F09 Biol 322 chi square notes

1. Before proceeding with the chi square calculation, clearly state the genetic hypothesis concerning the data. This hypothesis is an interpretation of the data that gives a precise prediction about what the expected outcome of your experiment should be (have been) assuming that your hypothesis/interpretation is correct.

2. Use the rules of probability to make explicit predictions of the types and proportions of progeny that should be observed if your hypothesis is true
In other words, your hypothesis should give a straight-forward prediction with respect to progeny classes (genotype or phenotype) and ratios

3. **For each class of progeny in turn, subtract the expected number from the observed number. Square this difference and divide it by the expected number.**   Note that you are to use the actual numbers of progeny, not the proportions, ratios, fractions or percentages.
Significant decimal places:
   - Express the final chi square value to 3 decimal places, because that is the accuracy of the table of critical values (see below)
   - To avoid rounding errors, *all intermediate computations*, including the expected values should be carried out to 4 decimal places

4. Sum the results of the calculation described in step 3 for all classes of progeny

Chi square value =
$$\chi^2 = \Sigma \frac{[O - E]^2}{E}$$
Σ = sum of value in each progeny category
O = observed value in a given category of progeny
E = expected value in that category (predicted by your genetic hypothesis/interpretation)

Tips for χ ^{2} chi squaring

ALWAYS USE ACTUAL NUMBERS; NEVER USE FRACTIONS OR
PERCENTAGES OR DECIMAL FRACTIONS

1. A comparison of ratios or percentages alone will never allow you to determined whether or not the *observed* data are significantly different from the *predicted* values.
2. The absolute numbers are important because they reflect the size of the experiment. The larger the sample size the closer the observed ratios or percentages can be expected to match the values predicted by the experimental hypothesis, *if the hypothesis is correct*.

5. Use the chi square table to determine p, which helps you assess whether the data (the χ ^{2} value) represent a good fit or a bad fit to the expected numbers

Table: Chi-Square Probabilities

df	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005
1	---	---	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838

degrees of freedom =   number of progeny classes – 1

P = probability that an equal or worse fit would occur by chance, assuming that your hypothesis is true

OR, in other words:

The P value answers this question: If the theory that generated the expected values were correct, what is the probability of observing such a discrepancy between observed and expected values

How do I determine if a particular p-value is significant?

*If p is large, the **observed deviation** from the expected results is considered **insignificant.***

*If the probability is very low (<0.05) the **observed deviation** from the expected results becomes **significant**.*

What does significant mean?
- *In statistics, a result is called statistically significant if it is unlikely to have occurred by chance*
- *The amount of evidence required to accept that an event is unlikely to have arisen by chance is known as the significance level or critical p-value: in traditional frequentist statistical hypothesis testing, the p-value is the frequency or probability with which the observed event would occur, if the null hypothesis were true.*
- *If the obtained p-value is smaller than the significance level, then the null hypothesis is rejected -- well, MAYBE*

- *The chi square test assists the investigator in accepting or rejecting a hypothesis by calculating the probability that the data are compatible with the hypothesis*
- *It can not be emphasized too strongly that any test of goodness-of-fit can only assist an investigator in making up his/her mind.*
- *It neither proves or disproves a hypothesis*

Interpreting the results of a chi square analysis

p value > 0.05

- *Your hypothesis may be correct* and any differences between O and E due to chance.
- On the other hand, a p value > 0.05 Does NOT prove your hypothesis as competing hypotheses may also have a p value that is > 0.05……

p value < 0.05

- *Your hypothesis may be incorrect.* The difference betwee E & O is not due to chance but due to an incorrect hypothesis. If we decide to reject the hypothesis based on the chi square analysis, what do we do or ask next?
- On the other hand, a p value < 0.05 does NOT disprove your hypothesis. *Your hypothesis may be correct* and something else is going that results in a difference between O and E is not due to just to chance.   We're not going to throw out our hypothesis just yet but:

What should you do next?
Where would you go from here to resolve the problems?   What could that something else be?

Significant

[sɪɡˈnɪfɪk(ə)nt] *adjective.*

Few words in the scientific lexicon are as confusing, or as loaded, as 'significant'. Statisticians wring their hands over its cavalier use to describe scientific validity. And backed by statistics or not, researchers commonly employ the word to illustrate the importance of their latest finding.

The very definition of statistical significance is misunderstood by most scientists, says Steven Goodman, a biostatistician at the Johns Hopkins School of Medicine in Baltimore, Maryland, and associate editor on *Annals of Internal Medicine*. Typically, researchers take a result to be statistically significant based on 'p-values'. This parameter is used, for example, to reveal whether a drug lowers cholesterol based on promising data collected in a clinical trial.

According to the common interpretation, a 'significant' result with a p-value of 0.05 or less means that there is a 5% or less chance that the drug is ineffective. According to the statistically accurate definition, there is a 5% or less chance of seeing the observed data even though the drug is, indeed, ineffective. Rhetorically, the difference may seem imperceptible; mathematically, say statisticians, it is crucial. In situations in which the data is somewhat ambiguous, there is a chance that results can be misinterpreted. "It's diabolically tricky," Goodman says.

Most statisticians resign themselves to abuse of the term's strict definition. But more grievous trespasses abound. "Statistical significance is neither a necessary nor a sufficient condition for proving a scientific result," says Stephen Ziliak, an economist at Roosevelt University in Chicago, Illinois, and co-author of *The Cult of Statistical Significance*. P-values are often used to emphasize the certainty

of data, but they are only a passive read-out of a statistical test and do not take into account how well an experiment was designed. A p-value would not reveal, for example, that everyone was taking different doses of that cholesterol drug. In many experiments, Ziliak says, "there are so many different errors that they tend to swamp the p-value errors".

Even if a result is a genuinely statistically significant one, it can be virtually meaningless in the real world. A new cancer treatment may 'significantly' extend life by a month, but many terminally ill patients would not consider that outcome significant. A scientific finding may be 'significant' without having any major impact on a field; conversely, the significance of a discovery might not become apparent until years after it is made. "One has to reserve for history the judgement of whether something is significant with a capital S," says Steven Block, a biophysicist at Stanford University in California.

In some situations other statistical methods can substitute, but Goodman believes that trying to use them in the scientific literature would be like "talking Swahili in Louisiana". He says he and other editors do their best to keep the term out of *Annals* though. "We ask them to use words like 'statistically detectable' or 'statistically discernable,'" he says.

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