assumes:
  – Well-mixed marriages (not true: mostly local marriages until recently)
  – Constant size population (not true: much smaller in the past)
  – In 33 generations the number of ancestors:
    \[2^{33} = 8 \text{ billion} > 7 \text{ billion people living today}\]

• Every pair of us living today should have at least one shared ancestor who lived
  – 33 generations * 20 years/generation=**660 years ago ~1300 AD**
Corrected for (mostly) local marriages and rare migrations.

With 5% of individuals migrating out of their home town, 0.05% migrating out of their home country, and 95% of port users born in the country from which the port emanates, the simulations produce a mean MRCA date of 1,415 BC and a mean IA date of 5,353 BC.
Archaea were discovered here at UIUC in 1977 by Carl R. Woese (1928-2012) and George E. Fox.

Earth is 4.5 Billion years old.

LUCA: 3.5-3.8 Billion years old.
Negative Binomial Definition

• In a series of independent trials with constant probability of success, $p$, let the random variable $X$ denote the number of trials until $r$ successes occur. Then $X$ is a negative binomial random variable with parameters:
  $0 < p < 1$ and $r = 1, 2, 3, \ldots$

• The probability mass function is:
  \[
  f(x) = C_{r-1}^{x-1} p^r (1 - p)^{x-r} \quad \text{for } x = r, r+1, r+2\ldots
  \]

• Compare it to binomial
  \[
  f(x) = C^n_x p^x (1 - p)^{n-x} \quad \text{for } x = 1, 2, \ldots n
  \]

NOTE OF CAUTION: Matlab, Mathematica, and many other sources use $x$ to denote the number of failures until one gets $r$ successes. We stick with Montgomery-Runger.
Negative Binomial Mean & Variance

• If $X$ is a **negative binomial** random variable with parameters $p$ and $r$,

$$
\mu = E(X) = \frac{r}{p} \quad \text{and} \quad \sigma^2 = V(X) = \frac{r(1-p)}{p^2} \quad (3-12)
$$

• Compare to **geometric** distribution:

$$
\mu = E(X) = \frac{1}{p} \quad \text{and} \quad \sigma^2 = V(X) = \frac{(1-p)}{p^2} \quad (3-10)
$$
Matlab exercise

• Find mean, variance, and PMF based on 100,000 geometrically-distributed numbers with $p=0.1$
• Repeat with negative binomial distribution with $p=0.1$, $r=3$
• Repeat with negative binomial distribution with $p=0.1$, $r=100$
• Hint: Use help page for random Matlab command on how to generate random numbers with different PMFs
Matlab: Geometric distributions

- Stats=100000;
- p=0.1;
- r2=random('Geometric',p,Stats,1);
- r2=r2+1;
- disp(mean(r2));
- disp(var(r2));
- disp(std(r2));
- [a,b]=hist(r2,1:max(r2));
- p_g=a./sum(a);
- figure; semilogy(b,p_g,'ko-');
Matlab: Negative binomial distributions

- Stats=100000;
- r=3; p=0.1;
- r2=random('Negative Binomial',r,p,Stats,1);
- r2=r2+r;
- disp(mean(r2));
- disp(var(r2));
- disp(std(r2));
- [a,b]=hist(r2, 1:max(r2));
- p_nb=a./sum(a);
- figure; semilogy(b,p_nb,'ko-');
Matlab: Negative binomial distributions

- Stats=100000;
- r=100; p=0.1;
- r2=random('Negative Binomial',r,p,Stats,1);
- r2=r2+r;
- disp(mean(r2));
- disp(var(r2));
- disp(std(r2));
- [a,b]=hist(r2, 1:max(r2));
- p_nb=a./sum(a);
- figure; semilogy(b,p_nb,'ko-');