# TwoOldGuys™ Study Guides
## BI114 Biological Concepts for Teachers
# Chapter 3. Inheritance and Evolution
# 3.2. Mutation

Based on Indiana's Academic Standards, Science, as adopted by the Indiana State Board of Education, Nov 2000.
*Numbers refer to the age-appropriate grade-level for the content.*

## Review

We covered Mendel's Principles, which are the theory of how inheritance allows traits to be passed from one generation to the next. Basically, each individual has two alleles for each trait. These alleles separate during gamete formation, so each gamete has only one allele for each trait. Fertilization recombines the alleles so the offspring have two alleles (one from each parent).

We shall next look at the mechanisms which allow some traits to be changed from one generation to the next, a process called Mutation.

## Mutation

*grades 5: to 8:*

### fictional mutants

Most children in this age group are already familiar with a number of fictional "mutants." Many of these fictional mutants are portrayed as super-heroes with super powers [spiderman, for example], or as super villains [werewolves, vampires, and such]. Other mutants in children's "literature" include miscellaneous monsters, such as oversized insects or spiders. While these portrayals provide a certain amount of

entertainment, they should not be misunderstood to describe any reality known to modern science.

## real mutants

Those mutants that have been confirmed by scientists turn out to be rather boring compared to the fictional versions. For example, the laboratory *white* mouse [and *white* rat] are mutations of the "wild type" or normal mouse or rat which are grey to black. As its name suggests the American Black Bear is black, however there is a common mutant which is called the *cinnamon* phase, which ranges from reddish-brown to brown [I have even seen a sun-bleached blond individual]. Even the familiar *gold*fish is a mutant of the wild brown to tan carp.

Plants also appear as mutants. One example involves dwarf plants, such as short-stem dandelions and a tree [*Juniper*] which grows as a shrub [the common nursery version of the tree]. Another interesting plant mutant grows as a shrub or small tree [poison oak] for which the wild type is a vine [poison ivy].

## mutants occur when genetic information is changed by environmental agents

Certain classes of environmental agents [pollutants] may change the genetic information that is supposed to be transmitted from parents to offspring. The best known of these agents is radiation [particularly ultra-violet [UV] light and X-rays. A number of chemical pollutants have been found to cause mutations when given to laboratory animals in large quantities.

The mechanism for how these agents can produce mutants is a bit complicated. An individual animal or plant exposed to sufficient amounts of the pollutant will have a change in the genetic information

[allele] for some trait. When this individual reproduces, it will transmit the changed information exactly as if the information were normal. Remembering Mendel's Principles, one parent will provide a normal allele, but the other parent will provide the mutant allele. Since the two alleles are recombined during fertilization, the resulting offspring will have one normal and one mutant allele. These individuals may produce an unusual appearance, but will transmit the changed information to their offspring.

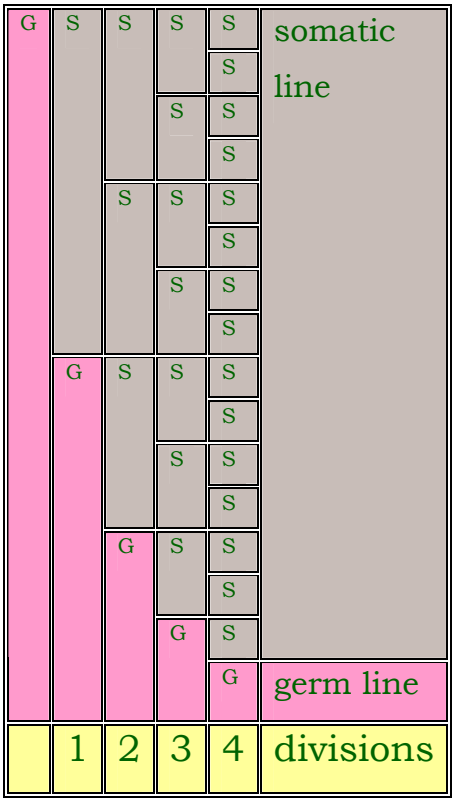
*grades secondary: to college:*

## ***Mutation = "Any change in the allele for a trait"***

The definition of mutation used to be "any change observed in a known trait." However, as we have learned more about the chemical nature of the genetic information, we have changed the definition to "any change in the allele [DNA sequence] for a trait." The explanation of the relationship between the DNA molecule and genetic traits can be found in Appendix D. For most of you, just knowing where this information can be found is more than you ever wanted to know, and the information which can be found is certainly more than you will ever need to know to teach at the elementary level. For our present purposes (in this text), DNA is basically coded information used by living things to develop their appearance (morphology) and their functions (physiology). Thus a change in an allele will result in a change either in the appearance or in the function of the creature.

In Section 3.1 (Genetics, inheritable characteristics, grade 7 to 8), you learned that there are specialized [sex] cells that combine to form a fertilized egg. We usually describe this as a male sperm unites with a female egg to form a fertilized egg or zygote. The zygote is a single cell which divides repeatedly to produce an adult with millions of cells. A

small group of cells [testes or ovaries] in the adult will produce new sperms or eggs depending on the sex of the adult. The small group of cells which produce the sex cells are called the germ line [reproductive cells], and the remainder of millions of cells of the adult are the somatic line [body cells]. When the single celled zygote divides, it produces a somatic cell and a germ cell. At the next division(s), the somatic cells produce two somatic cells, and the germ cell produces one germ cell and one somatic cell. Eventually the germ line will divide to produce only germ cells. This is illustrated in the figure below.




The current interest in germ cells relies on the ability of germ cells to produce somatic cells which then become only certain body parts.

A mutation could happen in any cell, but the effects are dramatically different depending on whether the cell is somatic or germ. The somatic mutation appears 'immediately' in the animal, and persists in any cells

produced from the mutated somatic cell. The germ line mutation will not show up until the germ cell produces a somatic cell in which the mutation appears. We normally expect germ line mutations to show up only in the offspring, not in the parents in which the germ line mutation occurred.

## Somatic line

A mutation in the somatic line affects only the individual, and usually only part of the individual. The part affected represents the daughter cells derived from the mutated somatic cell. A familiar somatic mutation in humans is patches of different color in skin [such as sun-freckles or age spots, either of which is a grey freckle compared to normal brown freckles]. The other familiar somatic mutation is skin cancer [or some other cancers].

## Germ line

We expect that the germ line mutations will not appear until some future generation. The mutated germ line cell will produce either sperms or eggs, one of which may eventually participate in fertilization, then grow to become a new adult animal carrying the mutation. However, some expressions of traits (recessive expression) can skip generation(s) before it actually becomes observable in the descendents of the mutated animal. This is illustrated for potential mutations from atomic weapons used during WWII.

| expected history of mutation<br>caused by atomic bomb at Hiroshima or Nagasaki | | | | |
|---|---|---|---|---|
| year | generation | relative[1]<br>spouse[2] | genotype<br>of offspring | phenotype<br>of offspring |
| 1948 | P-1 | he: Mm<br>she: MM | MM= 50%<br>Mm= 50%<br>mm= 0% | normal= 50%<br>carrier= 50%<br>mutant= 0% |
| 1968 | F-1 | sibling<br>MM | MM= 50%<br>Mm= 50%<br>mm= 0% | normal= 50%<br>carrier= 50%<br>mutant= 0% |
| 1988 | F-2 | 1st cousin<br>MM | MM= 50%<br>Mm= 50%<br>mm= 0% | normal= 50%<br>carrier= 50%<br>mutant= 0% |
| 2008 | F-3 | 2nd cousin<br>MM | MM= 50%<br>Mm= 50%<br>mm= 0% | normal= 50%<br>carrier= 50%<br>mutant= 0% |
| 2028 | F-4 | 3rd cousin<br>MM | MM= 50%<br>Mm= 50%<br>mm= 0% | normal= 50%<br>carrier= 50%<br>mutant= 0% |
| 2048 | F-5 | 4th cousin<br>MM | MM= 50%<br>Mm= 50%<br>mm= 0% | normal= 50%<br>carrier= 50%<br>mutant= 0% |
| 2068 | F-6 | 5th cousin<br>Mm (5th cuz) | MM= 25%<br>Mm= 50%<br>mm= 25% | normal= 25%<br>carrier= 50%<br>mutant= 25% |
| | [1]relative | most distant relative with mutation | | |
| | [2]spouse | possible genotype of spouse | | |

Real mutations are not as exciting as Hollywood versions. It does not matter how many radioactive spiders bite you, you will not be able to shoot webs from your wrists. Radiation does not produce giant, 40-foot tall ants; nor even killer tomatoes! Most mutations probably cause the expression of the allele to shift to the alternate for trait, such as normal two eyebrows in humans to uni-brow (hairs between the eyebrows).

Other mutations may create new expressions for the trait, such as the addition of red hair to the 'normal' dark brown – blond human hair color trait [this mutation appears to have occurred in an island population off the north coast of Europe].

## Mutagens

Things that have been shown to cause mutations in laboratory animals are called mutagenic agents or simply mutagens. Examples include:

- some organic chemicals
    - pesticides (biocides)
    - byproducts of tobacco & "recreational" drugs
    - food additives, prescription drugs
- radiation (ionizing, high-energy)
    - nuclear (gamma rays, alpha & beta particles)
    - x-rays and cosmic rays
    - Ultraviolet light ($UV_a$, $UV_b$, $UV_c$)
    - even visible light (Blue, Indigo, Violet)
    - ***NOT*** *microwaves, radio waves, power lines*

## spontaneous mutation

Some mutations seem to happen in the absence of any known mutagenic agents. There has been speculation by some scientists to explain these 'spontaneous' mutations:

- errors in DNA replication
- errors in mitosis or meiosis
- "other" (*unknown*)

Actually the "*unknown*" explanation includes the above spontaneous mutations, because there is no *known* mechanism for any of these spontaneous mutations.

## man-made

Mutations which were made deliberately by Humans are collectively referred to as genetic engineering.