

GFP Worms on the LEICA Dissecting Microscope

Joyce Ma, Jackie Wong, and Emily Hatch

May 2004

THIS IS **NOT** A DEFINITIVE FINAL REPORT

FORMATIVE evaluation studies like this one often:

- **are conducted quickly**, which may mean
 - small sample sizes
 - expedited analyses
 - brief reports

- **look at an earlier version** of the exhibit/program, which may mean
 - a focus on problems and solutions, rather than successes
 - a change in form or title of the final exhibit/program

Imaging Station – Formative Evaluation GFP Worms on the LEICA Dissecting Microscope: Searching for and Looking at Worms

Joyce Ma, Jackie Wong and Emily Hatch
May 2004

PURPOSE

This study was conducted to:

- To determine if visitors can find worms to look at
- To identify what visitors notice about the GFP worms, particularly if visitors notice the differences between the three strains of worms
- To gauge visitors interest in finding and looking at the worms

This report describes two iterations of this study done with two different sets of worms.

ITERATION 1

STRAINS OF WORMS

- The brain and parts of the nervous system glows (Figure 1)
- The throat and mouth glows (Figure 2)
- The nervous system glows with some worms inside others - aka bag of worms (Figure 3)

Figure 1. Brain (and parts of the nervous system) glows



Figure 2. Throat and mouth glows



Figure 3. Nervous system glows with little worms inside of bigger worms



METHOD

- Cued Interviews
- Interviews conducted on Sunday, May 2, 2004
- Visitors were recruited from the Life Sciences Area on the Mezzanine of the Exploratorium.
- Before each interview, the evaluator set the zoom. Visitors could not control the zoom on the LEICA.
- At the beginning of the evaluation, the evaluator told the visitors that they could use the microscope behind the glass to look at very small creatures, and that there are tiny worms

under the microscope and that they are special worms that glow green under UV light. Then the evaluator turned on the UV light for visitors.

- Visitors were asked to control the microscope with the joystick and the focus knob to try to find worms to look at. After finding a specimen, visitors were then asked to find the 3 different strains of worms.
- Each visitor was asked a series of questions about what they saw. These questions are in Appendix A.

PARTICIPANTS

- N = 7

Gender	Count
Female	3
Male	4
Total	7

Age Group	Count
Adult	7
Teen	0
Child	0
Total	7

FINDINGS

Finding and looking at a specimen

In this study, a visitor has found a specimen if 1) s/he stopped for 3 or more seconds and looked at a focused image of a worm or 2) s/he reports that s/he's found a worm and the worm on the monitor is in focus.

Were visitors able to find a specimen?

- All the visitors interviewed were able to find a specimen.
- However, 4 out of the 7 also misidentified worm tracks as the worms themselves.

How long did it take to find their first specimen?

- On average, visitors found a worm in 6 seconds (mean) or 7 seconds (median).

What strains did they find?

- Visitors found the following strain of worms.¹ Note that all the visitors interviewed found a worm that glowed green throughout and not just in a particular spot in its body.

¹ The evaluator conducting the interview identified which strain each visitor found.

Strain	Count
Brain glows	3
Throat and Mouth glows	3
Nervous system glows	7

What differences did visitors report seeing?

We asked visitors to describe any differences between the worms they saw. The following summarizes visitors' responses. The complete set of visitors' descriptions can be found in Appendix B.

- Active vs. Passive (5/7 visitors)
- Glows vs. Glows dimly or not at all (4/7 visitors)
- Big vs. Small (4/7 visitors)
- Different colors (2/7 visitors)
- Part Glowing vs. All Glowing (1/7 visitors)

Visitors also noticed the direction worms moved in

How interesting did visitors find the experience?

Interest Rating	Count
Interesting	4
Somewhat interesting	3
Neutral	0
Somewhat not interesting	0
Not interesting	0
Total	7

- Visitors found their experience interesting for the following reasons
 - The worms moved around (3/7 visitors)
 - Visitors enjoyed the search (1/7 visitors)
 - Visitors liked seeing the worms glow (1/7 visitors)
 - The image is aesthetically pleasing (1/7 visitors)
 - The worms are gross (1/7 visitors)

- A few visitors thought that the experience was not as interesting
 - The exhibit need to provide a better view of the microscope (1/7 visitors)
 - There's not much immediately apparent (1/7 visitors)

Finding and looking at the different strains

Were visitors able to find the different strains?

- Visitors were able to correctly identify the following

Strain	Count
Brain glows	3
Throat and Mouth glows	3
Nervous system glows	7

- However, some visitors (4/7) also misidentified the worm strains. Two of these visitors did not see a distinction between the brain strain and the mouth and throat strain. One visitor misidentified the nervous system strain with the brain and the mouth/throat strain. And, one visitor misidentified the mouth/throat strain.

What was difficult about finding the different strains?

- The brain and the mouth/throat strains are too similar
 - Visitor2: These two look similar (brain and gut) and are tough to identify.
 - Visitor3: These two (brain and throat/mouth) were a little more difficult to distinguish.
- It's difficult to see the worms
 - Visitor4: It was a little difficult because you didn't really know how deep they were (in media) or when they were going to be showing what you were looking for.
 - Visitor5: It's dark. Doesn't that make it more difficult to see them?
- There weren't very many of one particular strain
 - Visitor1: Um- I would say it was fairly easy, other than the fact that there weren't very many of those (brains).
- Moving xy was too slow
 - Visitor5: They're really slow {the joystick} - takes a long time to pan.

Did knowing the glowing parts make finding the worms easier?

- 4/7 visitors thought that knowing which part was glowing and seeing a picture of the different strains made finding the worms much easier.
- Alternatively, 3/7 visitors did not think knowing this helped them at all in their search.

Did knowing that a worm has a brain, mouth/throat, and nervous system make the experience more interesting?

- 4/7 visitors thought knowing that a worm has these parts made their experience more interesting. They gave the following reasons:
 - Visitor2: That's my favorite part so far- when handed a task I go right to work.
 - Visitor6: I would say this is more interesting. Because it gives you something to hunt for.
 - Visitor1: Just being able to identify the different parts of worms that you can't normally see. I think that's really neat. The central nervous system doesn't look as defined as in this picture- but it's still cool.
- 3/7 visitors did not think knowing this made any difference for their experience. They explained:
 - Visitor3: More interesting if I knew what the worms were and more about them. I tend to like the exhibits that give me a reasonable amount of information about what I'm looking at.
 - Visitor7: Pretty much the same if you're just looking for glowing worms. Because under this power magnification- there's really not too much difference between whole glowing and not. You can't see the brain, or the heart or something (in detail).

ITERATION 2

In this iteration, we replaced one strain of worms (bag of worms) with another strain, the Morimoto worms. In addition, in this second iteration, the worms had been on the plates for a longer time and had eaten the medium smooth by the time of this evaluation. Consequently, they were unable to tunnel through or to leave tracks in the medium. We believe that this substantially changed the visitor experience: Visitors did not have to change the focus to see the worms. There were no tracks in the background making it appeared more uniformed and less distracting.

STRAINS OF WORMS

(Differences between the first and the second iteration are noted with italics.)

- The brain and parts of the nervous system glows (Figure 1)
- The throat and mouth glows (Figure 2)
- *Morimoto worms. Clumps of proteins glow throughout the body.* (Figure 4)

Figure 4. Morimoto worms



METHOD

(Differences between the first and the second iteration are noted with italics.)

- Cued Interviews
- *Interviews conducted on Sunday, May 9, 2004*
- Visitors were recruited from the Life Sciences Area on the Mezzanine of the Exploratorium.
- At the beginning of the evaluation, the evaluator told the visitors that they could use the microscope behind the glass to look at very small creatures, and that there are tiny worms under the microscope and that they are special worms that glow green under UV light. Then the evaluator turned on the UV light for visitors.
- *We were unable to control the focus on the LEICA from the visitor cart. Instead, the evaluator set the focus for the LEICA. Because the worms could not tunnel into the medium, we were able to preset the focus so that worms were always in focus on the monitor.*
- Visitors were asked to control the microscope with the joystick *and the slider (zoom control) on the touchscreen* to try to find worms to look at. After finding a specimen, visitors were then asked to find the 3 different strains of worms.
- Each visitor was asked a series of questions about what they saw. These questions are in Appendix A.

PARTICIPANTS

- N = 8

Gender	Count
Female	3
Male	5
Total	8

Age Group	Count
Adult	7
Teen	1
Child	0
Total	8

FINDINGS

Finding and looking at a specimen

Again, a visitor has found a specimen if 1) s/he stopped for 3 or more seconds and looked at a focused image of a worm or 2) s/he reports that s/he's found a worm and the worm on the monitor is in focus.

Were visitors able to find a specimen?

- All the visitors interviewed were able to find a specimen.

How long did it take to find their first specimen?

- On average, visitors found a worm in 6 seconds (mean) or 5.5 seconds (median).

What strains did they find?

- Visitors found the following strain of worms.²

Strain	Count
Brain glows	2
Throat and Mouth glows	8
Morimoto	8

² The evaluator conducting the interview identified which strain each visitor found.

What differences did visitors report seeing?

- Glows vs. Glows dimly or not at all (6/8 visitors)
- Big vs. Small (5/8 visitors)
- Different parts of the body glowing (5/8 visitors)
- Move together or apart (3/8 visitors)
- Active vs. Passive (2/8 visitors)

How interesting did visitors find the experience?

Interest Rating	Count
Interesting	5
Somewhat interesting	1
Neutral	1
Somewhat not interesting	1
Not interesting	0
Total	8

- Visitors found their experience interesting for the following reasons
 - The worms moved around (3/8 visitors)
 - The image is aesthetically pleasing (2/8 visitors)
 - The microscope was fun to control (1/8 visitors)
 - Visitors liked seeing the worms glow (1/8 visitors)
 - The worms are interesting – nothing more specific (1/8 visitors)
- A few visitors thought that the experience was not as interesting because
 - They're just worms (1/8 visitors)
 - There's not much immediately apparent (1/8 visitors)
 - It needs more explanation (1/8 visitors)

Finding and looking at the different strains

Were visitors able to find the different strains?

- Visitors were able to correctly identify the following

Strain	Count
Brain glows	1
Throat and Mouth glows	8
Morimoto worms	8

- Half the visitors (4/8) also misidentified the worm strains, mistaking one for another. Three of these visitors mistook a mouth/throat worm for a brain worm, and one mistook a Morimoto worm for a brain worm.

What was difficult about finding the different strains?

- The brain and the Morimoto worms look similar (2/8 visitors)
 - Visitor1: The speckled and the brain ones are harder to distinguish (between those two).
 - Visitor2: yeah- especially the last two (brain and speckled)- they're really similar.
- It's difficult to see the worms unless you have a good zoom (2/8 visitors)
 - Visitor3: because until you zoom in you can't see them (that they're green)
 - Visitor5: I think as you zoom in more, the things are easier to spot.
- There weren't very many of one particular strain (2/8 visitors)
 - Visitor6: the last one (the brain was the most difficult one to find).
 - Visitor8: It was hard to find this one (brain). But that's okay.
- Some strains do not glow brightly enough (1/8 visitors)
 - Visitor7: (brain) This one doesn't glow as bright as the others. This is not very easy to find (speckled).
- The xy control is jumpy. That is, the step size is too large. (1/8 visitors)
 - Visitor4: I guess it's kind of jumpy when you're moving things (slide) around.
- The xy control is reversed. (1/8 visitors)
 - Visitor4: Well just that it's all reversed, the joystick's all reversed.

Did knowing the glowing parts make finding the worms easier?

- 6/8 visitors thought that knowing which part was glowing and seeing a picture of the different strains made finding the worms much easier.
- The other 2/8 visitors did not think knowing this helped them at all in their search.

Did knowing that worms have different parts like the mouth/throat and brain make the experience more interesting?

- All the visitors interviewed thought knowing that a worm has these parts made their experience more interesting. They gave the following reasons:
 - Visitor4: More interesting- because you realize that you're looking at something...that you're looking at a complex thing and that it's making its own choices, like about where to go (in the dish).
 - Visitor6: More interesting. Just knowing that they have certain systems and stuff, cause when you look at worm you don't think they have the same type of system that we do.

Three visitors focused, in particular, on the fact that worms have a 'brain.'

Visitor3: More interesting. They are more a living creature than just a worm and you are less likely to step on them if you know they have a brain.

Visitor5: More interesting now we know it's not just a worm, it has a brain. I think it doesn't matter. What it is is, knowing that there's a brain, there's nothing here to see that would make use of them having a brain. To show that they have a brain other than just the glow. You can't tell if they're smart or not.

Visitor8: More interesting [knowing they have brains] because maybe now it makes sense why they're moving the way they're moving. Puts some purpose into it.

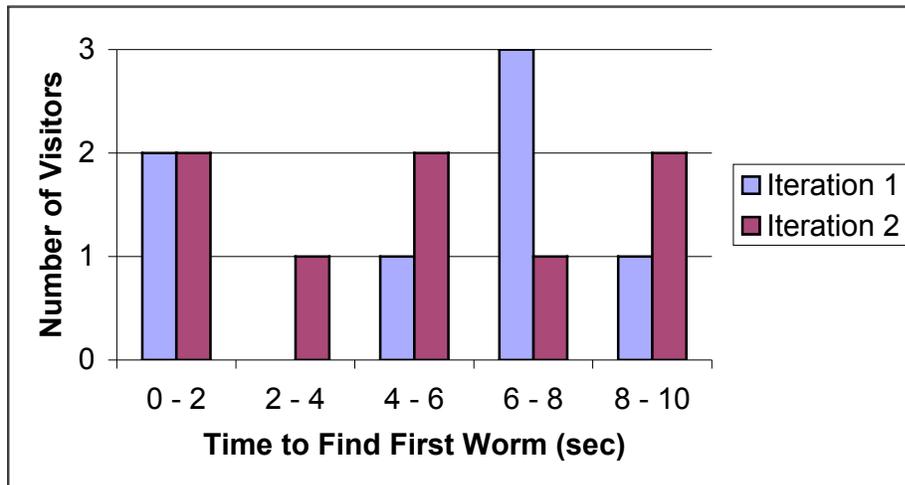
SUMMARY AND RECOMMENDATIONS

We compared and consolidated the findings from the two iterations to identify common trends and differences in the visitor experience with the first and second setup.

Finding and looking at a specimenFinding a specimen

- All the visitors interviewed were able to find a specimen to look at.
- Visitors took about 6 seconds to spot their first worm. A histogram showing visitors' search times is provided in Figure 5.

Figure 5. Histogram of Search Time



- However, when the worms were able to leave tracks in the medium, more than half the visitors misidentified the tracks as the worms themselves. Visitors need more support in simply identifying a worm when the medium (the background picture) is busy and distracting.

Differences visitors noticed between the worms on the plate

- Table 1 gives the tally of the differences visitors saw between the different worms on the plate.
- A majority of the visitors in both groups (iteration 1 and iteration 2) noticed differences in fluorescence and in size.
- However, only 1 out of 7 visitors in the first group noticed that different parts of the worms glowed under UV light. There was some (but not a statistically significant) improvement compared to the second iteration. We guess that this is partly because the worms were easier to see in the second iteration where the background medium was more uniform and less distracting. Even so, recognizing that different worms glow in different parts of their bodies is not immediately evident. This suggests that visitors need support in identifying the different strains of worms under the microscope.

Table 1. Differences visitors noticed between the worms they saw on the plate

Differences	Iteration 1 Count (out of 7)	Iteration 2 Count (out of 8)	Total (out of 15)
Glow vs. Glows dimly or not at all	4	6	10
Big vs. Small	4	5	9
Active vs. Passive	5	2	7
Different parts glowing	1	5	6
Moves together or apart	0	3	3
Different color worms	2	0	2

Visitor Interest Ratings

- In general, a majority (13 / 15) of the visitors found the worms *somewhat interesting to interesting* to look at. The most frequent reason visitors gave for finding the worms interesting was seeing the worms move.

Finding and looking at the different strains

- When we showed them pictures of the 3 different strains of worms, most visitors were able to find at least one of the strains on the plate, in both iterations.
- Overall, over half the visitors (10/15; 4/7 for Iteration 1, and 6/8 for Iteration 2) felt that having pictures of the different strains and knowing what parts glowed helped them to find the different types of worms on the plate.
- Furthermore, most visitors (12/15) thought that knowing that worms have different parts such as a brain, a throat, and a nervous system, made finding the different strains a more interesting experience.
- Nonetheless, in both iterations, at least half the visitors also misidentified the strains, mistaking one for another. In all but one of these cases, visitors confused the strain, in which the brain glows, with one of the other strains. This can indicate difficulties in identifying this particular strain and suggests that we need to provide visitors with additional help in finding this (glowing brain) strain of worms.

Visitors' Questions

The following summarizes the questions visitors asked for both iterations. This list may be informative for developing the content for the accompanying media piece for this specimen.

- Identification
 - What kind of worm is this?
 - What's their scientific name?

[This person mistook the tracks for the worms] I'm somewhat interested in the background- it almost looks like there are other worms in the background- what else am I seeing there (besides the glowing worms)?

Are they all the same?

Are they earthworms?

- GFP

Why are they glowing?

Why aren't they all glowing?

What makes them green?

Do you guys do transfections (tag the proteins) here? Are they under selection at all?

Are they (glowing) like this in the wild or are they created in the lab?

- Other features and attributes (besides GFP)

What are their actual sizes?

Why does it grow so big?

What's that line- (the glowing bit in a mouth throat)?

- Worm behavior

What are they doing?

What are they doing- just squirming around?

Can you do anything to affect their behavior?

How are they interacting? Is it accidental?

How do they move- what is the general pattern of their movement?

I saw some new things came out from the big one- I wonder how does it happen? What's going on?

Are the worms splitting?

- Life in the lab and in the dish

Where is the slide?

What is the media they're in?

How thick is the sample (agar base)?

What is this thing (pulsating slime blob)?

- Life in the world

Where are they found (in nature)?

Where does it (worm) grow?

What do the worms eat?

When do they sleep?

Are they like something that crawls on you?

- The microscope

What magnification is it?

Can you see them with the naked eye?

ACKNOWLEDGEMENTS

This material is based upon work supported by the National Institutes of Health Grant R25 RR15627 and the David and Lucile Packard Foundation (Grant 4365).



Department of Health and Human Services • National Institutes of Health

Supported by a Science Education
Partnership Award (SEPA) from the
National Center for Research Resources

APPENDIX A

Interview Questions

1. Can you describe what you see? So, pretend you're describing them to a friend who has never seen them before. [Probe to exhaustion: Anything else you notice?]

2. In general, did you find looking at these worms

Uninteresting	Somewhat Uninteresting	Neutral	Somewhat Interesting	Interesting
1	2	3	4	5

3. What was _____ about it?

4. Do you have any questions about what you see? Anything you would want to know?

5. Do you see any differences between these worms? What? [Probe to exhaustion]

6. I'd like you to try this. Can you find a worm that looks like this, this and this (give picture in following order and give short description of the part that glows)?

[Strain A] – this is its brain [point to glowing brain in picture]

[Strain B] – this is its gut [point to glowing gut in picture]

[Strain C] – this one has little worms inside [point to glowing worms in picture]/
this one has clumps of protein that glow [point to glowing spots on the Morimoto picture]

a. What, if anything was difficult about doing that?

b. Did you find that it was easier or harder to find a worm if you knew what parts glowed?
Or, did it really not matter?

c. How interesting is it to look at these different types of worm?

Uninteresting	Somewhat Uninteresting	Neutral	Somewhat Interesting	Interesting
1	2	3	4	5

d. What made it ____ for you?

7. In your opinion, does knowing that the worm has a brain or a gut make it more interesting, less interesting? Or, did it not matter?

APPENDIX B

What differences did visitors report seeing between the worms - Visitors' Responses

Iteration 1

- Glows vs. Glows dimly or not at all (4/7 visitors)
 - Visitor1: They were glowing. I saw some that weren't glowing
 - Visitor2: It's cool that they light up- some glow more than others.
 - Visitor3: They have a phosphorescent coating. Looks like some worms are coated and some are not. It enables you to see them as they move around and try to hunt or whatever it is they're trying to do.
 - Visitor7: Moving glowing worm...Something else in the background moving but not glowing ... The other one [non-glowing] seems to be less active... It's not glowing at same intensity [all over], [it's] kind of spotty
- Big vs. Small (4/7 visitors)
 - Visitor1: I saw a big one. They varied in size.
 - Visitor3: Some of them seem to be bigger or longer.
 - Visitor6: Size.
 - Visitor7: This one [glowing] is bigger. I don't know why- maybe because you have a better appreciation of its size. There are some smaller ones- I don't know why.
- Part Glowing vs. All Glowing (1/7 visitors)
 - Visitor1: The one- only part of it was glowing- looked like the inside organ - it (glowing organ) looks like just the bottom, the slimy part (of the worm), you know how slugs have that slimy part underneath.
- Active vs. Passive (5/7 visitors)
 - Visitor2: Some just lay there.
 - Visitor3: Some seem to move more than others.
 - Visitor4: Most of them aren't doing anything- just laying there. There are some of them that are more active ... The green ones seem to be fat and more active than anyone else [the yellow and white ones]
 - Visitor5: Well as compared to the others ones, they're bigger and they move faster [the green as opposed to the 'yellow' ones]... Some seem to be moving more than others.
 - Visitor7: Moving glowing worm... Something else in the background moving but not glowing. The other one [non-glowing] seems to be less active... Most of the time they are staying without moving. This one [glowing] is constantly moving.

- Different colors (2/7 visitors)
 - Visitor4: Some of them are different colors. There's green ones and then yellow ones, and white ones.
 - Visitor5: Different colors- the ones' green and the other's kind of a yellowish
- Visitors also noticed the direction worms moved in
 - Visitor6: Worms. They go both ways- [what do you mean?]. They don't just go forwards- they go backwards as well as forwards.
 - Visitor5: Moves one direction and then the other- it doesn't continue in a forward motion.
 - Visitor3: They can move back and forward equally well- so you think you've got it and then one backs up and moves the opposite way.

Iteration 2

- Glows vs. Glows dimly or not at all (6/8 visitors)
 - Visitor1: Some of them are glowing, some of them are not.
 - Visitor2: Yes- some of them have that have green things and some of them no.
 - Visitor3: Some have a fluorescent reaction and some doesn't. I guess that's because of the potassium.
 - Visitor5: The only thing is that it's (they're) green, some show green and some don't - the small ones don't.
 - Visitor7: Some glow under the UV light.
 - Visitor8: Some don't have green on them, but it looks dead (the one they found that didn't glow).
- Big vs. Small (5/8 visitors)
 - Visitor1: There's a big size difference, some of them are more active than others.
 - Visitor4: In size, yeah I noticed their (different) size.
 - Visitor5: Some are large and some are small.
 - Visitor6: You know, the different growing stages. You can see tiny ones here.
 - Visitor7: Some are bigger some are smaller.
- Different parts of the body glowing (5/8 visitors)
 - Visitor1: It looks like their heads are glowing green. Once in a while you see one with, like, some green specks in it.
 - Visitor3: Usually the glowing is in the head.

Visitor4: And some of them have different patterns of greens- some of them are speckled and some of them are (glowing) in the head.

Visitor5: This one's like solid (green) and this one's spotty (green).

Visitor6 Some of them have back specks on them. Some (worms), basically, the textures are different cause one worm had the direction that it's traveling, the head, lined like, and one has specks all over.

- Move together or apart (3/8 visitors)

Visitor1: Sometimes they swim side by side- they herd. There are some speckles

Visitor4: Some of them move together.

Visitor8: Some of them don't mind being next to some of them. But some of them just don't want company, like they have their own agenda. [

- Active vs. Passive (2/8 visitors)

Visitor1: Some of them are more active than others

Visitor8: Some move really fast some are slow.