

## Topic 10: Genetics and evolution -- 4 lessons, once a week

Topic 10: Genetics and evolution 8 hours

10.1 Essential idea: Meiosis leads to independent assortment of chromosomes and unique composition of alleles in daughter cells.

10.1 Meiosis

10.1 Nature of science:

Making careful observations—careful observation and record keeping turned up anomalous data that Mendel's law of independent assortment could not account for. Thomas Hunt Morgan developed the notion of linked genes to account for the anomalies. (1.8)

Understandings:

- \* Chromosomes replicate in interphase before meiosis.
- \* Crossing over is the exchange of DNA material between non-sister homologous chromatids.
- \* Crossing over produces new combinations of alleles on the chromosomes of the haploid cells.
- \* Chiasmata formation between non-sister chromatids can result in an exchange of alleles.
- \* Homologous chromosomes separate in meiosis I.
- \* Sister chromatids separate in meiosis II.
- \* Independent assortment of genes is due to the random orientation of pairs of homologous chromosomes in meiosis I.

10.1 Applications and skills:

- \* Skill: Drawing diagrams to show chiasmata formed by crossing over.

10.1 Guidance:

- \* Diagrams of chiasmata should show sister chromatids still closely aligned, except at the point where crossing over occurred and a chiasma was formed.

10.1 Syllabus and cross-curricular links:

Biology

Topic 1.6 Cell division

Topic 3.3 Meiosis

Topic 11.4 Sexual reproduction

10.1 Aims:

- \* Aim 6: Staining of lily anthers or other tissue containing germ-line cells and microscope examination to observe cells in meiosis are possible activities.

Topic 10: Genetics and evolution

10.2 Essential idea: Genes may be linked or unlinked and are inherited accordingly.

10.2 Inheritance

10.2 Nature of science:

Looking for patterns, trends and discrepancies—Mendel used observations of the natural world to find and explain patterns and trends. Since then, scientists have looked for discrepancies and asked questions based on further observations to show exceptions to the rules. For example, Morgan discovered non-Mendelian ratios in his experiments with *Drosophila*. (3.1)

10.2 Understandings:

- \* Gene loci are said to be linked if on the same chromosome.
- \* Unlinked genes segregate independently as a result of meiosis.
- \* Variation can be discrete or continuous.
- \* The phenotypes of polygenic characteristics tend to show continuous

variation.

\* Chi-squared tests are used to determine whether the difference between an observed and expected frequency distribution is statistically significant.

Applications and skills:

\* Application: Morgan's discovery of non-Mendelian ratios in *Drosophila*.

\* Application: Completion and analysis of Punnett squares for dihybrid traits.

\* Application: Polygenic traits such as human height may also be influenced by environmental factors.

\* Skill: Calculation of the predicted genotypic and phenotypic ratio of offspring of dihybrid crosses involving unlinked autosomal genes.

\* Skill: Identification of recombinants in crosses involving two linked genes.

\* Skill: Use of a chi-squared test on data from dihybrid crosses.

Theory of knowledge:

\* The law of independent assortment was soon found to have exceptions when looking at linked genes. What is the difference between a law and a theory in science?

10.2 Utilization:

\* An understanding of inheritance allowed farmers to selectively breed their livestock for specific characteristics.

10.2 Syllabus and cross-curricular links:

Biology Topic 3.4 Inheritance

Aims:

\* Aim 4: Use analytical skills to solve genetic crosses.

\* Aim 8: Ethical issues arise in the prevention of the inheritance of genetic disorders.

Topic 10: Genetics and evolution

10.2 Inheritance Guidance:

\* Alleles are usually shown side by side in dihybrid crosses, for example, TtBb. In representing crosses involving linkage, it is more common to show them as vertical pairs, for example: TB/tb

\* This format will be used in examination papers, or students will be given sufficient information to allow them to deduce which alleles are linked.

10.3 Essential idea: Gene pools change over time.

10.3 Gene pools and speciation

10.3 Nature of science:

Looking for patterns, trends and discrepancies—patterns of chromosome number in some genera can be explained by speciation due to polyploidy. (3.1)

10.3 Understandings:

\* A gene pool consists of all the genes and their different alleles, present in an interbreeding population.

\* Evolution requires that allele frequencies change with time in populations.

\* Reproductive isolation of populations can be temporal, behavioural or geographic.

\* Speciation due to divergence of isolated populations can be gradual.

\* Speciation can occur abruptly.

10.3 Applications and skills:

\* Application: Identifying examples of directional, stabilizing and disruptive selection.

\* Application: Speciation in the genus *Allium* by polyploidy.

\* Skill: Comparison of allele frequencies of geographically isolated populations.

10.3 Guidance:

\* Punctuated equilibrium implies long periods without appreciable change and short periods of rapid evolution.

10.3 Theory of knowledge:

\* Punctuated equilibrium was long considered an alternative theory of evolution and a challenge to the long established paradigm of Darwinian gradualism. How do paradigm shifts proceed in science and what factors are involved in their success?

10.3 Utilization:

\* Many crop species have been created to be polyploid. Polyploidy increases allelic diversity and permits novel phenotypes to be generated. It also leads to hybrid vigour.

10.3 Syllabus and cross-curricular links:

Biology Topic 5.1 Evidence for evolution

PPTs:

PART\_1-Cell\_Division\_\_Genetics\_\_\_Molecular\_Biology\_PowerPoint.pptx

lect021.ppt

00\_meiosis.pptx

Videos:

Chromosomes Crossing Over - Linked Genes.flv

Crossing Over-1.flv

Sex Chromosomes.wmv

Website resource:

<https://www.socscistatistics.com/tests/chisquare2/default2.aspx>

\*click on "Alternative Chi-Square Calculators

Simple 2 x 2 table calculator", on the right-hand side of the screen

\* The result is the same regardless of whether successive values are being put in rows or in columns.

\* The input did not allow decimal-place inputs, so what I input is not exactly the same as the book's p. 426 example, but using similar numbers to the book example, "The chi-square statistic is 0.2601. The p-value is .967354. The result is not significant at  $p < .05$ ."

With another example: 200, 118, 118, 118, (farther from the 9:3:3:1 mendelian expected ratio), "The chi-square statistic is 71.6794. The p-value is  $< 0.00001$ . The result is significant at  $p < .05$ ."

Assignments & Assessments:

● 10.1 & 10.2 Kognity Questions (/28)

● TOK Research Task (/7)

Find references to the work of 1983 Nobel Prize winner Barbara McClintock who made important contributions to the field of genetics. Describe the way her work presented observations that did not fit in with current understanding of genetics (10.1

Nature of science topic), how her observations described exceptions to currently accepted laws and rules (10.2 Nature of science topic), described a new pattern or trend (10.3 Nature of science topic), or even presented a challenge to the prevalent paradigm (10.3 TOK topic).

Proper citations are required: Author, Date, Title, Website (since your research will probably be online), and DOI (if you can find one). Record step-by-step (keep track of and describe) the method used to find the research including search engine used, keywords used, which materials you decided not to use and why, and why you chose to use the references you selected.

- 10.3 Kognity Questions (/17)

- 10.1 - 10.3 Kognity Exam-Style Questions (4 questions, comments only)

\* Students requested to no longer use Kognity and so I considered them exempt from this homework that had already been assigned.

\* HL students also requested to begin studying unit 11 because it is an extension of the recently covered topic 6, and so we began study of unit 11 even though we had not yet finished unit 10. Our plan is to return to unit 10 afterward and finish next month.

\* Students requested to no longer use the .ppts that I have been uploading or to watch videos, and to have more lecture-style classes, and so upcoming lessons will predominantly follow the book, highlight and focus on the main points found there.