

# Water bioinformatics

<b>Focus questions</b>	<p>How might we determine the organisms that impact water using biotechnology?</p> <p>How can we identify individual organisms in a complex mixture of DNA?</p> <p>What computer tools are needed to decode the source of a DNA sequence?</p>
<b>Vocabulary</b>	<p>Bioinformatics, water quality, National Center for Biotechnology Information (NCBI), Basic Local Alignment Search Tool (BLAST), eDNA sequencing, barcodes, eukaryotes, prokaryotes, harmful algal blooms (HABs), taxon, rbcL gene, COI gene</p>

Water ecosystems contain many organisms both macroscopic (visible with the naked eye) and microscopic. DNA analyses help scientists understand the structure of these complex environments. For example, DNA analyses can find:

- group or **taxon** linked to a healthy water system
- threats to human health
- endangered species
- invaders that compete for resources with native species

The community of organisms within lakes and rivers can be examined by extracting DNA directly from a water sample. This special type of DNA sample is called an environmental DNA (eDNA) sample. The resulting eDNA sample contains DNA from all cells collected within the water sample, including whole organisms or decaying tissue. The **eDNA sequencing** technique looks at genes or non-coding regions of the genome that are critical to life, but each species has a unique sequence signature. These regions are called **barcodes**, analogous to the unique barcodes that label products scanned at supermarket checkouts. The DNA barcode regions are different between **eukaryotes** and **prokaryotes**. Within these major groups there are subcategories of ideal barcodes. For example, identification using the **rbcL gene** which encodes the large subunit of ribulose biphosphate carboxylase, commonly referred to as rubisco, a key enzyme in photosynthesis is ideal for plants, whereas the **COI gene** which codes for cytochrome C protein which is critical in ATP synthesis, is best suited for animal identification.

Read the following scenario, then obtain the sequence of your water organism. Use the NCBI database to determine the organism and its impact on water quality.

## Scenario

Ohioland Water Institute and Buckeye Genetic Laboratories have an ongoing water-monitoring project in Lake County. Last week, a summer field technician collected 100mL of water from Lake Erie for eDNA analysis. Buckeye Genetic Laboratories performed eDNA sequencing and released the report containing the top 10 sequences recovered from the water sample. Your job as a bioinformatician is to help identify the source of DNA by searching for similar sequences within the NCBI database using BLAST.

# Sequence 1

## Procedure

1. Search the NCBI database to identify the following sequence of DNA.
2. Visit [ncbi.nlm.nih.gov](http://ncbi.nlm.nih.gov)
3. Click on 'BLAST' in the right column.
4. Click on 'Nucleotide blast'; paste in DNA sequence in the rectangle; submit; wait for result.  
*You can find sequences at [ntf.plus/watersequences](http://ntf.plus/watersequences).*

>Sequence-1

```
CAACAAATCATAAAGATATTGGTTCTTTATATTTTATTCTTTCTCTGTGNGCTGGCCTTGTGG
GCACGGGTTTTAGTGTTCCTTATTCGTTTAGAGCTAAGGGCACCTGGAAGCGTCCTTGGTGATT
TTCAATTATATAATTTAATTGTCACCACTCATGGGCTTGTTATAATTTTTTTCTAGTAATAC
CTATAATAATGGGGGGATTTCGGAAATTGATTGGTACCAATAATACTGAGTCTTCCTGATATAG
GTTTTCTCGTCTTAATAATGTTAGTTTTGGGTTTTACCTGTCTCTATAGGACTTCTATTTT
GTTTCAGCTTTTAGGGAAGGAGGATTCGGGGGTGTTGAACCTTATACCCTCCTTTATCTAGAG
TTATAGGACATTCAGGGCCTGCGATAGATTTTTTGATTTTATCTTTCATATTGGGGGAGCTT
CTTCGATTATGGCTTCTATTAATTTTTATAGGACATGAGGTAATATACGTGCTGGATGTCATC
AATTTTACCGGGTCCCTTTGTTCTGCACATCTATTGGTGTGACCAGATTCTTTTAATCTTAG
CAATGCCTGTATTAGCTGGGGCTTTAACAAATATTATTAAGTATCGAAATTTTAACACAAGAT
TTTTTGATCCAACAGGATTAGGAGATCCTTTATTATTTGTTTCATCTTTTTTAATTTTTTGTC
ACCCTGAAG
```

## Reflection

1. Which organism does this sequence identify?
2. What is its classification (bacteria, plant, animal)?
3. How does your identified organism impact freshwater systems?
4. If the organism is a threat, are there ways to manage it to reduce its threat? Explain.
5. Can you think of other organisms and their DNA that may be found in the water sample?

## Sequence 2

### Procedure

1. Search the NCBI database to identify the following sequence of DNA.
2. Visit [ncbi.nlm.nih.gov](http://ncbi.nlm.nih.gov)
3. Click on 'BLAST' in the right column.
4. Click on 'Nucleotide blast'; paste in DNA sequence in the rectangle; submit; wait for result.  
*You can find sequences at [ntf.plus/watersequences](http://ntf.plus/watersequences).*

>Sequence-2

```
ATGTCACCACAAACAGAGACTAAAGCAAGTGTTGGATTCAAAGCTGGTGTTAAAGATTACAAA
TTGAATTATTATACTCCTGAGTATGAGACAAAAGATACGGATATCTTGGCAGCATTCCGAGTA
ACTCCTCAACCTGGAGTTCACCTGAAGAAGCAGGGGCTGCAGTAGCTGCCGAATCTTCTACT
GGTACATGGACAACCTGTGTGGACTGATGGACTTACCAGCCTTGATCGTTACAAAGGACGATGC
TACCATATCGAACCCGTTGCTGGAGAAGAAAATCAATTTATTGCTTATATAGCTTACCCATTA
GACCTTTTTGAAGAAGGTTCTGTTACTAACATGTTTACCTCCATTGTAGGTAACGTATTTGGG
TTTTAAAGCTTTACGAGCTCTACGTTTGGAAAGATTTGCGAATTCCTCCTGCTTATTCCAAAAC
TTCCAAGGCCACCTCATGGGATCCAAGTTGAGAGAGATAAATTGAACAAGTATGGTCGTCCT
CTATTGGGATGTACCATCAAACCAAAATTGGGATTATCCGCGAAAAACTACGGTAGAGCGGTT
TATGAATGTCTACGTGGTGGACTTGATTTTACCAAGGATGATGAAAACGTAAACTCACAAACA
TTTATGCGTTGGAGAGACCGTTTCTTATTTTGTGCCGAAGCAATTTATAAAGCACAAAGCCGAA
ACAGGTGAAATTAAGGGCATTACCTAAATGCTACTGCAGGTACATGCGA
```

### Reflection

1. Which organism does this sequence identify?
2. What is its classification (bacteria, plant, animal)?
3. How does your identified organism impact freshwater systems?
4. If the organism is a threat, are there ways to manage it to reduce its threat? Explain.
5. Can you think of other organisms and their DNA that may be found in the water sample?

## Sequence 3

### Procedure

1. Search the NCBI database to identify the following sequence of DNA.
2. Visit [ncbi.nlm.nih.gov](http://ncbi.nlm.nih.gov)
3. Click on 'BLAST' in the right column.
4. Click on 'Nucleotide blast'; paste in DNA sequence in the rectangle; submit; wait for result.  
*You can find sequences at [ntf.plus/watersequences](http://ntf.plus/watersequences).*

#### >Sequence-3

```
TAAAGCTTCAGCCATTTTACCGCGAAAATGATTATTTTCTACGAATCACAAAGATATTGGAAC
TTTATATTTTCTTTTTGGAAGCTTGAGCCGGCATAGTCGGAACCTTCTCTTAGTCTTTTAATTCC
AGCTGAATTAGGTCAACCAGGATCTTTAATTGGAGATGACCAAATTTATAATGTTATTGTAAC
TGCTCATGCTTTTGTAAATAATTTTTTTCATGGTTATACCTATTATAATTGGAGGGTTTGGAAA
TTGACTTGTTCCATTAATACTGGGGGCCCCAGATATGGCCTTTCCACGAATAAATAATATAAG
TTTTTGACTTCTTCCCTCACTAACTCTTCTTTTAGCCAGCTCTTTCGTAGAAAGAGGAGC
TGGGACAGGATGAACGGTTTATCCCCATTAGCATCAGGAATTGCCCATGCAGGAGCAGCCGT
AGATTTAGCTATTTTTAGTCTCCACCTTGCTGGGGTATCCTCAATTTTAGGTGCTGTAAATTT
TATTACTACAGTAATTAATATACGATCACCAGGTATAACTTTTGATCGAATACCTCTATTTGT
TTGAGCTGTTGCTATTACTGCTCTCCTTCTTCTCTCTTTACCAGTCTTAGCTGGAGCTAT
TACTATACTTCTTACAGATCGTAATTTAAATACCTCATTTTTTCGATCCAGCTTCAGGAGGAGA
CCATATTTTATATCAACATTTATTCTGATTCTTT
```

### Reflection

1. Which organism does this sequence identify?
2. What is its classification (bacteria, plant, animal)?
3. How does your identified organism impact freshwater systems?
4. If the organism is a threat, are there ways to manage it to reduce its threat? Explain.
5. Can you think of other organisms and their DNA that may be found in the water sample?

## Sequence 4

### Procedure

1. Search the NCBI database to identify the following sequence of DNA.
2. Visit [ncbi.nlm.nih.gov](http://ncbi.nlm.nih.gov)
3. Click on 'BLAST' in the right column.
4. Click on 'Nucleotide blast'; paste in DNA sequence in the rectangle; submit; wait for result.  
*You can find sequences at [ntf.plus/watersequences](http://ntf.plus/watersequences).*

#### >Sequence-4

```
CCTTTATCTAGTATTTGGTGCTTGAGCCGGAATAGTGGGCACAGCCCTAAGCCTACTCATCCG
AGCGGAACTAAGCCAGCCCGGCGCTCTCCTTGGAGACGACCAAATTTATAACGTAATTGTTAC
GGCACATGCCTTTGTAATAATCTTCTTTATAGTAATACCTATTATGATTGGGGGTTTTGGGAA
CTGGCTCATCCCCTCATAATTGGTGCCCCGATATGGCATTCCCTCGAATAAATAACATAAG
CTTTTGACTCCTGCCCCCTCTTCTTCTCCTTCTTGCCTCCTCAGGGGTTGAGGCGGGAGC
TGGCACCGGGTGGACTGTTTACCCCCACTAGCTGGAAACCTAGCACACGCCGGGGCATCTGT
AGACTTAACCATCTTTTCTCTACATTTAGCAGGAATTTCTCAATTCTAGGCGCAATTAATTT
TATTACAATATTATTAACATGAAACCCCCGCTATTTCTCAATACCAGACCCCTTTATTTGT
TTGAGCCGTATTAATTACCGCTGTACTTCTACTACTTTCCCTCCCCGTGCTCGCCGCTGGCAT
TACAATGCTCCTTACGGACCGAAATCTAAACACCACATTCTTTGACCCTGCAGGAGGAGGAGA
CCCTATTCTCTATCAACACCTA
```

### Reflection

1. Which organism does this sequence identify?
2. What is its classification (bacteria, plant, animal)?
3. How does your identified organism impact freshwater systems?
4. If the organism is a threat, are there ways to manage it to reduce its threat? Explain.
5. Can you think of other organisms and their DNA that may be found in the water sample?

## Sequence 5

### Procedure

1. Search the NCBI database to identify the following sequence of DNA.
2. Visit [ncbi.nlm.nih.gov](http://ncbi.nlm.nih.gov)
3. Click on 'BLAST' in the right column.
4. Click on 'Nucleotide blast'; paste in DNA sequence in the rectangle; submit; wait for result.  
*You can find sequences at [ntf.plus/watersequences](http://ntf.plus/watersequences).*

>Sequence - 5

```
AAATTGAAGAGTTTGATCATGGCTCAGATTGAACGCTGGCGGCAGGCCTAACACATGCAAGTC
GAACGGTAACAGGAAGAAGCTTGCTTCTTTGCTGACGAGTGGCGGACGGGTGAGTAATGTCTG
GGAAACTGCCTGATGGAGGGGGATAACTACTGGAAACGGTAGCTAATACCGCATAACGTCGCA
AGACCAAAGAGGGGGGACCTTCGGGCCTCTTGCCATCGGATGTGCCAGATGGGATTAGCTAGT
AGGTGGGGTAACGGCTCACCTAGGCGACGATCCCTAGCTGGTCTGAGAGGATGACCAGCCACA
CTGGAACTGAGACACGGTCCAGACTCCTACGGGAGGCAGCAGTGGGGAATATTGCACAATGGG
CGCAAGCCTGATGCAGCCATGCCGCGTGTATGAAGAAGGCCTTCGGGTTGTAAAGTACTTTCA
GCGGGGAGGAAGGGAGTAAAGTTAATACCTTTGCTCATTGACGTTACCCGCAGAAGAAGCACC
GGCTAACTCCGTGCCAGCAGCCGCGGTAATACGGAGGGTGAAGCGTTAATCGGAATTACTGG
GCGTAAAGCGCACGCAGGCGGTTTGTAAAGTCAGATGTGAAATCCCCGGGCTCAACCTGGGAA
CTGCATCTGATACTGGCAAGCTTGAGTCTCGTAGAGGGGGGTAGAATTCAGGTGTAGCGGTG
AAATGCGTAGAGATCTGGAGGAATACCGGTGGCGAAGGCGGCCCCCTGGACGAAGACTGACGC
TCAGGTGCGAAAGCGTGGGGAGCAAACAGGATTAGATACCCTGGTAGTCCACGCCGTAAACGA
TGTCGACTTGGAGGTTGTGCCCTTGAGGCGTGGCTTCCGGAGCTAACGCGTTAAGTCGACCGC
CTGGGGAGTACGGCCGCAAGGTTAAACTCAAATGAATTGACGGGGGGCCCGCACAAAGCGGTGG
AGCATGTGGTTTTAATTCGATGCAACGCGAAGAACCTTACCTGGTCTTGACATCCACAGAACTT
TCCAGAGATGGATTGGTGCCCTTCGGGAAGTGTGAGACAGGTGCTGCATGGCTGTCGTCAGCTC
GTGTTGTGAAATGTTGGGTTAAGTCCCGCAACGAGCGCAACCCTTATCTTTTGTGGCCAGCGG
TCCGGCCGGGAAGTCAAAGGAGACTGCCAGTGATAAACTGGAGGAAGGTGGGGATGACGTCAA
GTCATCATGGCCCTTACGACCAGGGCTACACACGTGCTACAATGGCGCATACAAAGAGAAGCG
ACCTCGCGAGAGCAAGCGGACCTCATAAAGTGCGTCGTAGTCCGGATTGGAGTCTGCAACTCG
ACTCCATGAAGTCGGAATCGCTAGTAATCGTGGATCAGAATGCCACGGTGAATACGTTCCCGG
GCCTTGTACACACCGCCGTCACACCATGGGAGTGGGTTGCAAAAGAAGTAGGTAGCTTAACC
TTCGGGAGGGCGCTTACCACTTTGTGATTCATGACTGGGGTGAAGTCGTAACAAGGTAACCGT
AGGGGAACCTGCGGTTGGATCACCTCCTTA
```

### Reflection

1. Which organism does this sequence identify?
2. What is its classification (bacteria, plant, animal)?
3. How does your identified organism impact freshwater systems?
4. If the organism is a threat, are there ways to manage it to reduce its threat? Explain.
5. Can you think of other organisms and their DNA that may be found in the water sample?

## Sequence 6

### Procedure

1. Search the NCBI database to identify the following sequence of DNA.
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4. Click on 'Nucleotide blast'; paste in DNA sequence in the rectangle; submit; wait for result.  
*You can find sequences at [ntf.plus/watersequences](http://ntf.plus/watersequences).*

>Sequence-6

```
ATAGGTGTTGTTTATTTTTGTTGGGTTTGTGGGGTGGTTTTATTGGTTTGGGGTTAAGTCTA
TTGATTCGTTTAAAATTTGTGAGCCTTATTATAATTTGATACCTTCTGAGGTCTATAATTAT
CTAATTACTAATCATGGGATTGCAATGATATTCTTTTTTTGATGCCTGTATTGATTGGTGGG
TTTGGTAAATATCTTTTGCCTTTTTTGTGGGTTTAGATGATTTGGCATTGCCTCGTTTAAAT
TCTTTAAGTGTGTGGTTGATGGTTCCCTTCGATGTTCTATATGGAGTTGAGTTTGGTTTGTGGT
GCTGGGGTTGGGTGGACGTTTTATCCTCCTTTATCAATTCAGAGATCAATGGGGGTAGGTGTT
GATTATTTAATGTTTTCGTTGCATTTAGCTGGTGGTTTCTAGGTGTTAGGTTCTGTGAAATTT
ATAACTACTATTTTTTTGAATCTTAGTTGTCGGGTTTCTGTGATTGTTTGGTCGTATTTATTT
ACGTCTGTTTTATTATTATTATCTTTGCCTGTTTTGGCTGCGGGTATAACTATGTTGTTGTTT
GATCGAAAATTTGGTACTGCCTTTTTTGAACCTTGTGGGGGGGGTATCCTATCTTGTTTCAA
CATTTATTTTGGTTTTTTGGTCATCCCGAGGTATATGTCTTGATTTTGCCAGGGTTTGAATT
GTTAGGCACATTTGTATGAACTTGAGTAAAAAAGATTCTTCTTTTGGTTATTATGGGTTGGTT
TGTGCTATGGGCTCTATAGTGTGTTTAGGTAGTGTGGTGTGGGCTCATCATATGTTTATGGTG
GGCTTAGATGTTAAGACTGCTGTGTTTTTTAGTTCTGTTACTATGGTTATTGGTATTCCGACC
GGTATTAAGGTTTTTTCTTGGTTATATATGTTGGGTACTAGTTACTTGCGTGGAATGGAGCCA
ATTGTATTGTGGGTGTTGGGTTTTATTTTCTTTTTACTGTGGGGGGGGTACC
```

### Reflection

1. Which organism does this sequence identify?
2. What is its classification (bacteria, plant, animal)?
3. How does your identified organism impact freshwater systems?
4. If the organism is a threat, are there ways to manage it to reduce its threat? Explain.
5. Can you think of other organisms and their DNA that may be found in the water sample?

## Sequence 7

### Procedure

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3. Click on 'BLAST' in the right column.
4. Click on 'Nucleotide blast'; paste in DNA sequence in the rectangle; submit; wait for result.  
*You can find sequences at [ntf.plus/watersequences](http://ntf.plus/watersequences).*

>Sequence-7

```
TTCATACGCTGTAAAACTACTGATATTTTAGCATTATTCCGTATTACTCCACAACCAGGTGT
AGATCCAGTAGAAGCAGCAGCAGCTGTGGCTGGTGAATCTTCAACAGCAACATGGACTGTTGT
ATGGACAGATTTATTAACAGCTTGTGAGCGCTACCGTGCTAAAGCTTACCGTGTAGATCCTGT
TCCAAATGCAACTGATCAATACTTCGCTTTCATCGCTTATGAATGTGATTTATTTGAAGAAGG
TTCTTTAGCTAACTTAACAGCTTCTATTATCGGTAACGTATTTGGTTTCAAAGCTGTATCTGC
TTTACGTTTAGAAGATATGCGTATTCCTCACTCATACTTAAAAACATTCCAAGGTCCTGCTAC
AGGTATCGTTGTAGAAGCTGAGCGTTTAAACAAATACGGTGTTCCTTTATTAGGTGCAACTGT
AAAACCTAAATTAGGTTTATCAGGTA AAAACTACGGTCGTGTAGTATATGAAGGTTTAAAGG
TGGTTTAGACTTCTTAAAAGATGATGAAAACATTA ACTCACAACCGTTCATGCGTTGGAGAGA
ACGTTTCTTAAACTGTATGGAAGGTATTAACCGTGCTGCAGCTGCAACAGGTGAAGTTAAAGG
TTCTTACTTAAACATCACTGCTGCTACTATGGAAGA ACTTTACAAACGTGGTGAGTACGCTAA
AGCTGTAGGTTCTGTAATCGTTATGATCGATTTAGTTTTAGGTTACACAGCAATTCAAAGTGC
TGCTATCTGGGCTCGTGAAAACGATTTAGTATTACACTTACACCGTGCAGGTA ACTCAACTTA
CGCTCGTCAAAAAAATCC
```

### Reflection

1. Which organism does this sequence identify?
2. What is its classification (bacteria, plant, animal)?
3. How does your identified organism impact freshwater systems?
4. If the organism is a threat, are there ways to manage it to reduce its threat? Explain.
5. Can you think of other organisms and their DNA that may be found in the water sample?



## Sequence 8

### Procedure

1. Search the NCBI database to identify the following sequence of DNA.
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3. Click on 'BLAST' in the right column.
4. Click on 'Nucleotide blast'; paste in DNA sequence in the rectangle; submit; wait for result.  
*You can find sequences at [ntf.plus/watersequences](http://ntf.plus/watersequences).*

#### >Sequence - 8

```
ATCATGGAGAGTTTGATCCTGGCTCAGGATGAACGCTGGCGGCGTGCCTAACACATGCAAGTC
GAACGGGAATCTTCGGATTCTAGTGGCGGACGGGTGAGTAACGCGTAAGAATCTAACTTCAGG
ACGGGGACAACAGTTGGAAACGACTGCTAATACCCGATATGCCGCGAGGTGAAACCTAATTGG
CCTGAAGAAGAGCTTGCCTCTGATTAGCTAGTTGGTGGGGTAAGAGCCTACCAAGGCGACGAT
CAGTAGCTGGTCTGAGAGGATGAGCAGCCACACTGGGACTGAGACACGGCCCAGACTCCTACG
GGAGGCAGCAGTGGGGAATTTTCCGCAATGGGCGAAAGCCTGACGGAGCAACGCCGCGTGAGG
GAGGAAGGTCTTTGGATTGTAAACCTCTTTTCTCAAGGAAGAAGTTCTGACGGTACTTGAGGA
ATCAGCCTCGGCTAACTCCGTGCCAGCAGCCGCGGTAATACGGGGGAGGCAAGCGTTATCCGG
AATTATTGGGCGTAAAGCGTCCGCAGGTGGTCAGCCAAGTCTGCTGTCAAATCAGTTGCTTA
ACGACCTAAAGGCGGTGGAAACTGGCAGACTAGAGAGCAGTAGGGGTAGCAGGAATTCCCAGT
GTAGCGGTGAAATGCGTAGAGATTGGGAAGAACATCGGTGGCGAAAGCGTGCTACTGGGCTGT
ATCTGACACTCAGGGACGAAAGCTAGGGGAGCGAAAGGGATTAGATACCCCTGTAGTCCTAGC
CGTAAACGATGGATACTAGGCGTGGCTTGTATCGACCCGAGCCGTGCCGAAGCTAACGCGTTA
AGTATCCCGCCTGGGGAGTACGCACGCAAGTGTGAAACTCAAAGGAATTGACGGGGGCCCGCA
CAAGCGGTGGAGTATGTGGTTTAATTCGATGCAACGCGAAGAACCTTACCAAGACTTGACATG
TCGCGAACCCCTGGTGAAAGCTGGGGGTGCCTTCGGGAGCGCGAACACAGGTGGTGCATGGCTG
TCGTCAGCTCGTGTCTGAGATGTTGGGTTAAGTCCCAGCAACGAGCGCAACCCTCGTTCTTAG
TTGCCAGCATTAAAGTTGGGGACTCTAAGGAGACTGCCGGTGACAAACCGGAGGAAGGTGGGGA
TGACGTCAAGTCAGCATGCCCCTTACGTCTTGGGCGACACACGTAATAATGGTCGGGACAA
AGGGCAGCGAACTCGCGAGAGCCAGCGAATCCAGCAAACCCGGCCTCAGTTCAGATTGCAGG
CTGCAACTCGCCTGCATGAAGGAGGAATCGCTAGTAATCGCCGGTCAGCATAACGGCGGTGAAT
TCGTTCCCAGGCTTGTACACACCGCCCGTCACACCATGGAAGCTGGTCACGCCGAAGTCAT
TACCTCAACCGCAAGGAGGGGGATGCCAAGGCAGGGCTAGTGACTGGGGTGAAGTCGTAACA
AGGTAGCCGTACCGGAAGGTGTGGCTGGATCACCTCCTTA
```

### Reflection

1. Which organism does this sequence identify?
2. What is its classification (bacteria, plant, animal)?
3. How does your identified organism impact freshwater systems?
4. If the organism is a threat, are there ways to manage it to reduce its threat? Explain.
5. Can you think of other organisms and their DNA that may be found in the water sample?

## Sequence 9

### Procedure

1. Search the NCBI database to identify the following sequence of DNA.
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3. Click on 'BLAST' in the right column.
4. Click on 'Nucleotide blast'; paste in DNA sequence in the rectangle; submit; wait for result.  
*You can find sequences at [ntf.plus/watersequences](http://ntf.plus/watersequences).*

#### >Sequence-9

```
CCTTTATCTTGTATTTGGTGCCTGAGCCGGAATAGTAGGAACCGCCTTAAGCCTCCTCATTCCG
GGCCGAACTTAGCCAACCCGGGTCGCTTCTAGGTGATGACCAAATTTATAACGTTATCGTCAC
TGCCCACGCCTTTGTAATAATTTTCTTTATAGTAATGCCTATCCTTATTGGAGGATTTGGAAA
CTGACTTGTACCACTAATAATCGGAGCCCCAGACATAGCATTCCCACGAATAAATAACATAAG
CTTCTGACTACTACCCCATCATTCTTCTACTCCTAGCTTCTTCTGGTGTGGAAGCTGGAGC
CGGAACAGGATGAACCGTATACCCACCTCTTGCAGGGAAGTTAGCCCACGCAGGAGCATCAGT
AGACCTAACAATTTTCTCACTTCACCTAGCAGGTGTTTCATCAATTCTAGGGGCAATCAACTT
TATTACTACAACCATCAACATGAAACCCCGCCATCTCTCAATACCAAACACCCCTGTTTCGT
CTGATCCGTGCTTGTAAACCGCCGTATTGCTCCTTCTATCATTACCTGTTTTAGCCGCAGGAAT
TACAATGCTCCTAACAGACCGAAACCTTAATACCACATTCTTTGACCCGGCAGGAGGAGGAGA
CCCAATCCTTTATCAACACTTATTC
```

### Reflection

1. Which organism does this sequence identify?
2. What is its classification (bacteria, plant, animal)?
3. How does your identified organism impact freshwater systems?
4. If the organism is a threat, are there ways to manage it to reduce its threat? Explain.
5. Can you think of other organisms and their DNA that may be found in the water sample?

## Sequence 10

### Procedure

1. Search the NCBI database to identify the following sequence of DNA.
2. Visit [ncbi.nlm.nih.gov](http://ncbi.nlm.nih.gov)
3. Click on 'BLAST' in the right column.
4. Click on 'Nucleotide blast'; paste in DNA sequence in the rectangle; submit; wait for result.  
*You can find sequences at [ntf.plus/watersequences](http://ntf.plus/watersequences).*

>Sequence-10

```
AAATCTTCGGCGACGACTCCGTAACAATTCGGTGGTGGTACTCTCGGACACCCTTGGGGTA
ACGCTCCTGGTGCTACTGCTAACCGCGTAGCTTTGGAAGCAGTTGTTCAAGCTCGTAACGAAG
GTCGTAACCTTGGCTCGTGAAGGTAATGATATTATCCGCGAAGCTGCTAAGTGGTCTCCTGAGT
TGGCTGTTGCTTGCCTGCGAACTGTGGAAAGAAATCAAGTTCGAGTTTGAAGCTATGGATACCGTCT
GATCTTCAAGTAACAAGTAAAAAGTTAAAAGGTAAGAAAAATAATTATTCTTTCTTTTGACTT
TTGACTTTTTACTGTTTATGGGCTAGGTCAAGTATGGATTTTAAGCAAATTGCGAAAGAGACA
GCCAACACTCTCCAAAGCTACCTGACTTATCAGGCGTTAAGGACTGTATTGGCACAGTTAGGC
GAAACAAATCCTCCTCTAGCACATTGGTTGCAAACTTCTCCGCTGGGAAAATCCAAGACGGA
GAAGCATACATAGAGGAAGTGTCTAGAAAAGTCAGATTTAGCATTACGGATTATGACTGTC
AGGGAACACATAGCGGCAGAAGTGGCAGAATTCTTACCAGAAATGGTTTGTAGTGGCATTTCAG
CAAGCCAATATGGAACAACGTCGCCAGCATCTCGAACGCATTACGCAACTAGACTTATCAAGT
CCTAGCCCAAAAACACCAAAGACAGATAATATCTAATTCTAATTTGGATAATTTATCCAATTA
GTCAGTCAACCAAATAATAAAAAATCTCCCCCACTTACAAAAACTATGCAAACCTTTACCTAA
AGAGCGTCGT
```

### Reflection

1. Which organism does this sequence identify?
2. What is its classification (bacteria, plant, animal)?
3. How does your identified organism impact freshwater systems?
4. If the organism is a threat, are there ways to manage it to reduce its threat? Explain.
5. Can you think of other organisms and their DNA that may be found in the water sample?

## Rubric for self-assessment

Skill	Yes	No	Unsure
I can explain the use of barcodes to compare organisms.			
I can use the NCBI database to identify organisms based on DNA sequences.			
I can describe the impact of various water organisms on water quality.			