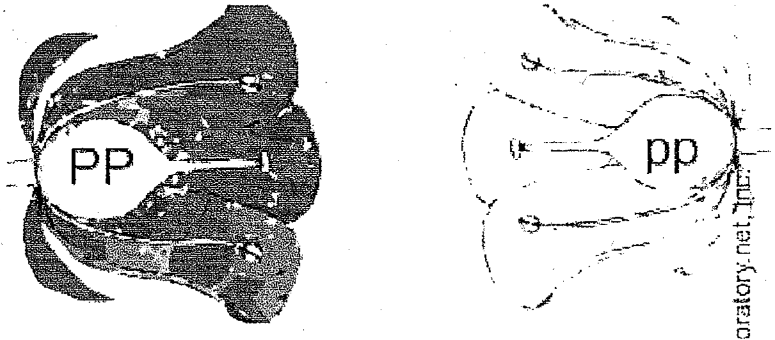
Mendel's Factors & Muller's mutations – page 1 of 9

As you almost certainly already know (and can review here), in the 1800's Mendel deduced the existence of genetic factors (which we now know as genes).

These factors are passed unaltered from parent to offspring - but importantly, not all factors held by a parent are transmitted (note on simplifications).

Each parent has two copies of each gene, but one and only one copy is transmitted to any particular offspring. Which copy is transmitted is random (stochastic).



Mendel's hypothesis: Pure-bred lines carry two copies of the factor that determines flower color.

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As you answer these questions, remember, there is rarely a single correct answer.

What did Mendel know about the physical nature of his factors?

He knew it was in the pollen. These ~~had heritable~~
They controlled physical characteristics and were heritable.

Does thinking at the molecular level clarify or confuse your understanding genes and mutations?

Clarifies. Knowing the mechanisms help us to understand and knowing the structures helps.

submit

Mendel's Factors & Muller's mutations – page 2 of 9

One of Mendel's major discoveries was that genes can exist in different forms, now known as **alleles**. Within a particular organism, there are two alleles of each gene; these alleles can be the same or different.

While there are at most two different alleles within a single organism, there can be many different alleles within a population. Typically, the most common alleles are known as "wild type".

An important question is, where did these various alleles come from? One hint came from the observation that new alleles could arise spontaneously - these new alleles are known as mutations.

Herman J. Muller won the Nobel prize in 1946 for his work showing that mutations could be generated by exposing an organism to radiation, specifically X-rays.

As you answer these questions, remember, there is rarely a single correct answer.

What does the ability of X-rays to generate mutations tell you about the physical nature of genes?

~~They are not static, they are vulnerable to interactions and control by other molecules~~

NO, because Muller didn't show where the mutation occured (in the gene or in the gene product)

Does it tell you anything about the physical nature of gene products?

See above. We don't know if the mutation occurs in translation, txn, or post-translation

submit

Mendel's Factors & Muller's mutations – page 3 of 9

Let us assume that each gene encodes a gene product (we are not concerned about what a gene product is or what it does). We can now consider all of the logically possible effects of a mutation. Compared to the original, or "wild type" gene product ("***wt***"), the mutant gene product ("***mut***") could be

● more active
● less active
● totally inactive or absent, or
● have a new activity
○ or have no effect

There are two more possibilities. The first arises because there are two copies of each gene in an organism – it is therefore possible that the mutated (***mut***) gene product could interferes with the activity of the wild type mutant (***wt***) gene product. We will call this

- antagonistic

Finally, there could be mutations that produce no visible effect, we will call these

- neutral

As you can imagine, neutral mutations are difficult to identify or study.

As you answer this question, remember, there is rarely a single correct answer.

When a mutation in a gene occurs, the mutated gene product is most likely to be (compared to the original gene product)...

☒ neutral
☐ more active
☐ less active >
☐ inactive or absent
☐ have a new activity
☐ interfere with the activity of the wild type gene product

Please explain the logic of your answer.

submit

Mendel's Factors & Muller's mutations – page 4 of 9

Now here is Muller's trick - a way of evaluating the activity of a gene without knowing what that activity is!

In the fruit fly *Drosophila melanogaster*, the organism that Muller worked with, it is possible to make deletions and duplications of genes. We can analyze their effects based on some (over simplistic) assumptions:

- the deletion of a gene (which we note as Δ) leads to the absence of the gene product.
- the duplication of a gene (which we note as 2x) leads to twice the gene activity.

As you answer this question, remember, there is rarely a single correct answer.

If you know your molecular biology, you know that there are cases where these assumptions are not strictly true. Can you describe such situations.

- Multiple copies of the gene.
- Biosynthetic pathways/feedback/combinations could all be effected by deletion of single genes. ie multiple gene products Δ
- ~~doubling gene product may not increase~~
- double gene does not neccessarily lead to 2x ~~gene product~~ gene activity, because the gene may be regulated by other factors.

submit

Mendel's Factors & Muller's mutations – page 5 of 9

We will use deletions and duplication to compare the activity of the original version of the gene (***wt***) with the mutant version (***mut***). *Drosophila* is diploid, so there are (normally) two copies of each gene. We indicate our situation as

$\frac{wt}{wt}$ produces the original phenotype

$\frac{mut}{wt}$ produces the mutant phenotype, if ***mut*** is dominant

$\frac{mut}{mut}$ produces the mutant phenotype, if ***mut*** is recessive

For the moment, let us assume that ***mut*** is recessive for the trait we are looking at (remember, recessive and dominant are not absolutes; a mutation/allele can be recessive for one trait and dominant for another).

Now let us ask, is the phenotype of

$\frac{mut}{\Delta}$ the same, more, or less severe (extreme) than the phenotype of $\frac{mut}{mut}$?

If ***mut*/Δ** and ***mut*/*mut*** individuals have the same phenotype, Muller concluded that that ***mut*** does not encode a functional gene product; either no product is produced or the product produced has no activity - he called such a mutation/allele **amorphic** (no activity).

If the phenotype of ***mut*/*mut*** is less severe than that of ***mut*/Δ**, Muller concluded that ***mut*** produced a gene product with some, but less than normal activity - he called that a **hypomorphic** (low activity) allele.

As you answer these questions, remember, there is rarely a single correct answer.

Why (do you think) Muller ~~come~~ came to these conclusions?

- If mut is recessive and has an active gene product, then mut/mut would show a recessive trait, and mut/Δ would look different (assuming that gene dosage is a factor).

↳ Therefore, because the flies look the same the gene product must be inactive

In molecular terms, how might a mutation reduce but not eliminate or change the activity of a gene product ? ↳ A mutation could alter the 3D structure or available binding domains, which would lessen the (but not inhibit) binding specificity

Mendel's Factors & Muller's mutations – page 6 of 9

To extend our analysis, let us now compare the "strength" of the trait expressed in organisms with the following genotypes. Remember we have been assuming that that *mut* is recessive. We find that the phenotype of

<u>*mut*</u> is more severe <u>*wt*</u>
mut than that of Δ

If *mut* is dominant (with respect to the trait we are considering) then,

<u>*mut*</u> is more severe <u>*mut*</u> which is more <u>*mut*</u>
2x *wt* than that of *wt* severe than Δ.

Muller concluded that *mut* produced either more of, or a more active version of the gene product than *wt* version of the gene. He termed such an allele **hypermorphic** (more function).

As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to this conclusion?

Because too much gene product creates a phenotype ~~that~~ that is bad. So if mut ~~creat~~ is overactive mut + wt will create more severe phenotypes

In molecular terms, how could a mutation increase, but not change the activity of a gene product?

If you increase the activity of a gene product, you are changing the activity. This question is poorly worded.

submit

Mendel's Factors & Muller's mutations – page 7 of 9

At this point, we have found a way to identify (using deletions and duplications of the gene under study), whether a mutation abolishes gene function, reduces it, or enhances it. But are there other possible effects of a mutation?

Muller found some. Consider the following is the case. The trait is dominant and the phenotype of

$\frac{mut}{wt}$ is more severe than that of $\frac{mut}{2\text{x } wt}$

Muller called mutations that behaved in this way **antimorphic**, that is, the mutated gene product function antagonized the function of the wild type gene product.

A related behavior can be observed with a recessive trait, in this case

$\frac{mut}{mut}$ is less severe than that of $\frac{2\text{x } mut}{wt}$

but this requires that we have a duplication of the mutant allele.

As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to his conclusion about antimorphic mutations?

In molecular terms, how could a mutation produce an antimorphic gene product?

Mendel's Factors & Muller's mutations – page 8 of 9

Muller identified one final class of mutation, their behavior was described by the following relationship; the phenotype of

$\frac{mut}{mut}$ is the same as or worse than $\frac{mut}{\Delta}$ but different from $\frac{wt}{wt}$

Remember, we are assuming that ***mut*** is recessive!
If ***mut*** is dominant then the phenotype of

$\frac{mut}{\Delta}$ is the same as $\frac{mut}{wt}$ is the same as $\frac{mut}{2\text{x } wt}$

Muller called such mutations **neomorphic**; he assumed that the mutated gene product had a new function or activity, a function/activity that the original gene product did not have.

As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to this conclusion? ?

In molecular terms, how could a mutation produce a neomorphic gene product?

submit

Mendel's Factors & Muller's mutations – page 9 of 9

At this point we have exhausted the universe of possible types of mutations. For any particular trait, influenced by a mutation, we can place the mutation in one of Muller's groups, or in the group with no effect, which we could call neutral or "normomorphic".

That said, remember we are talking about the mutation's effects on a single trait. The situation gets more complex when we recognize that many traits are influenced by multiple genes, and many genes influence multiple traits, but we will worry about that elsewhere.

As you answer these questions, remember, there is rarely a single correct answer.

Which types of mutation might enhance an organism's ability to adapt to a new environment, and how would that work?

hypermorphic: If theres an envi pressure you need to resist more heartily

Neomorphic

All ~~but amorphic~~, in changing enviornment,

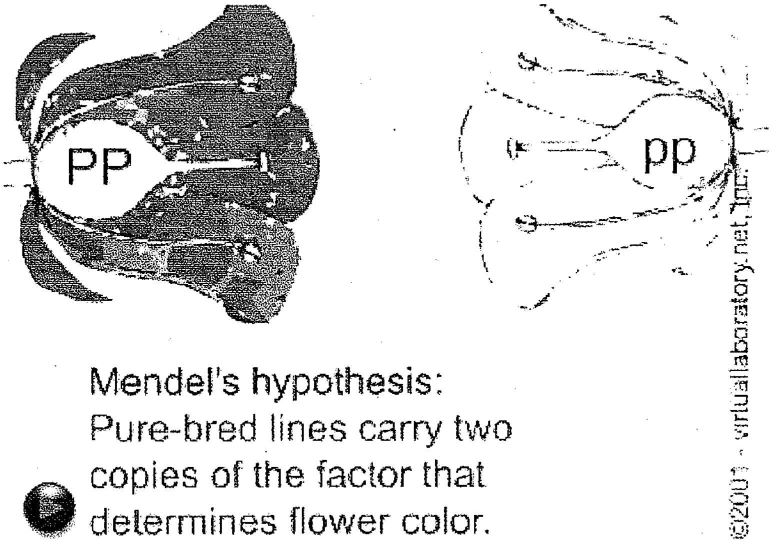
If mutations are random, how can they generate new behaviors, functions, and adaptations?

Random mutations that have a beneficial & visible effect on the organisms fitness will be passed on (if the mutaton is in the gametes) and thru further mutations can develop, more specifically, new fxns & adaptations

submit

Mendel's Factors & Muller's mutations – page 1 of 9

As you almost certainly already know (and can review here), in the 1800's Mendel deduced the existence of genetic factors (which we now know as genes).



Mendel's hypothesis:
Pure-bred lines carry two copies of the factor that determines flower color.

These factors are passed unaltered from parent to offspring - but importantly, not all factors held by a parent are transmitted (note on simplifications).

Each parent has two copies of each gene, but one and only one copy is transmitted to any particular offspring. Which copy is transmitted is random (stochastic).

As you answer these questions, remember, there is rarely a single correct answer.

What did Mendel know about the physical nature of his factors?

They were quantifiable

Does thinking at the molecular level clarify or confuse your understanding of genes and mutations?

Helps ... gives distinctive descriptions of where the changes come from

submit

Mendel's Factors & Muller's mutations – page 2 of 9

One of Mendel's major discoveries was that genes can exist in different forms, now known as **alleles**. Within a particular organism, there are two alleles of each gene; these alleles can be the same or different.

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As you answer these questions, remember, there is rarely a single correct answer.

What does the ability of X-rays to generate mutations tell you about the physical nature of genes?

That they can change

Does it tell you anything about the physical nature of gene products?

that they can change too

submit

Mendel's Factors & Muller's mutations – page 3 of 9

Let us assume that each gene encodes a gene product (we are not concerned about what a gene product is or what it does). We can now consider all of the logically possible effects of a mutation. Compared to the original, or "wild type" gene product ("***wt***"), the mutant gene product ("***mut***") could be

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Finally, there could be mutations that produce no visible effect, we will call these

- neutral

As you can imagine, neutral mutations are difficult to identify or study.

As you answer this question, remember, there is rarely a single correct answer.

When a mutation in a gene occurs, the mutated gene product is most likely to be (compared to the original gene product)...

☐ neutral
☐ more active
☒ less active
☒ inactive or absent
☐ have a new activity
☐ interfere with the activity of the wild type gene product

Please explain the logic of your answer.

There are more ways to not work than there are to work so if the change is by chance, it will most likely make it work poorly or not at all.

submit

Mendel's Factors & Muller's mutations – page 4 of 9

Now here is Muller's trick - a way of evaluating the activity of a gene without knowing what that activity is!

In the fruit fly *Drosophila melanogaster*, the organism that Muller worked with, it is possible to make deletions and duplications of genes. We can analyze their effects based on some (over simplistic) assumptions:

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- the duplication of a gene (which we note as 2x) leads to twice the gene activity.

As you answer this question, remember, there is rarely a single correct answer.

If you know your molecular biology, you know that there are cases where these assumptions are not strictly true. Can you describe such situations.

There are regulatory functions in the genome. Duplicating a silenced gene won't make any more gene product neither will the removal of a silenced gene make it any quicker.

submit

Mendel's Factors & Muller's mutations – page 5 of 9

We will use deletions and duplication to compare the activity of the original version of the gene (*wt*) with the mutant version (*mut*). *Drosophila* is diploid, so there are (normally) two copies of each gene. We indicate our situation as

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$\frac{\mathit{mut}}{\mathit{mut}}$ produces the mutant phenotype, if ***mut*** is recessive

For the moment, let us assume that ***mut*** is recessive for the trait we are looking at (remember, recessive and dominant are not absolutes; a mutation/allele can be recessive for one trait and dominant for another).

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As you answer these questions, remember, there is rarely a single correct answer.

Why (do you think) Muller came to these conclusions?

Having two copies of a somewhat functional gene product is better than only one so
if mut/mut is better off than mut/Δ the product should have some, but low, activity

---

In molecular terms, how might a mutation reduce but not eliminate or change the activity of a gene product ?

degeneracy in, the genetic code could explain the no effect, some Amino Acids
are similar to another so. exchange could lower activity, but not change it.

Mendel's Factors & Muller's mutations – page 6 of 9

To extend our analysis, let us now compare the "strength" of the trait expressed in organisms with the following genotypes. Remember we have been assuming that that ***mut*** is recessive. We find that the phenotype of

$$\frac{mut}{mut} \text{ is more severe than that of } \frac{wt}{\Delta}$$

If ***mut*** is dominant (with respect to the trait we are considering) then,

$$\frac{mut}{2x\ wt} \text{ is more severe than that of } \frac{mut}{wt} \text{ which is more severe than } \frac{mut}{\Delta}.$$

Muller concluded that ***mut*** produced either more of, or a more active version of the gene product than ***wt*** version of the gene. He termed such an allele **hypermorphic** (more function).

As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to this conclusion?

Each addition of the wt gene introduces the normally active gene along with the over reactive gene so $\frac{mut}{\Delta}$ = 2xgene product $(\frac{wt}{wt})$ • $\frac{mut}{wt}$ = 3x gene product and $\frac{m\ wt}{2xwt}$ = 4x the amount of gene product

In molecular terms, how could a mutation increase, but not change the activity of a gene product?

The mutation could increase the binding efficiency of the enzyme or change the conformation binding site of the enzyme to always on,

submit

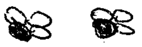
Mendel's Factors & Muller's mutations – page 7 of 9

At this point, we have found a way to identify (using deletions and duplications of the gene under study), whether a mutation abolishes gene function, reduces it, or enhances it. But are there other possible effects of a mutation?

Muller found some. Consider the following is the case. The trait is dominant and the phenotype of

1:1

$\frac{mut}{wt}$ is more severe than that of $\frac{mut}{2x\ wt}$ 2:1



Muller called mutations that behaved in this way **antimorphic**, that is, the mutated gene product function antagonized the function of the wild type gene product.

A related behavior can be observed with a recessive trait, in this case

no effect

$\frac{3\ wx}{wt}$ wt

$\frac{mut}{mut}$ is less severe than that of $\frac{mut}{wt}$ $\frac{2x\ mut}{wt}$

Doom!

ok

not so good

but this requires that we have a duplication of the mutant allele.

As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to his conclusion about antimorphic mutations?

In this case it IS desirable to make a different protein as apposed to a protein that disrupts the wildtype functional protein because if you make two of a protein that is bad and one that is good but they can't work toogther. However an only mutant protein may work.

= will not work

✓ works

ok mutant

0 – wt.

In molecular terms, how could a mutation produce an antimorphic gene product?

See above.

Mendel's Factors & Muller's mutations – page 8 of 9

Muller identified one final class of mutation, their behavior was described by the following relationship; the phenotype of

$\frac{mut}{wt}$ give $\longleftrightarrow$

$\frac{mut}{mut}$ is the same as or worse than $\frac{mut}{\Delta}$ but different from $\frac{wt}{wt}$

Remember, we are assuming that ***mut*** is recessive!
If ***mut*** is dominant then the phenotype of

$\frac{mut}{\Delta}$ is the same as $\frac{mut}{wt}$ is the same as $\frac{mut}{2x\ wt}$

Muller called such mutations **neomorphic**; he assumed that the mutated gene product had a new function or activity, a function/activity that the original gene product did not have.

As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to this conclusion? ?

Because it produces a different direction from $\frac{wt}{wt}$ it must have a new function

In molecular terms, how could a mutation produce a neomorphic gene product?

Could alter the binding specificity to latch onto and activate a different protein

submit

Mendel's Factors & Muller's mutations – page 9 of 9

At this point we have exhausted the universe of possible types of mutations. For any particular trait, influenced by a mutation, we can place the mutation in one of Muller's groups, or in the group with no effect, which we could call neutral or "normomorphic".

That said, remember we are talking about the mutation's effects on a single trait. The situation gets more complex when we recognize that many traits are influenced by multiple genes, and many genes influence multiple traits, but we will worry about that elsewhere.

As you answer these questions, remember, there is rarely a single correct answer.

Which types of mutation might enhance an organism's ability to adapt to a new environment, and how would that work?

If mutations are random, how can they generate new behaviors, functions, and adaptations?

submit

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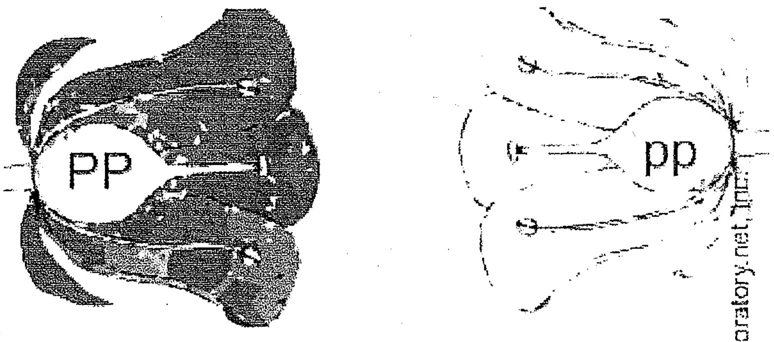

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As you answer these questions, remember, there is rarely a single correct answer.

What did Mendel know about the physical nature of his factors?

- He knew they were heretible.
- He knew they were involved with sex. (pollen, egg, ovary)

Does thinking at the molecular level clarify or confuse your understanding genes and mutations?

- Clarify, because it gives us physical, concrete, processes for heretible traits.

submit

Mendel's Factors & Muller's mutations – page 2 of 9

One of Mendel's major discoveries was that genes can exist in different forms, now known as **alleles**. Within a particular organism, there are two alleles of each gene; these alleles can be the same or different.

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As you answer these questions, remember, there is rarely a single correct answer.

What does the ability of X-rays to generate mutations tell you about the physical nature of genes?

They are stored in physical objects that are delicate enough to produce error.

Does it tell you anything about the physical nature of gene products?

- They are very small
- they are also prone to error or change.

submit

Mendel's Factors & Muller's mutations – page 3 of 9

Let us assume that each gene encodes a gene product (we are not concerned about what a gene product is or what it does). We can now consider all of the logically possible effects of a mutation. Compared to the original, or "wild type" gene product ("*wt*"), the mutant gene product ("*mut*") could be

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Finally, there could be mutations that produce no visible effect, we will call these

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As you can imagine, neutral mutations are difficult to identify or study.

As you answer this question, remember, there is rarely a single correct answer.

When a mutation in a gene occurs, the mutated gene product is most likely to be (compared to the original gene product)...

☑ neutral
☐ more active
☐ less active
☐ inactive or absent
☐ have a new activity
☐ interfere with the activity of the wild type gene product

Please explain the logic of your answer.

Most genetic information is not crucial to the success of a gene product. For example, our genomes contain lots of code that is never even accessed for information

submit

Mendel's Factors & Muller's mutations – page 4 of 9

Now here is Muller's trick - a way of evaluating the activity of a gene without knowing what that activity is!

In the fruit fly *Drosophila melanogaster*, the organism that Muller worked with, it is possible to make deletions and duplications of genes. We can analyze their effects based on some (over simplistic) assumptions:

- the deletion of a gene (which we note as Δ) leads to the absence of the gene product.
- the duplication of a gene (which we note as 2x) leads to twice the gene activity.

As you answer this question, remember, there is rarely a single correct answer.

If you know your molecular biology, you know that there are cases where these assumptions are not strictly true. Can you describe such situations.

many genes are redundant...→ deletion of one copy of the gene might not knock out the whole product that the genome encodes for...

gene activity also might depend on substrate levels — more gene product doesn't equal more substrate

submit

Mendel's Factors & Muller's mutations – page 5 of 9

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For the moment, let us assume that ***mut*** is recessive for the trait we are looking at (remember, recessive and dominant are not absolutes; a mutation/allele can be recessive for one trait and dominant for another).

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If the phenotype of ***mut*/*mut*** is less severe than that of ***mut*/Δ**, Muller concluded that ***mut*** produced a gene product with some, but less than normal activity - he called that a **hypomorphic** (low activity) allele.

As you answer these questions, remember, there is rarely a single correct answer.

Why (do you think) Muller come to these conclusions?

amorphic — if the amount of mutated gene product floating around doesn't change phenotype, then product has no activity
for hypomorphic — if mut/mut (more gene product) is more active than mut/Δ, than product must do stuff

In molecular terms, how might a mutation reduce but not eliminate or change the activity of a gene product ?

whether silent (thank you redundant aa code) or recessive or minor, the mutation can affect efficiency of protein rather than an all-or-nothing mutation.

Mendel's Factors & Muller's mutations – page 6 of 9

To extend our analysis, let us now compare the "strength" of the trait expressed in organisms with the following genotypes. Remember we have been assuming that that ***mut*** is recessive. We find that the phenotype of

$\frac{mut}{mut}$ is more severe than that of $\frac{wt}{\Delta}$

If ***mut*** is dominant (with respect to the trait we are considering) then,

$\frac{mut}{2x\ wt}$ is more severe than that of $\frac{mut}{wt}$ which is more severe than $\frac{mut}{\Delta}$.

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As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to this conclusion?

- In observing phenotypes of these different combinations, muller noticed that the presence of a hypermorphic gene was enough to cause problems. This indicates a dominant or gain-of-function mutant product.

In molecular terms, how could a mutation increase, but not change the activity of a gene product?

Mutation of a transcription factor will not change the activity of a gene, but may effect how readily the gene is transcribed

submit

Mendel's Factors & Muller's mutations – page 7 of 9

At this point, we have found a way to identify (using deletions and duplications of the gene under study), whether a mutation abolishes gene function, reduces it, or enhances it. But are there other possible effects of a mutation?

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Muller called mutations that behaved in this way **antimorphic**, that is, the mutated gene product function antagonized the function of the wild type gene product.

A related behavior can be observed with a recessive trait, in this case

$\frac{mut}{mut}$ is less severe than that of $\frac{2x\ mut}{wt}$

but this requires that we have a duplication of the mutant allele.

As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to his conclusion about antimorphic mutations?

he noticed that the interaction of mut w/ wt was more severe than mut/mut, indicating that the interaction is more important than the change in gene product function

In molecular terms, how could a mutation produce an antimorphic gene product?

If the mutation creates a prion-like product, that product can then go 'infect' or negatively affect the wt product

submit

Mendel's Factors & Muller's mutations – page 8 of 9

Muller identified one final class of mutation, their behavior was described by the following relationship; the phenotype of

$\frac{mut}{mut}$ is the same as or worse than $\frac{mut}{\Delta}$ but different from $\frac{wt}{wt}$

Remember, we are assuming that ***mut*** is recessive!
If ***mut*** is dominant then the phenotype of

$\frac{mut}{\Delta}$ is the same as $\frac{mut}{wt}$ is the same as $\frac{mut}{2x\ wt}$

Muller called such mutations **neomorphic**; he assumed that the mutated gene product had a new function or activity, a function/activity that the original gene product did not have.

As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to this conclusion? ?

He observed a gain-of-function mutation. This may have been done by observing a gene product in a new area post-mutation.

In molecular terms, how could a mutation produce a neomorphic gene product?

A single point mutation can completely alter the catalytic activity of the gene product, giving it new dominantly behaving functions.

submit

Mendel's Factors & Muller's mutations – page 9 of 9

At this point we have exhausted the universe of possible types of mutations. For any particular trait, influenced by a mutation, we can place the mutation in one of Muller's groups, or in the group with no effect, which we could call neutral or "normomorphic".

That said, remember we are talking about the mutation's effects on a single trait. The situation gets more complex when we recognize that many traits are influenced by multiple genes, and many genes influence multiple traits, but we will worry about that elsewhere.

As you answer these questions, remember, there is rarely a single correct answer.

Which types of mutation might enhance an organism's ability to adapt to a new environment, and how would that work?

any random mutation that happens to interact w/the new environment in a positive way for the organisms (i.e. dealing w/toxics, slight body structure changes, etc.)

If mutations are random, how can they generate new behaviors, functions, and adaptations?

only one mutation can uncover a whole host of mutations that have been building up, perhaps creating new adaptations . . .

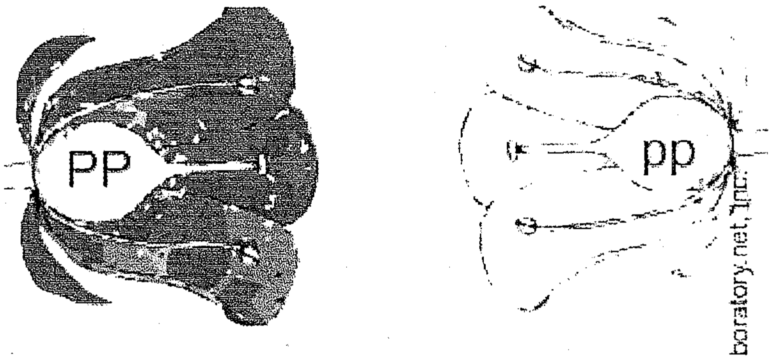
submit

Mendel's Factors & Muller's mutations – page 1 of 9

As you almost certainly already know (and can review here), in the 1800's Mendel deduced the existence of genetic factors (which we now know as genes).

These factors are passed unaltered from parent to offspring - but importantly, not all factors held by a parent are transmitted (note on simplifications).

Each parent has two copies of each gene, but one and only one copy is transmitted to any particular offspring. Which copy is transmitted is random (stochastic).



Mendel's hypothesis:
Pure-bred lines carry two copies of the factor that determines flower color.

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As you answer these questions, remember, there is rarely a single correct answer.

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genes
What did Mendel know about the physical nature of his factors?

He knew that it passed down from parent to offspring. He understood the concept of dominant and recessive.

Does thinking at the molecular level clarify or confuse your understanding genes and mutations?

Clarifies those concepts.

submit

Mendel's Factors & Muller's mutations – page 2 of 9

One of Mendel's major discoveries was that genes can exist in different forms, now known as **alleles**. Within a particular organism, there are two alleles of each gene; these alleles can be the same or different.

While there are at most two different alleles within a single organism, there can be many different alleles within a population. Typically, the most common alleles are known as "wild type".

An important question is, where did these various alleles come from? One hint came from the observation that new alleles could arise spontaneously - these new alleles are known as mutations.

Herman J. Muller won the Nobel prize in 1946 for his work showing that mutations could be generated by exposing an organism to radiation, specifically X-rays.

As you answer these questions, remember, there is rarely a single correct answer.

What does the ability of X-rays to generate mutations tell you about the physical nature of genes?

Genes can mutate and therefore induce variability in a species/community.

Does it tell you anything about the physical nature of gene products?

That genes code for specific phenotypes - these phenotypes vary due to the genetic code.

submit

Mendel's Factors & Muller's mutations – page 3 of 9

Let us assume that each gene encodes a gene product (we are not concerned about what a gene product is or what it does). We can now consider all of the logically possible effects of a mutation. Compared to the original, or "wild type" gene product ("*wt*"), the mutant gene product ("*mut*") could be

- more active
- less active
- totally inactive or absent, or
- have a new activity

There are two more possibilities. The first arises because there are two copies of each gene in an organism – it is therefore possible that the mutated (*mut*) gene product could interferes with the activity of the wild type mutant (*wt*) gene product. We will call this

- antagonistic

Finally, there could be mutations that produce no visible effect, we will call these

- neutral

As you can imagine, neutral mutations are difficult to identify or study.

As you answer this question, remember, there is rarely a single correct answer.

When a mutation in a gene occurs, the mutated gene product is most likely to be (compared to the original gene product)...

☒ neutral
☐ more active
☐ less active
☐ inactive or absent
☐ have a new activity
☐ interfere with the activity of the wild type gene product

Please explain the logic of your answer.

Because you have 2 copies of that gene, unless the gene that is mutated is the dominant allele in a heterozygous pair of alleles it won't be affected.

submit

Mendel's Factors & Muller's mutations – page 4 of 9

Now here is Muller's trick - a way of evaluating the activity of a gene without knowing what that activity is!

In the fruit fly *Drosophila melanogaster*, the organism that Muller worked with, it is possible to make deletions and duplications of genes. We can analyze their effects based on some (over simplistic) assumptions:

- the deletion of a gene (which we note as Δ) leads to the absence of the gene product.
- the duplication of a gene (which we note as 2x) leads to twice the gene activity.

As you answer this question, remember, there is rarely a single correct answer.

If you know your molecular biology, you know that there are cases where these assumptions are not strictly true. Can you describe such situations.

One situation is when a gene is silenced - so that the gene product is not expressed.

Also, you can have RNA regulation that can cause the gene product to degraded too quickly or not quickly at all.

The number of promoters for that gene can effect expression.

submit

Mendel's Factors & Muller's mutations – page 5 of 9

We will use deletions and duplication to compare the activity of the original version of the gene (***wt***) with the mutant version (***mut***). *Drosophila* is diploid, so there are (normally) two copies of each gene. We indicate our situation as

$\frac{wt}{wt}$ produces the original phenotype

$\frac{mut}{wt}$ produces the mutant phenotype, if ***mut*** is dominant

$\frac{mut}{mut}$ produces the mutant phenotype, if ***mut*** is recessive

For the moment, let us assume that ***mut*** is recessive for the trait we are looking at (remember, recessive and dominant are not absolutes; a mutation/allele can be recessive for one trait and dominant for another).

Now let us ask, is the phenotype of

$\frac{mut}{\Delta}$ the same, more, or less severe (extreme) than the phenotype of $\frac{mut}{mut}$?

If ***mut*/Δ** and ***mut*/*mut*** individuals have the same phenotype, Muller concluded that that ***mut*** does not encode a functional gene product; either no product is produced or the product produced has no activity - he called such a mutation/allele **amorphic** (no activity).

If the phenotype of ***mut*/*mut*** is less severe than that of ***mut*/Δ**, Muller concluded that ***mut*** produced a gene product with some, but less than normal activity - he called that a **hypomorphic** (low activity) allele.

As you answer these questions, remember, there is rarely a single correct answer.

Why (do you think) Muller come to these conclusions?

by observing phenotypes he came to these conclusion's in the first one if there is not phenotype change then the gene is not important, but in the seccund there is gene function and without the second gene there is more of a mutan phenotype meaning there has to be a protein product produced.

In molecular terms, how might a mutation reduce but not eliminate or change the activity of a gene product ? The mutation might not change the structure of the protein then the activity is not greatly affected. It depends on the charge of the amino acids

Mendel's Factors & Muller's mutations – page 6 of 9

To extend our analysis, let us now compare the "strength" of the trait expressed in organisms with the following genotypes. Remember we have been assuming that that ***mut*** is recessive. We find that the phenotype of

$\frac{mut}{mut}$ is more severe than that of $\frac{wt}{\Delta}$

If ***mut*** is dominant (with respect to the trait we are considering) then,

$\frac{mut}{2x\ wt}$ is more severe than that of $\frac{mut}{wt}$ which is more severe than $\frac{mut}{\Delta}$.

Muller concluded that ***mut*** produced either more of, or a more active version of the gene product than ***wt*** version of the gene. He termed such an allele **hypermorphic** (more function).

As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to this conclusion?

because there is more gene product, the mutated one is having more effect then the wild type one.

In molecular terms, how could a mutation increase, but not change the activity of a gene product?

The mutation could be in an active site making it more active but still w/ the same function or the protein may not degraded as fast.

submit

Mendel's Factors & Muller's mutations – page 7 of 9

At this point, we have found a way to identify (using deletions and duplications of the gene under study), whether a mutation abolishes gene function, reduces it, or enhances it. But are there other possible effects of a mutation?

Muller found some. Consider the following is the case. The trait is dominant and the phenotype of

$$\frac{mut}{wt} \text{ is more severe than that of } \frac{mut}{2\text{x } wt}$$

Muller called mutations that behaved in this way **antimorphic**, that is, the mutated gene product function antagonized the function of the wild type gene product.

A related behavior can be observed with a recessive trait, in this case

$$\frac{mut}{mut} \text{ is less severe than that of } \frac{2\text{x } mut}{wt}$$

but this requires that we have a duplication of the mutant allele.

As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to his conclusion about antimorphic mutations?

there is a competating relationship, the mutated product must mess with the wildtype product when there is more wild type the mutated product is not as evident.

In molecular terms, how could a mutation produce an antimorphic gene product?

The mutant product is competing with the wt and if it is more active then it can affect the function of the wt.

Mendel's Factors & Muller's mutations – page 8 of 9

Muller identified one final class of mutation, their behavior was described by the following relationship; the phenotype of

$\frac{mut}{mut}$ is the same as or worse than $\frac{mut}{\Delta}$ but different from $\frac{wt}{wt}$

Remember, we are assuming that *mut* is recessive!
If *mut* is dominant then the phenotype of

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Muller called such mutations **neomorphic**; he assumed that the mutated gene product had a new function or activity, a function/activity that the original gene product did not have.

As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to this conclusion? ?

There is no change in phenotype so the wt is not being affected the mut takesover function for the wild type.

In molecular terms, how could a mutation produce a neomorphic gene product?

It change the amino acid sequence enough to change the function of a protein.

submit

Mendel's Factors & Muller's mutations – page 9 of 9

At this point we have exhausted the universe of possible types of mutations. For any particular trait, influenced by a mutation, we can place the mutation in one of Muller's groups, or in the group with no effect, which we could call neutral or "normomorphic".

That said, remember we are talking about the mutation's effects on a single trait. The situation gets more complex when we recognize that many traits are influenced by multiple genes, and many genes influence multiple traits, but we will worry about that elsewhere.

As you answer these questions, remember, there is rarely a single correct answer.

Which types of mutation might enhance an organism's ability to adapt to a new environment, and how would that work?

Differnt mutatons could change te cell membran to help te organism survie in new invirement so it could hava diffent salty or Cholesteral content.

If mutations are random, how can they generate new behaviors, functions, and adaptations?

mutations create varabilty, if the mutaton is good for te environment then it will stick around if not ten it will disapeare.

submit

Mendel's Factors & Muller's mutations – page 1 of 9

As you almost certainly already know (and can review here), in the 1800's Mendel deduced the existence of genetic factors (which we now know as genes).

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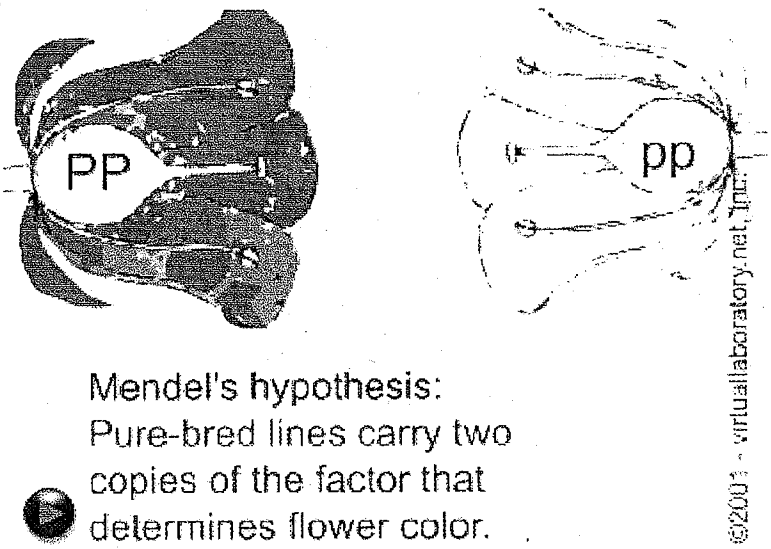

Mendel's hypothesis: Pure-bred lines carry two copies of the factor that determines flower color.

As you answer these questions, remember, there is rarely a single correct answer.

What did Mendel know about the physical nature of his factors?

He saw certain traits that showed up more than others. He saw traits that the parents didn't have. Saw ~~amounts~~ patterns of certain traits.

Does thinking at the molecular level clarify or confuse your understanding genes and mutations?

The molecular clarifies our understanding of genes and mutations.

submit

Mendel's Factors & Muller's mutations – page 2 of 9

One of Mendel's major discoveries was that genes can exist in different forms, now known as **alleles**. Within a particular organism, there are two alleles of each gene; these alleles can be the same or different.

While there are at most two different alleles within a single organism, there can be many different alleles within a population. Typically, the most common alleles are known as "wild type".

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As you answer these questions, remember, there is rarely a single correct answer.

What does the ability of X-rays to generate mutations tell you about the physical nature of genes?

X-rays can affect the DNA which affects genes in the DNA.

Does it tell you anything about the physical nature of gene products?

If the gene changes than the gene products will change.

submit

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Mendel's Factors & Muller's mutations – page 3 of 9

Let us assume that each gene encodes a gene product (we are not concerned about what a gene product is or what it does). We can now consider all of the logically possible effects of a mutation. Compared to the original, or "wild type" gene product ("*wt*"), the mutant gene product ("*mut*") could be

- more active
- less active
- totally inactive or absent, or
- have a new activity

There are two more possibilities. The first arises because there are two copies of each gene in an organism – it is therefore possible that the mutated (*mut*) gene product could interferes with the activity of the wild type mutant (*wt*) gene product. We will call this

- antagonistic

Finally, there could be mutations that produce no visible effect, we will call these

- neutral

As you can imagine, neutral mutations are difficult to identify or study.

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When a mutation in a gene occurs, the mutated gene product is most likely to be (compared to the original gene product)...

☑ neutral
☐ more active
☐ less active
☐ inactive or absent
☐ have a new activity
☐ interfere with the activity of the wild type gene product

Please explain the logic of your answer.

Because organisms have different DNA sequence but still have the same function so they are neutral. otherwise there would be no variation and no evolution.

submit

Mendel's Factors & Muller's mutations – page 4 of 9

Now here is Muller's trick - a way of evaluating the activity of a gene without knowing what that activity is!

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- the duplication of a gene (which we note as 2x) leads to twice the gene activity.

As you answer this question, remember, there is rarely a single correct answer.

If you know your molecular biology, you know that there are cases where these assumptions are not strictly true. Can you describe such situations.

Other factors regulated gene activity so just because a gene is duplicated doesn't mean it will have twice the activity.

submit

Mendel's Factors & Muller's mutations – page 5 of 9

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For the moment, let us assume that ***mut*** is recessive for the trait we are looking at (remember, recessive and dominant are not absolutes; a mutation/allele can be recessive for one trait and dominant for another).

Now let us ask, is the phenotype of

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If the phenotype of ***mut*/*mut*** is less severe than that of ***mut*/Δ**, Muller concluded that ***mut*** produced a gene product with some, but less than normal activity - he called that a **hypomorphic** (low activity) allele.

As you answer these questions, remember, there is rarely a single correct answer.

Why (do you think) Muller come to these conclusions?

The first conclusion is because the mut gene is not active so mut/mut and mut/Δ have the same phenotype.
The second one is that mut/Δ only has one copy so less gene product is produced.

In molecular terms, how might a mutation reduce but not eliminate or change the activity of a gene product ?

It could change the DNA sequence that recruits the transcription machinery.

Mendel's Factors & Muller's mutations – page 6 of 9

To extend our analysis, let us now compare the "strength" of the trait expressed in organisms with the following genotypes. Remember we have been assuming that that ***mut*** is recessive. We find that the phenotype of

$\frac{\textit{mut}}{\textit{mut}}$ is more severe than that of $\frac{\textit{wt}}{\Delta}$

If ***mut*** is dominant (with respect to the trait we are considering) then,

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Muller concluded that ***mut*** produced either more of, or a more active version of the gene product than ***wt*** version of the gene. He termed such an allele **hypermorphic** (more function).

As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to this conclusion?

So with the mut/2xwt there is 3x the activity compared to mut/wt which is 2x the activity of mut/Δ.

In molecular terms, how could a mutation increase, but not change the activity of a gene product?

a better sequence or an enhancer added for the transcription machinery.

submit

Mendel's Factors & Muller's mutations – page 7 of 9

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A related behavior can be observed with a recessive trait, in this case

$\frac{mut}{mut}$ is less severe than that of $\frac{2x\ mut}{wt}$

but this requires that we have a duplication of the mutant allele.

As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to his conclusion about antimorphic mutations?

So mut/2x wt has more wt gene product so that would dominate compared to mut/wt which would compete with each other.

In molecular terms, how could a mutation produce an antimorphic gene product?

The mutant product could bind to the wt product or compete for the same molecules.

Mendel's Factors & Muller's mutations – page 8 of 9

Muller identified one final class of mutation, their behavior was described by the following relationship; the phenotype of

$$\frac{mut}{mut} \text{ is the same as or worse than } \frac{mut}{\Delta} \text{ but different from } \frac{wt}{wt}$$

Remember, we are assuming that ***mut*** is recessive!
If ***mut*** is dominant then the phenotype of

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As you answer these questions, remember, there is rarely a single correct answer.

How (do you think) did Muller come to this conclusion? ?

So the mut/mut and mut/Δ have a different phenotype than wt/wt.

In molecular terms, how could a mutation produce a neomorphic gene product?

The gene product could be different and now can act on another molecule.

submit

Mendel's Factors & Muller's mutations – page 9 of 9

At this point we have exhausted the universe of possible types of mutations. For any particular trait, influenced by a mutation, we can place the mutation in one of Muller's groups, or in the group with no effect, which we could call neutral or "normomorphic".

That said, remember we are talking about the mutation's effects on a single trait. The situation gets more complex when we recognize that many traits are influenced by multiple genes, and many genes influence multiple traits, but we will worry about that elsewhere.

As you answer these questions, remember, there is rarely a single correct answer.

Which types of mutation might enhance an organism's ability to adapt to a new environment, and how would that work?

neomorphic could allow the new activity to be helpful for the organism.

If mutations are random, how can they generate new behaviors, functions, and adaptations?

mutations can cause less activity of a gene or functions.

submit