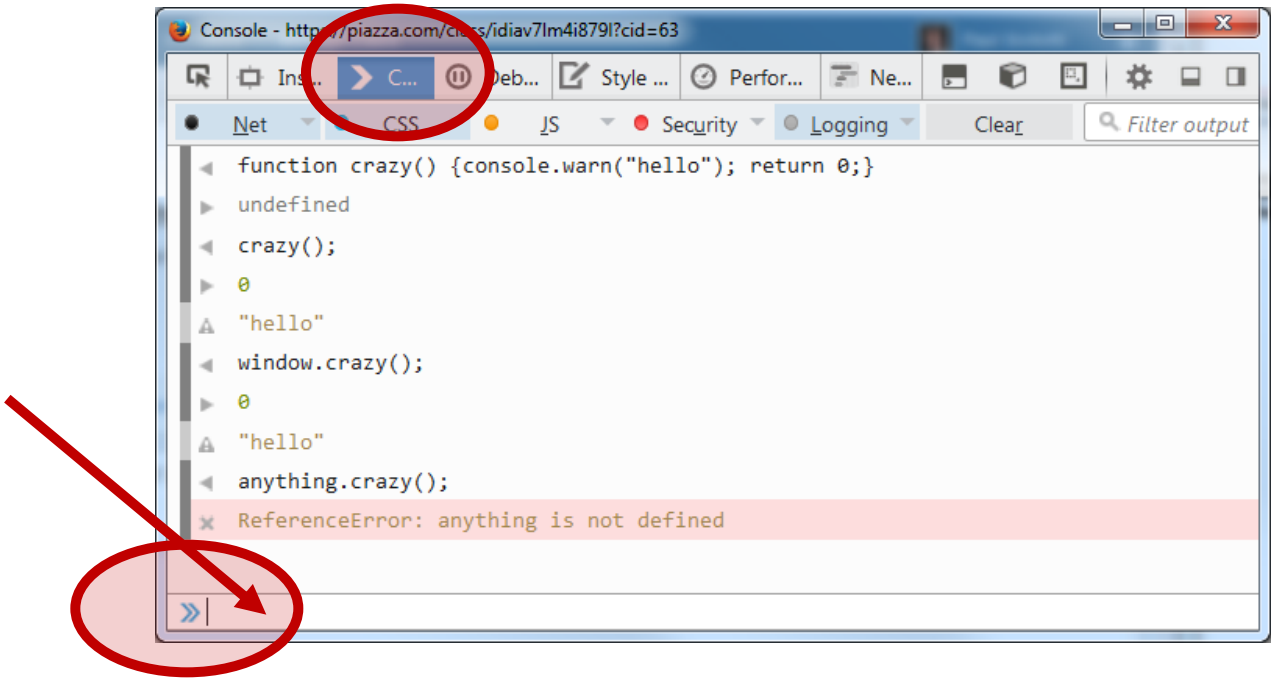
JavaScript: DOM and Events

Lecture 18

Objects are Everywhere

- Global variables in JavaScript are a lie
- Implicitly part of some "global object", provided by execution environment
  - See FF Developer Tools: Console



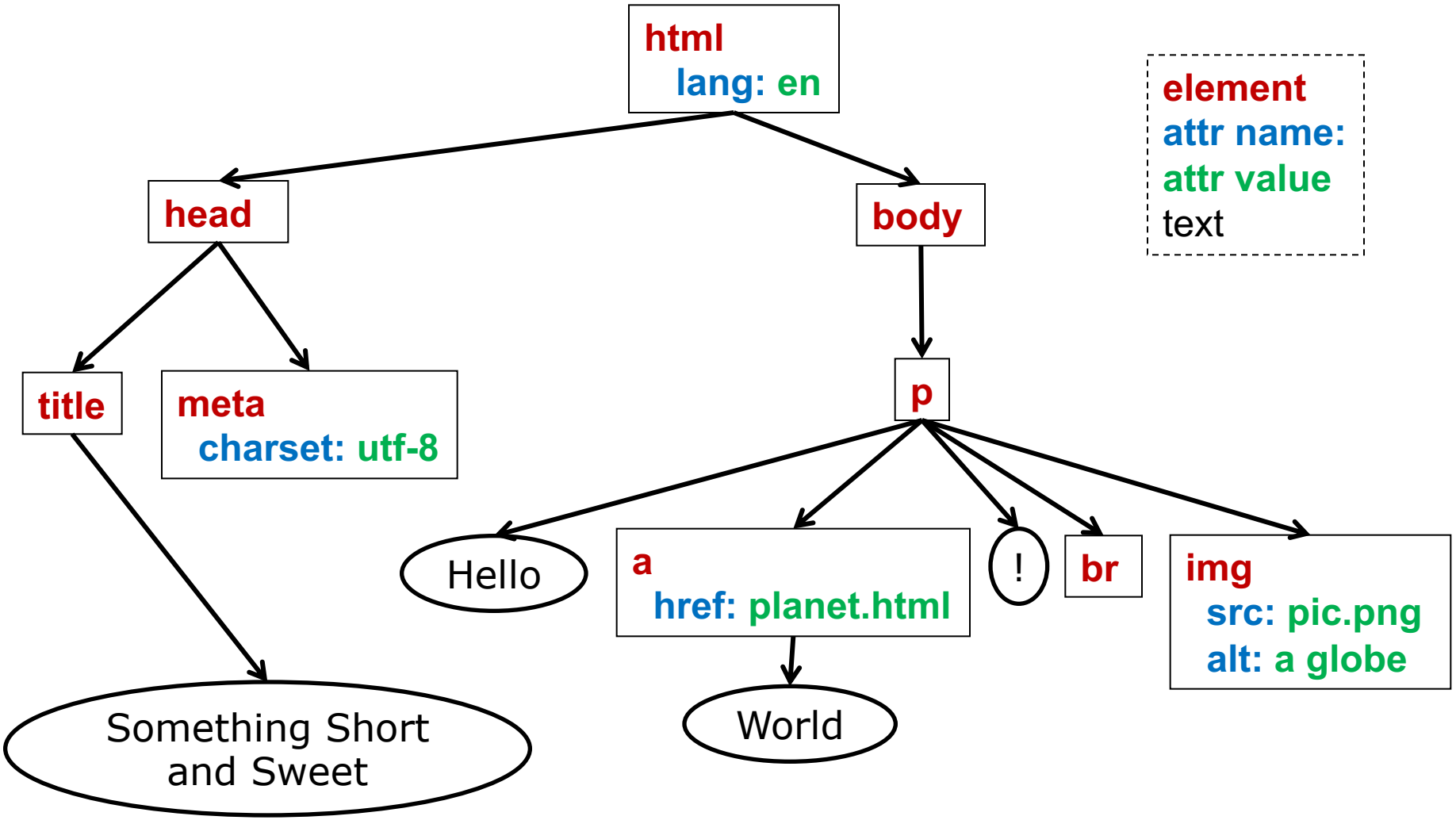
Window Object

- For JavaScript running in a browser, implicit global object is the window

```
>> this
<- Window
```

- Many properties, including
  - **`location`** (url of displayed document)
  - **`status`** (text in status bar of browser)
  - **`history`**
  - **`innerHeight`**, **`innerWidth`**
  - **`alert()`**, **`prompt()`**
  - **`document`** (tree of displayed document)

Document is a Tree



DOM: "Document Object Model"

- DOM is a language-neutral API for working with HTML (and XML) documents
  - Different programming languages have different bindings to this API
  - But all are similar to JavaScript's API
- In JavaScript, tree nodes → objects
  - A tree node (*i.e.* an element with attributes)

```
<input type="text" name="address">
```

  - A JavaScript object with many properties

```
{ tagName: "INPUT",
  type: "text",
  name: "address", /* lots more… */ }
```

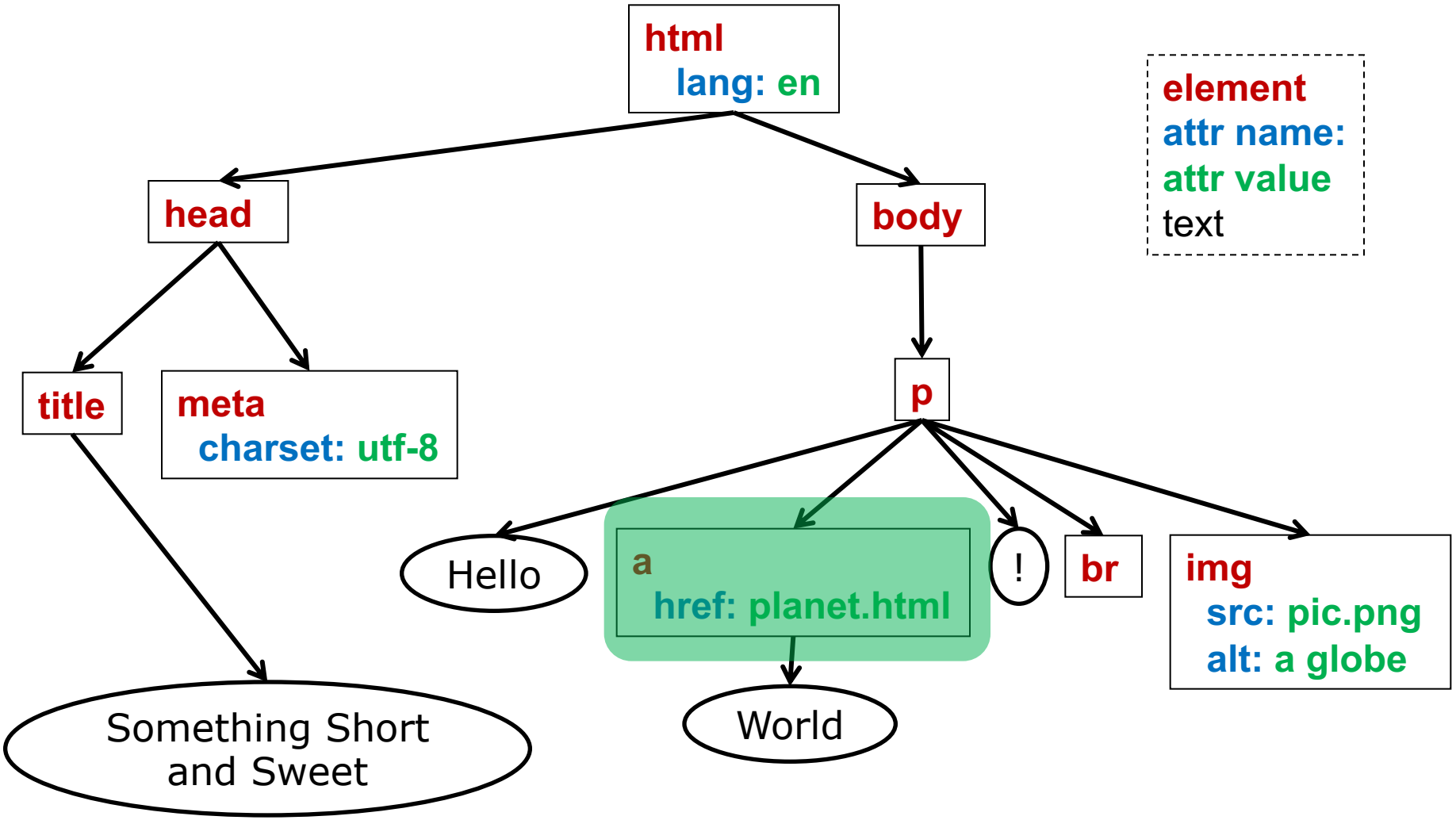
DOM History

- Ad hoc DOM existed from the beginning of JavaScript
  - Core purpose of client-side execution: Enable user interaction with the document
  - Need a connection between programming language (JavaScript) and the document
- DOM 1 specification (W3C) in '98
  - Standardized mapping tree→objects and functions for *modifying* the tree
- DOM 2 ('00): added styles and event handling
- DOM 3 ('04): fancier tree traversal & indexing schemes
- DOM "4" ('15…):
  - Actually just a "living document"
  - Some non-backwards-compatible changes

Simplest Mapping

- **`window's document property`**
  - **`write()`**: outputs text to document body
  - **`forms`**: array of forms in a page
    - **`elements[]`**: array of widgets in a form
  - **`anchors`**: all anchors in document
  - **`links`**: all links in document
  - **`getElementById(string)`**: find a node
  - *etc…*

Document is a Tree



Node is a JavaScript Object

- Properties
  - **`parentNode`**, **`childNodes`**, **`firstChild`**, **`lastChild`**, **`nextSibling`**, **`previousSibling`**
  - **`innerHTML`**
  - **`tagName`**
    - HTML upper case (A), XML lower case (a)
  - **`attributes`**, **`name`**, **`id`**, **`class`**
  - **`style`**
    - Hyphenated property in CSS (*e.g.*, "font-size") becomes camelCase in JavaScript (*e.g.*, "fontSize")
- Methods
  - **`appendChild(node)`**, **`removeChild(node)`**, **`insertBefore(node)`**
  - **`hasAttribute(attr)`**, **`removeAttribute(attr)`**, **`getAttribute(attr)`**, **`setAttribute(attr)`**
  - **`getElementsByTagName(name)`**

Demo: Web Console


```
>> let b = document.body;
>> b.tagName;
>> b.childNodes;
>> b.style.backgroundColor = "green";
>> let x = document.getElementById
                ("page-content");
>> x.innerHTML;
>> x.innerHTML = "<h1>Hello</h1>";
```

How to Find a Node in Tree

1. Hard coding with "flat" techniques
   - Array of children

     ```
     document.forms[0].elements[0]
     ```
   - Downside: too brittle
   - If the document structure changes a little, everything breaks
2. Using an element's *name* attribute
   - In HTML:

     ```
     <form name="address"> …
     <input name="zip"... />  </form>
     ```
   - In JavaScript:

     ```
     document.address.zip
     ```
   - Downside: direct path still hard coded

How to Find a Node in Tree

3. To get a unique element: document method **`getElementById`**
   - In HTML

     ```
     <td id="shipping">...</td>
     ```

   - In JavaScript

     ```
     document.getElementById("shipping")
     ```

   - Downside: every element you want to find needs unique ID
4. Combination: element ID for form, arrays for options in selection element

Example


```
<form id="wheels">
  <input type="checkbox" name="vehicles"
         value="car" /> Car
  <input type="checkbox" name="vehicles"
         value="truck" /> Truck
  <input type="checkbox" name="vehicles"
         value="bike" /> Bike
</form>

let numChecked = 0;
let elt = document.getElementById("wheels");
for (let i = 0; i < elt.vehicles.length; i++) {
  if (elt.vehicles[i].checked)
    numChecked++;
}
```

Interactive Documents

- To make a document interactive, you need:
  - Widgets (ie HTML elements)
    - Buttons, windows, menus, etc.
  - Events
    - Mouse clicked, window closed, button clicked, etc.
  - Event listeners
    - Listen (ie wait) for events to be triggered, and then perform actions to handle them

Events Drive the Flow of Control

- This style is *event driven* programming
- Event handling occurs as a loop:
  - Program is idle
  - User performs an action
    - Eg moves the mouse, clicks a button, types in a text box, selects an item from menu, …
  - This action generates an event (object)
  - That event is sent to the program, which responds
    - Code executes, could update document
  - Program returns to being idle

Handling Events Mechanism

- Three parts of the event-handling mechanism
  - *Event source*: the widget with which the user interacts
  - *Event object*: encapsulated information about the occurred event
  - *Event listener*: a function that is called when an event occurs, and responds to the event

Programmer Tasks

- Define an event handler
  - Any function can be an event handler
  - Often need information about the triggering event in order to know what response is needed
- Register handler with source element
- Detect event and invoke handler
  - Ha! Just kidding, you do NOT do this

Simple Example: Color Swaps


```
<p>This page illustrates changing colors</p>
<form>
  <p>
    <label> background:
      <input type="text" name="back" size="10"
        onchange="foo('bg', this.value)" />
    </label> <br />
    <label> foreground:
      <input type="text" name="fore" size="10"
        onchange="foo('fg', this.value)" />
    </label>
  </p>
</form>
```

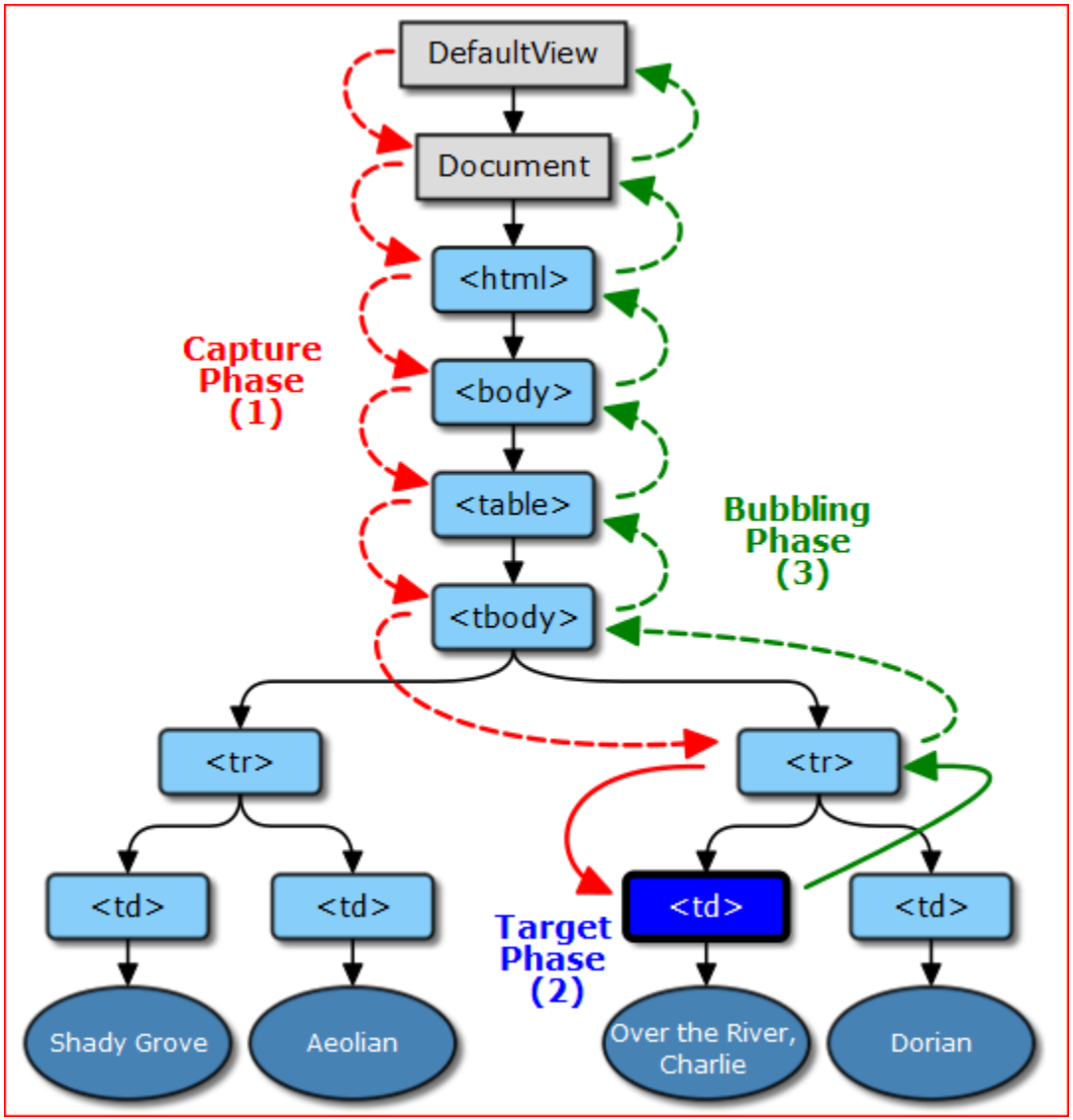
Color Swaps (JavaScript)


```
function foo(place, color) {
  if (place === "bg")
    document.body.style.backgroundColor =
        color;
  else
    document.body.style.color = color;
}
```

Event Propagation

- Elements are nested in tree
- When an event occurs, which element's handler(s) is(are) notified?
- First, *propagation path* is calculated: from root to smallest element
- Then event dispatch occurs in 3 phases
  1. Capture (going *down* the path)
  2. Target (smallest element)
  3. Bubble (going *up* the path, reverse of 1)

http://www.w3.org/TR/DOM-Level-3-Events/



Bubbling Up

- Usually, handling is done in phase 2 and 3
- Example: mouse click on hyperlink
  - Handler for **`<a>`** element displays a pop-up ("Are you sure you want to leave?")
  - Once that is dismissed, event flows up to enclosing **`<p>`** element, then **`<div>`** then… *etc.* until it arrives at root element of DOM
  - This root element (*i.e.* **`window`**) has a handler that loads the new document in the current window

Programmer Tasks

- Define a handler
  - Easy, any function will do
- Register handler
  - Multiple ways to link (HTML) tree elements with (JavaScript) functions
- Be triggered by the event
  - Ha! Still kidding
- Get information about triggering event
  - Multiple (incompatible) ways for handler to get the event object

Registering an Event Handler

- Three techniques, ordered from:
  - Oldest (most brittle, most universal) to
  - Newest (most general, least standard)

1. Inline (link in HTML itself)

```
<a href="page.html" onclick="foo()">…
```

2. Direct property (link in JavaScript)

```
let e = … // find source element in tree
e.onclick = foo;
```

3. Chained (In JavaScript, browser differences)

```
let e = … // find source element in tree
e.addEventListener("click", foo, false);
```

Inline Registration (pre DOM)

- Use HTML *attributes* (vary by element type)
  - For window: **`onload`**, **`onresize`**, **`onunload`**,…
  - Forms & elements: **`onchange`**, **`onblur`**, **`onfocus`**, **`onsubmit`**,…
  - Mouse events: **`onclick`**, **`onmouseover`**, **`onmouseout`**,…
  - Keyboard events: **`onkeypress`**, **`onkeyup`**,…
- The *value* of these attributes is JavaScript code to be executed
  - Normally just a function invocation
- Example

```
<a href="page.html" onclick="foo()">…
```

- Advantage: Quick, easy, universal
- Disadvantage: mixes code with content

Direct Registration (DOM 1)

- Use *properties* of DOM element objects
  - **onchange**, **onblur**, **onfocus**,…
  - **onclick**, **onmouseover**, **onmouseout**,…
  - **onkeypress**, **onkeyup**,…
- Set this property to appropriate handler

```
let e = … // find source element in tree
e.onclick = foo;
```

- Note: no parentheses!

```
e.onclick() = foo; // what does this do?
e.onclick = foo(); // what does this do?
```

- Disadvantage? No arguments to handler
  - Not a problem, handler gets event object
- Real disadvantage: 1 handler/element

Example


```
let x =
document.getElementsByTagName("div");
for (let i = 0; i < x.length; i++) {
  x[i].onmouseover = function () {
    this.style.backgroundColor="red"
  }
  x[i].onmouseout = function () {
    this.style.backgroundColor="blue"
  }
}
```

Chained Registration (DOM 2)

- Each element has a *collection* of handlers
- Add/remove handler to this collection

```
let e = … //find source element in tree
e.addEventListener("click", foo, false);
```

- Note: no "on" in event names, just "**click**"
- Third parameter: **true** for capture phase
- Disadvantage: browser incompatibilities

```
e.addEventListener() // FF, Webkit, IE9+
e.attachEvent()      // IE5-8
```

- Some browser compatibility issues with DOM and events
- Solution: Libraries
  - Eg jQuery, Dojo, Prototype, YUI, MooTools,…

Example


```
let x =
document.getElementsByTagName("div");
for (var i = 0; i < x.length; i++) {
  x[i].addEventListener ("click",
    function () {
      this.act = this.act || false;
      this.act = !this.act;
      this.style.backgroundColor =
       (this.act ? "red" : "gray");
    },
    false);
}
```

Task: Getting Event Object

- Most browsers: parameter to handler

```
function myHandler(event)
```

- IE: event is property of window
- Common old-school idiom:

```
function myHandler(event) {
  event = event || window.event;
  … etc …
```

- Again, libraries are the most robust way to deal with these issues

Summary

- DOM: Document Object Model
  - Programmatic way to use document tree
  - Get, create, delete, and modify nodes
- Event-driven programming
  - Source: element in HTML (a node in DOM)
  - Handler: JavaScript function
  - Registration: in-line, direct, chained
  - Event is available to handler for inspection