

## Blast Searcher Formative Evaluation

March 02, 2006

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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

BLAST Searcher  
Formative Evaluation  
March 2, 2006  
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**Search human genes**  
Find human genes that contain a DNA sequence you create.

Create a DNA sequence using the keys below.

A T G C

T T T A

**GO**

**SAMPLE SEQUENCES**  
AGT  
GGTTAA  
CCCCCCC

Press GO.  
The computer will find  
human genes that contain  
your DNA sequence.

**START OVER**

## Goals

Multimedia developer Kristen Sikes and science writer Jen Frazier developed this exhibit to give visitors an introduction to the way in which researchers use computers to search and analyze genetic data, a science called bioinformatics. Specifically, the exhibit hopes to provide visitors with an opportunity to do their own searches for sequences within the human genome and to explore the physical properties and functions of the genes that they find.

The goals of this formative evaluation study are:

- To learn whether visitors are able to perform searches and easily navigate between screens
- To see if visitors understand that they are searching human DNA and finding genes that serve different biological functions

- To see if visitors are impressed by the number of genes and their functions
- To see if visitors are confused, overwhelmed or intimidated by the large amount or technical nature of the information they are presented
- To determine whether visitors continue to have difficulties uncovered during the previous round of evaluation. Specifically:
  - Do they continue to enter single searches that exactly match the example given on the first screen?
  - Are visitors still confused by the biological jargon used in the gene function descriptions?

Although a secondary goal of the exhibit is to teach visitors that genes are made of specific units [ACTG] and contain information, visitors are not expected learn about specific processes or units, such as the functions of transcription or properties and roles of amino acids, proteins, etc.

The previous version of this exhibit was evaluated in May, 2005. Since that time, the changes that have been made include:

- A subset of gene function descriptions have been rewritten in non-technical language and the search engine has been modified to bring these changes to the top of the results pages
- Searches are limited to the human genome, rather than that of 5 different species
- The screen layouts are simplified and have fewer pictures
- Visitors can explore a glossary of technical terms: Genes, DNA, ACTG, Proteins
- Visitors can elect to read a screen that explains the field of bioinformatics

## Summary of Results

While using the exhibit:

- Visitors spend a moderate amount of time (1 minute, 23 seconds on average) using the exhibit
- When they first approach the exhibit, some visitors (4 of 13) hit the “GO” button before entering a search sequence, although most of these eventually went on to complete a search
- Visitors no longer limit their searches to four letters or enter just “ATCG”
- Most of the searches observed (6 of 9) were 7 characters long, the maximum allowed by the current interface
- Visitors had no trouble conducting searches or browsing their results. We found that 12 of 13 visitors (92%) were able to conduct a successful search, 11 of 13 (85%) saw the results page, and 7 of 13 (54%) looked at secondary results pages

- Few visitors explored the deeper layers of the exhibit. Only 8 of 13 (62%) of visitors navigated past the results screen at all: 5 of 13 (38%) Viewed a gene function screen, 4 of 13 (31%) viewed a gene sequence, and only 1 of 13 (8%) looked at ANY other screen

During the interview:

- Visitors found the exhibit moderately interesting
- Most visitors (6 of 9) were not confused by the exhibit. Of the 3 visitors who reported confusion, 2 reported problems in navigation, and 1 reported problems with content
- Visitors were not confused or overwhelmed by the specific screens they viewed. Only for the Gene Sequence screen did more than a third of visitors who viewed it report problems. Visitors understood that they were conducting searches of human DNA

Visitors thought the exhibit was trying to show the complexity of DNA or the size or variety of genes in the genome

## Methods

For this study, the exhibit was placed in the Life Sciences area on the Mezzanine, in close proximity to other genetics exhibits. Data collected for this study was uncued-eligible visitors were selected randomly from those people who approached the exhibit on their own. Visitors were observed while using the exhibit and upon leaving were asked to participate in an interview about their experience.

Visitors were randomly selected for the study. We chose every second visitor who appeared to be 12 or older and who either touched the exhibit twice or spent 20 seconds or more clearly looking at it. We recruited individuals only: if the selected visitor used the exhibit together with or at the same time as someone else, we observed and asked them only about their own actions and experience.

13 visitors were observed while using the exhibit. Of these, 8 participated in the full interview and 1 participated in a partial interview. One additional visitor was observed and interviewed but not included in the study because she had recently had a brain injury that caused memory and vision deficits that kept her from using the exhibit unassisted.

Interviewees were asked a series of questions about the exhibit and were asked to examine and comment on images of screens that they had seen while using the exhibit. Visitors were not shown or asked about any part of the exhibit that they hadn't encountered on their own before being approached for an interview.

## Visitor Demographics

| Age   | Interviewed | Not interviewed | Female   | Male     | Total     |
|-------|-------------|-----------------|----------|----------|-----------|
| 13-17 | 0           | 1               | 0        | 1        | <b>1</b>  |
| 18-29 | 3           | 0               | 1        | 2        | <b>3</b>  |
| 30s   | 2           | 1               | 0        | 3        | <b>3</b>  |
| 40s   | 4           | 2               | 3        | 3        | <b>6</b>  |
| Total | <b>9</b>    | <b>4</b>        | <b>4</b> | <b>9</b> | <b>13</b> |

## Detailed Results

### Observations of visitors as they used the exhibit

#### *Total time spent at exhibit (minutes: seconds)*

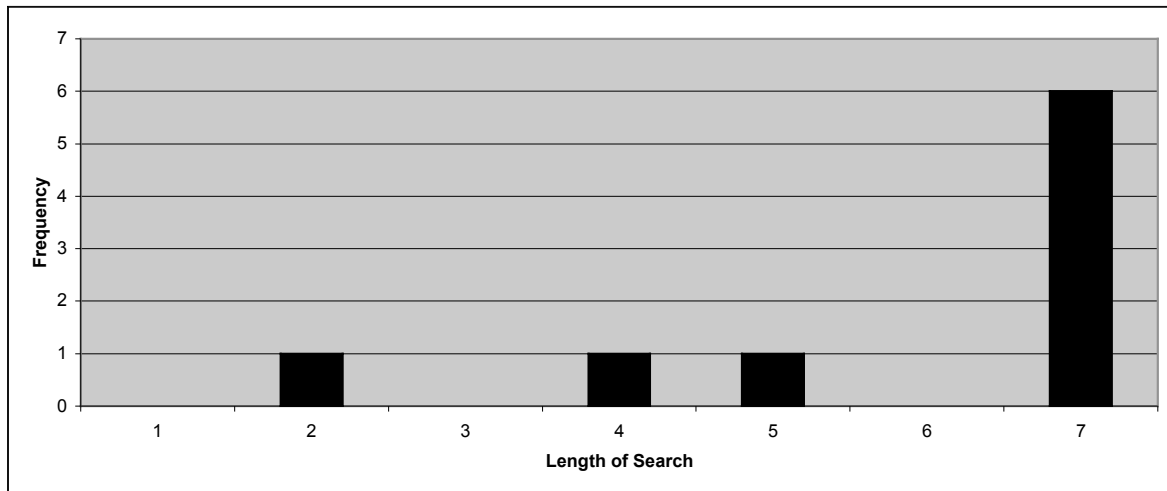
| Mean | High | Low  | Median | Total     |
|------|------|------|--------|-----------|
| 1:23 | 5:04 | 0:04 | 0:00   | <b>13</b> |

Visitors spend a moderate amount of time at the exhibit, slightly longer than for typical “planned discovery” exhibits, but not as long as typical for APE exhibits.

#### *Initial search problems*

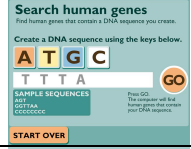
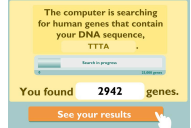
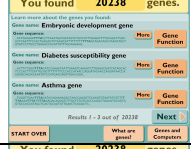

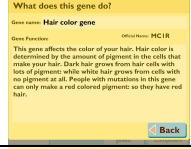

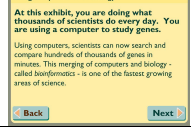
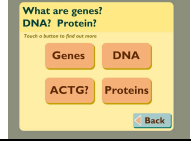
| Hit 'go' but never entered letters | Hit 'go' before letters but solved problem | Did NOT hit 'go' first | Total     |
|------------------------------------|--|------------------------|-----------|
| 1                                  | 3  | 9                      | <b>13</b> |

4 of 13 visitors observed (31%) hit the “GO” button on the first page before entering a letter sequence to search. Of these, 3 later went on to successfully search, while one person left without successfully searching. During the interview this person explained her experience: “I wasn't paying much attention. I hit the 'go' button and it didn't go, so I walked away.”

*Length of string sequences inputted by visitors*

Unlike with the previous version of the exhibit, visitors performed searches of various sequence lengths. 6 of 9 (67%) of searches observed were of 7 letters, the maximum allowed in the current search box.

## Screens viewed

| Page                      | Layers       | Screenshots   | Total Number of visitors [N=13] | Total percentage |
|---------------------------|--------------|---|---------------------------------|------------------|
| Search                    | First        |    | <b>13</b>                       | <b>100%</b>      |
| Orbit                     | Second       |    | <b>12</b>                       | <b>92%</b>       |
| Results 1                 | Third        |    | <b>11</b>                       | <b>85%</b>       |
| Results 2                 | Fourth       |    | <b>7</b>                        | <b>54%</b>       |
| Gene Function             | Fourth       |   | <b>5</b>                        | <b>38%</b>       |
| Gene Sequence             | Fourth       |  | <b>4</b>                        | <b>31%</b>       |
| Bioinformatics definition | Fourth       |  | <b>1</b>                        | <b>8%</b>        |
| All Glossary screens      | Fourth/fifth |  | <b>0</b>                        | <b>0%</b>        |

We found that while all 12 of 13 visitors (92%) were able to do a search, 11 of 13 (85%) saw the results page and 7 of 13 (54%) looked at secondary results pages, few visitors explored the deeper layers of the exhibit. Only 8 of 13 (62%) of visitors navigated past the results screen at all: 5 of 13 (38%) Viewed a gene function screen, 4 of 13 (31%) viewed a gene sequence, and only 1 of 13 (8%) looked at ANY other screen.

## Interviews of visitors after they had finished using the exhibit

After visitors used the exhibit, we interviewed them about their experience. The questions and results are described below.

### 1. First, how interesting was the exhibit for you? Would you say it was... [N=9]

| Not interesting | Somewhat interesting | Interesting | Very interesting |
|-----------------|----------------------|-------------|------------------|
| 1               | 3                    | 3           | 2                |

Visitor responses to this question were somewhat more positive than when asked the same question about the previous version of the exhibit. When asked why they gave that rating, people reported less confusion and more interest in the results of their searches than for the last version.

#### 1b. Can you say why you chose \_\_\_\_ ?

##### *The number or variety of results (4 of 9)*

It was nice to put together the protein sequence in what we have in our bodies, and the function of each one. There were a lot of results though- 3000 to 4000. [Was that a problem?] Not a problem, but it was good to see how many genes have that sequence but hard to go through all o them. Maybe you could put the important ones first.

Actually, I saw Genetic Mutations [adjacent exhibit] but I thought it [BLAST] was interesting too. It's [a new exhibit]. I played on it like a piano. I was struck by how many gene sequences I could find and it was like 9000. I started seeing how long the sequences were that show up, and I realized how many they [scientists] would have to go through

[Shrugs] I thought that it was cool to see what the different genes it created when it seems random the way I pushed the buttons

Because you could do any random set of letters and it would come up with answers that match.

##### *It's a new or interesting topic (2 of 9)*

Because it's a new thing for me. {what's new about it?}] Because I don't know about DNA analysis

Because I'm interested in the human genome project

##### *It's too complicated (1 of 9)*

It's kind of cool to see which genes are which, but it's kind of complicated. I don't know if kids would be into it. [why not?] I didn't get it, but I just breezed through it.

##### *Other (2 of 9)*

I didn't really take the time to look at it. [Why?] Because I'm here with three 6 year olds  
 No particular reason. By the second part of it I lost interest by [results] page 2. [Why?] Because it's not interactive enough. I like more than just a screen to touch. Great, it gave me 10000 results of the code I entered, but so what? Why do I care? [At the end of the interview I asked him if he knew he could click on the See Gene and What Gene do buttons] Yes, but I didn't want to, I'd seen enough.

## 2. Was there anything confusing about the exhibit?

| yes | no | total    |
|-----|----|----------|
| 3   | 6  | <b>9</b> |

3 of 9 visitors thought that there was something confusing about the exhibit.

### 2b. What specifically was confusing?

#### *Difficulties in searching or navigation (2 of 3)*

I didn't figure out how to make it work. [what did you try?] I wasn't paying much attention. I hit the 'go' button and it didn't go, so I walked away.  
 How to start it over. I didn't understand which screen was the beginning screen.

#### *Did not understand what was presented (1 of 3)*

It was pretty straightforward, but I didn't read, I didn't get it. [why do you think it was hard to get?] I don't know.

## 3. What do you think is the main idea behind the exhibit? What do you think it's trying to tell or show you?

8 of 9 (89%) visitors were able to say what they thought the exhibit was about. 4 of those 8 understood that they were seeing different genes or DNA. The other 4 thought the exhibit was designed to show the complexity of DNA or the size of the genome. The one person who could not give a main idea left the exhibit before performing a search.

#### *Different sequences in DNA (4 of 9)*

Um... I don't know. I wanted to see what it was. [what was it?] Just showing the different genes in your DNA

Pretty much there are countless sequences in our genes, and no matter what you put there will be numerous results in your body.

To help people understand DNA. [can you be more specific?] the differences in DNA That multiple gene sequences could be in a number of things, or the value of technology mixed with medicine.

*Complexity of DNA* (4 of 9)

How complex our DNA is. It's not random, and we're more complex than people realize. That sort of like, if ...[pause] Something like a single sequence of letters can be so many complex things.

The complexity of genes in general [how did it show that?] The amount of letters in one gene was 21000

[V2: I think that how different DNA from us is and you can show from this computer that it's not easy to know these things.] V1: You want to find the things and to show people how complicated the system is.

*Don't know* (1 of 9)

I didn't really use it. I have no idea.

**4. Can you just complete this statement for me "I never realized that...."**

6 of 8 (79%) visitors were able to tell us something they learned from the exhibit. 3 of them showed that they understood that the genes they found were within the human body or affect us, and 3 of them understood the size or complexity of the genome.

*Genes found are within us* (3 of 8)

That I had that in my body

The hair was interesting; I learned that that's why kids have red hair.

That there were so many genes that affect you

*Complexity of DNA* (3 of 8)

V2: I never realized that there are so many combinations if you put TAGG there are so many things the sequence is in.

that there are so many differentiations in genes

genes were so complex

*Don't know* (1 of 8)

I wouldn't [complete the sentence]. I got up to follow the kids, so I don't know how to answer this.

5. So here are some pictures of some screens that you might have seen. Can you look through the stack and pick out the ones that were too complicated, had too much information on them, or were confusing?

| Page          | Frequency | Total percentage | Total Number of visitors that viewed |
|---------------|-----------|------------------|--------------------------------------|
| Gene Sequence | 2         | <b>67%</b>       | <b>3</b>                             |
| Results 1     | 2         | <b>29%</b>       | <b>7</b>                             |
| Search        | 2         | <b>25%</b>       | <b>8</b>                             |
| Orbit         | 0         | <b>0%</b>        | <b>8</b>                             |
| Gene Function | 0         | <b>0%</b>        | <b>2</b>                             |

We asked visitors only things that they saw while using the exhibit, so our data on this question is limited to the five screens above. The only screen that more than a third of visitors thought was complicated or confusing was the Gene sequence screen.

6. Now I'd like to go back to the screens that you picked out. For each of them, can you tell me why you picked it? Can you show me specifically what you mean?

Search page

## Search human genes

Find human genes that contain a DNA sequence you create.

**Create a DNA sequence using the keys below.**

A

T

G

C

GO

**SAMPLE SEQUENCES**

AGT

GGTTAA

CCCCCCCC

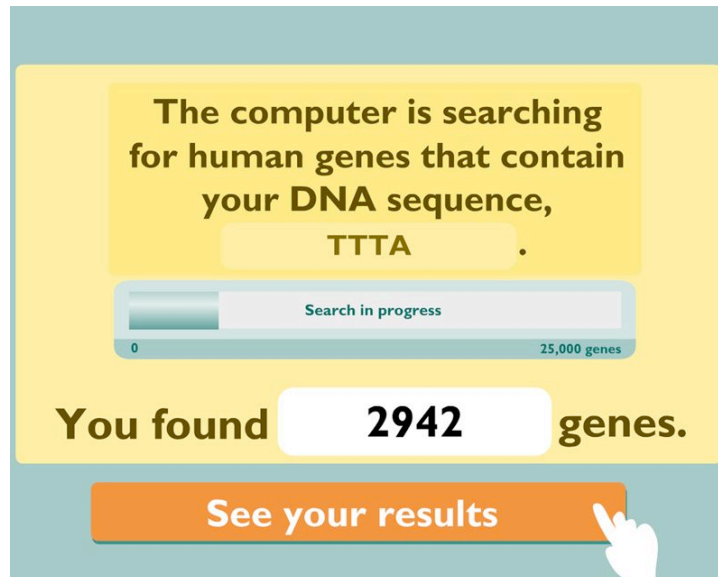
Press GO.

The computer will find human genes that contain your DNA sequence.

START OVER

*Unclear what was being searched (2 of 2)*

You need to explain what one of these [ACTG] stand for. What each of them are. I didn't understand right away. I didn't see how the letters correlated into gene sequences.

*Orbit Screen**Orbit screen stayed up too long (1 of 1)*

The only thing- when you put in the letters and hit 'go' it would start counting but you didn't know there was a key to jump to the next screen. [you didn't know that it would go on it's own after some time?] I figured it out. [how long should we leave the screen up?] 15 seconds or so.

Results Screen

**You found 20238 genes.**

Learn more about the genes you found:

**Gene name: Obesity gene**  
**Gene sequence:**  
 ...CATTAAGAGTTTGAATTTATCCCTGCTTTTCTGGGCTTTGAGGGGGTATAGAA  
 AGGTTGGGGGACATGGAAGGTTGTGTGGAAAACCATGGTGGATTGCACCAAGC  
 ATCACCCCTGCTGGTGGTCACCCGGTGGGGGAATGC... [More](#) [Gene Function](#)

**Gene name: Hair color gene**  
**Gene sequence:**  
 ...TTGCTGTGCTTTATCTGCTGTGCCTTTTCTCCCGGCCCTAGGCCGGAAGGTGCT  
 CTACCAAGCGTGGACCGAAGTAATCCACCCCATGTGATCCTCTCTGAGATCAAGG  
 AAGCCGCTCGCTGCCCTGCCCGGTAAAGGAGAAAGGC... [More](#) [Gene Function](#)

**Gene name: DNA polymerase gene**  
**Gene sequence:**  
 ...GAGGAAATCTTTAATGTCCAACCTGGGTTAATACAGGAACTTTTTGTTTTTAA  
 CTATCTTTTGGATTAAAGGCTGCACTGAAACCGTGATCATGCCACTGCACTCCAGCCTG  
 GGTGACAGAGTGAGACCCTGTCTCAAAAACAAAACAA... [More](#) [Gene Function](#)

[Back](#) Results 4 - 6 out of 20238 [Next](#)

[START OVER](#) [What are genes?](#) [Genes and Computers](#)

*Didn't understand what the results were (1 of 3)*

V2: But it's good that you saw your sequence I picked in [results page]. V1: The meaning of ATGC because I don't understand the letters exactly. I don't understand the letter combining.

*Large number of results (1 of 3)*

there were a lot of results on here but it's good to know how many there are in our bodies

*Thought results were interesting (1 of 3)*


the most interesting thing was seeing that genes you selected had that sequence.

Gene Sequence Screen

Sequence for the gene: **Hair color gene**

Your sequence: **TTTA**

GAGACCCTCTGACTAACACGGTGAACCACGCTCTACTAAAAATACAAAAATTAGCCGGCGTGTGGCGGCACCTGTA  
 GTCCAGCTACTGGGAGGCTGAGGCAGGAGAATGGCATGAACCCAGGAGGAGAGCTTGAGTGAGCCGAGATCGGCCA  
 CTGCACCTCAGCCTGGGCAACATAGTGAGACTCCGCTCAAAAAAAGAAAAAAGAAAAAAGACGGGCTCCTCCGAGG  
 GGCTGTGAGGGGTGAGGGTGAATCCCTCTTAAGACGGGCTCCTCCGAGGGGCTGTGAGGGGTGAGGGTGAATCCCTC  
 CTTAAGATGGGCTCCTCCGAGGGGCTGTGAGGGGTGAGGGTGAATCCCTCCTTAAGACGGGCTCCGCGGGCGGGT  
 GGCTCAGCCTGTAATCTAGCACTTTGGGAGGCCGAGGTGGGGGATCACGAGGTGAGGATCGAGACCATCTGACTA  
 ACACGGTGAACACGCTCTCTACTAAAAATACAAAAATTAGCCGGCGTGTGGCGGCACCTGTAGTCCAGCTACTTGGG  
 AGGCTGAGGCAGGAGAATGGCATGAACCCAGGAGGAGAGCTTGACAGTGAGCCGAGATCGGCCACTGCACTCCAGCCTGG  
 GCAACATAGTGAGACTCCGCTCTCAAAAAAAGAAAAAAGAAAAAAGACGGGCTCCTCCGAGGGGCTGTGAGGGGTGAG  
 GGTAATCCCTCCTTAAGAGGGGCTCCTCCGAGGGGCTGTGAGGGGTGAGGGTGAATCCCTCCTTAAGATGGGCTCC  
 TCCGAGGGGCTGTGAGGGGTGAGGGTGAATCCCTCCTTAAGACGGGCTCCGCGGGCGGGTGGCTCAGCCTGTAAT  
 CCTAGCACTTTGGGAGGCCGAGGTGGGGGATCACGAGGTGAGGATCGAGACCATCTGACTAACACGGTGAACCCAG  
 TCTACTAAAAATACAAAAATTAGCCGGCGTGTGGCGGCACCTGTAGTCCAGCTACTGGGAGGCTGAGGCAGGA  
 GAATGGCATGAACCCAGGAGGAGAGCTTGCAGTGAGCCGAGATCGGCCACTGCACTCCAGCCTGGGCAACATAGCGAGA  
 CTCGCTCAAAAAAAGAAAAAAGAAAAAAGACGGGCTCCTCCGAGGGGCTGTGAGGGGTGAGGGTGAATCCCTCCT  
 TAAGACGGGCTCCTCCGAGGGGCGGTGAGGGGTGAGGGTATTGGGTGAGGATACACACATTAGTGAACACT  
 ATCGCCTATTAGATGCTCTGGAAGCAGCATCCCTTTCTCGTTCTGTGGTTCCAGGGCTCTGTCTGGGCCGAGGAG  
 GCCACGGGCTGGGTTGGGAGCTTCTAGCAAGGAGAAACGTGCCCCAGAGGGCTGGCCAGGCCTAGTCTGCT  
 CGCTGAACCCAAAAGTTTCTCCCTCTGTCTTAAGAGCACTTTGTCTCTCTGGGGCTGATGGAGCTGGCCATAGCTC  
 CACCAAGTGACCGTGTCTGAAACGGGCTGGGAGGCCCTGTCTTTGGCAGAGCTGTGCTGTGTACAGGCTGT  
 AGGCTCAGCACTCCCTTGAAGGAGGTGGGCTGCCAAGAACCGCTGCCACTACCCAGAACACTGGAGTCACTGCAG  
 GCTCTGCGCTCGGGCCGCTCCCTACATGGCGGCTCTGCCCTAACCTGCACTGCTGGCTCTCCACTGGGCACAGGT  
 GGCTCCGCTCCAGCAGCTGCCATGGGTCAGCTTTGTGATTAACAATCCAAACGGGCGGGCACGGTGGCTCAGGC  
 CTGTAATCCAGCACTTTGGAGGCCGAGGAGGATCGCTTGAAGTGGAGTTCGAGACCGCTGTGCAACCGGT  
 GAAACCTTTCTACAAAAATATAAAATTAGCCGGGTGTGGTGGCGAGCGCTGTAATCCAGCACTTTCGAGGCTGAG  
 GAAGTGGATCACTGAGGTCAAGAGTCAAGACCGCTGGCCAGCATGGTGAACCTGTCTACTAAACATACAAAAAT  
 TAACGGGGCTGTAGTGTGGCCCTGTGATCCAGTACTCGGAGGCTGAGGAGGAGAAATCGTTGAGCCTGGGAGGT  
 GGAGTTGACAGTGGCCGATTTCCCAACCGCTCAGCCTGAGCAACAGATGAGACCTCTCTAGAAAAACAAAA  
 AAACCCAAACCTATGTGTGGAGGGTGTGGGTGAGTCTTCCCTGGATGCAAAATGGGGCCCTGGCAGCCTCCTTGGG  
 GCTGGTGAAGGAGACCCAGCCTCAGACCTGGGACGCCAGCAGCAACTCAGAATACCCCGAAGCAAGCCG

[Back](#) Total gene length: **16838** letters 

*Did not know what they were looking at it (but knew it was long) (1 of 3)*

It's not too confusing, but I don't know what it is [that it's showing] but it shows how long it is.

*Hard to see search sequence (1 of 3)*

For some people, they might not see where their sequence lights up. I was patient and saw it in three spots.

*Impressed by size of gene (1 of 3)*

It blew me away- how much there was- it was cool. I was wondering why it took so long to search, and then I saw the length of the sequence.

Gene Function Screen

**What does this gene do?**

Gene name: **Hair color gene**

Gene Function: Official Name: **MC1R**

**This gene affects the color of your hair. Hair color is determined by the amount of pigment in the cells that make your hair. Dark hair grows from hair cells with lots of pigment: while white hair grows from cells with no pigment at all. People with mutations in this gene can only make a red colored pigment: so they have red hair.**

[◀ Back](#)

*Liked the number of explanations and level of complexity (1 of 1)*

I like how you gave an explanation of each one. [how was the text in the explanation, for you, specifically the level and complexity?] It's pretty good.

### 7. Is there anything else you'd like to say about the exhibit?

*Liked the exhibit (3 of 8)*

V2: I think it's clear and a good thing. We have the same in our museum in Austria but not so good.

I thought that it was pretty cool.

No, it was pretty cool. I was wondering why it took so long to search, and then I saw the length of the sequence.

*Problem with navigation (1 of 8)*

The only thing- when you put in the letters and hit 'go' it would start counting but you didn't know there was a key to jump to the next screen. [you didn't know that it would go on it's own after some time?] I figured it out. [how long should we leave the screen up?] 15 seconds or so.

*Nothing to add (4 of 8)*

No.

No.

No.

No.

## 8. Do you have any special interest, knowledge or training in genetics or biology?

*None (3 of 8)*

No.

No.

No. But I'm developing user interface systems. I make interactive displays for children with Flash, so I know how this works. It's simple, so I lost interest.

*High school or college coursework (4 of 8)*

My college biology class.

I took two semesters of college biology

V2: No, just the university normal classes.

High school biology. I think it's interesting.

*Experience teaching (1 of 8)*

I'm a teacher. I taught 8th grade science. I'm also an artist, so I see things in 3D.

## Conclusions

BLAST Searcher seems to work very well as an introduction to the scope and variety of the human genome. Visitors found the exhibit fairly interesting and had little trouble navigating through the screens. Most visitors understood that they were searching the human genome and, unlike during the previous evaluation, visitors did not report feeling confused or overwhelmed by the amount or complexity of the information presented. Although these improvements may be due in part by the simplifications made to the interface and the clarifications made to the gene function descriptions, it is hard to be certain of this because few visitors navigated beyond the results pages. Those that did see these screens, however, did not report the problems they had the last time.

Although few visitors explored the detailed information about the genes they found, they did not seem to feel that their overall experience at the exhibit was lacking. The addition of glossary information did not appear to enhance or detract from visitors' experience. Although the buttons that lead to these screens were placed next to the often used Start Over button visitors did not seem compelled to click on at them. However, as with the gene sequence and function buttons, visitors did not appear to miss this lack information.

## Recommendations

We recommend modifying the search page so that visitors aren't confused when they hit the "GO" button before entering search terms. Rather than adding additional instructions to the page, we recommend a pop-up window or similar feedback when this occurs in order to focus on the search window and letter buttons.

We recommend increasing the visibility of the searched letters when viewed within the Gene Sequence screen.

We recommend continuing to simplify the language of the gene function descriptions in a manner similar to the Hair Color Gene function screen pictured above.

We recommend not making changes that encourage visitors to view gene sequences or functions more often than they do now. To lead visitors to view information that they may not have the background to understand could cause visitors to feel overwhelmed or intimidated by the topic of bioinformatics, or even that of genetics as a whole. Although that information is presented in a much more digestible format than in the previous version it would be very difficult to simplify it more without 'dumbing down.'

Although few visitors utilized them, we suggest retaining the bioinformatics and genetic term glossaries and leaving them at a back layer. By doing this, the people who do want this information can find it without overwhelming other visitors or complicating the layout.

We recommend not reducing the number of curated gene function descriptions that involve 'personal afflictions' such as cancer, obesity, or asthma. Although there is a risk of people not learning that genes are involved in all aspects of body functions, pilot study visitors often expressed the most interest in these descriptions, especially if they had personal or familial connections to them.

Rather than expanding the breadth of the exhibit's message further changes should focus on its current strength: showing visitors the size, variety, and searchability of the human genome.

## Acknowledgments

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