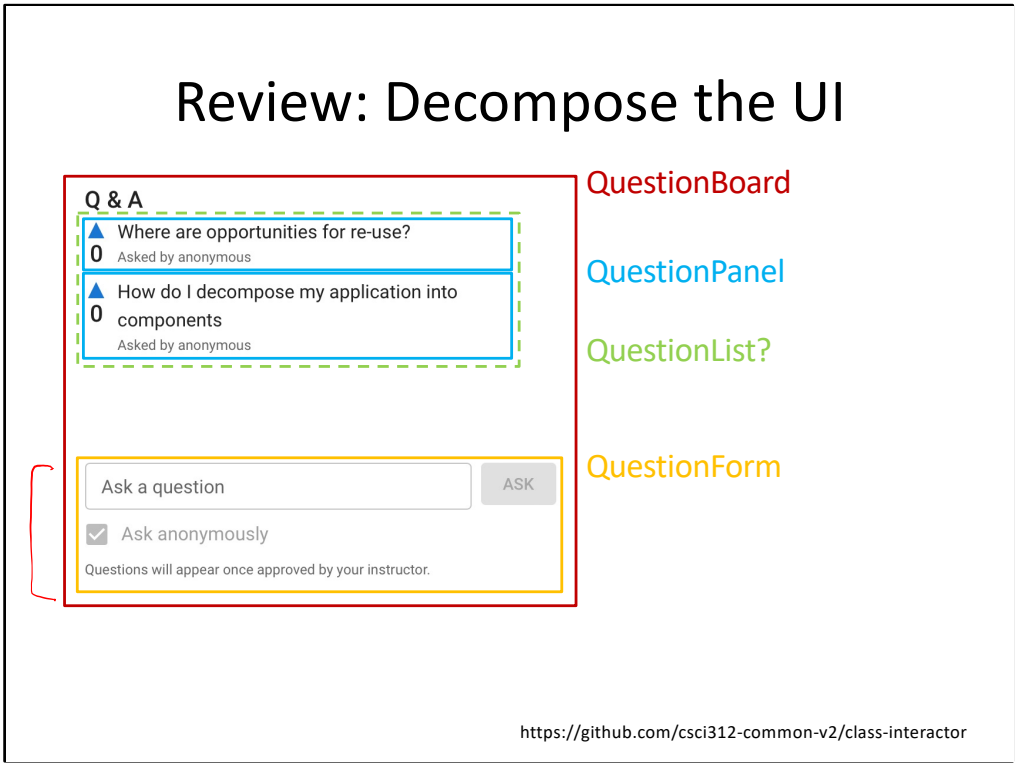
Recall: "Thinking in React"

1. Break the UI into a component hierarchy
2. Build a static version in React
3. Identify the minimal (but complete) representation of state
4. Identify where your state should live
5. Add "inverse" data flow (data flows down, callbacks flow up)

https://react.dev/learn/thinking-in-react



To start, we don't need to create multiple components – technically. It will work to have one giant React component. But it will be difficult to maintain. That doesn't mean the alternate extreme, extracting lots of "fine grain" components is the right approach either (moderation in all things). A suggestion: Start from the top, with "simple components" (a term we will talk about in a second), and only extract/split components when needed. When is it needed? Some signs: repeated content, repeated interaction, and the components gets too "big" to the review it all at one time on the screen.

https://www.developerway.com/posts/components-composition-how-to-get-it-right

How would you decompose this view from the "class interactor"?

- [click] Let's start with an enclosing `QuestionBoard`
- What are the repeated elements? QuestionPanel? [click]
- Should the QuestionForm be a separate component, or part of the whole? Probably separate to minimize complexity of the overall QuestionBoard.

[click]

Depending on the implementation approach we might also implement a QuestionList component that wraps the array of QuestionPanels. The actual application does not use one, but I could imagine doing so if we started to have customized sorting logic,

etc. What that hints to us, and what we will talk about in more detail today, is that components aren't just about the view, we can create components anywhere there is a valuable *composition boundary*.

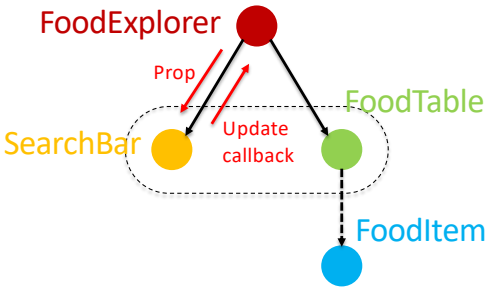
As a note, the class-interactor is partly a test-bed/demonstrator for this class. I encourage you to check out its code as model of the kinds of things we are working towards this semester.

Review: React state placement

Typing in search box filters entries

Search:

Sushi	Sushi is a traditional Japanese dish of prepared vinegared rice
Dal	The most common way of preparing dal is in the form of a soup to which onions, tomatoes and various spices may be added
Pierogi	Pierogi are filled dumplings made by wrapping unleavened dough around a savoury or sweet filling and cooking in boiling water
Shish kebab	Shish kebab is a popular meal of skewered and grilled cubes of meat.
Dim sum	Dim sum is a large range of small dishes that Cantonese people traditionally enjoy in restaurants for breakfast and lunch



- SearchBar and FoodTable both need the “search term”
- State should “live” in the nearest common ancestor, i.e., FoodExplorer

https://react.dev/learn/sharing-state-between-components

Let’s look at another example, a ”filterable” list adapted from the React documentation. What components need the search term? Both the SearchBar form (to display what is entered) and the FoodTable, to perform the filtering with that search term. <click> The state should be placed in the nearest common ancestor, FoodExplorer. And will flow down the children as props and ”up” via callbacks. <click>

What would the problem with defining search term state in SearchBar? We would need to two copies, one in in SearchBar and FoodExplorer. Recall we only want a single source of truth.

How might we approach it differently if the search was only applied after clicking a search button? Then we we would have two pieces of state, the text currently being modified, and the last search term applied. The former could live in SearchBar, the latter would still live in FoodExplore..

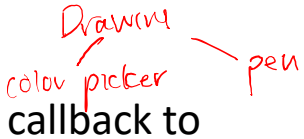
From Dan Abromov: https://overreacted.io/writing-resilient-components/#principle-4-keep-the-local-state-isolated

If you’re not sure whether some state is local, ask yourself: “If this component was rendered twice in different places, should this interaction reflect in the other copy?” Whenever the answer is “no”, you found some local state. …

Consider a social media Post component. It has a list of Comment threads (that can be expanded) and a NewComment input….
For example, imagine we rendered the same Post twice. Let's look at different things inside of it that can change.

- *List of comments.* This is similar to post content. We'd want adding a new comment in one tree to be reflected in the other tree too. So ideally, we would use some kind of a cache for it, and it **should not** be a local state of our Post.
- *Expand/Collapse.* I would be weird in expanding/collapsing in one view changes the other, so this be local to the comment threads.
- *The value of new comment input.* It would be odd if typing a comment in one input would also update an input in another tree. Unless inputs are clearly grouped together, usually people expect them to be independent. So, the input value **should** be a local state of the NewComment component.

You are embedding the color picker in a drawing app (to pick the pen color), where should you maintain the color state?



A. In the ColorPicker, and use a callback to communicate changes to the parent drawing component
B. In the drawing component
C. Neither. I heard I am supposed to use Redux to manage state.

Answer: B (although A could be the right choice depending on our goal).

The React philosophy to is to maintain one source of truth. Thus, there should be one instance of the pen color (in the drawing component that needs it) and it is passed as a prop to the color picker (and updated from the color picker via callback). The tradeoff of this approach is that we may have ”lace” that state through many components. There are several ways to mitigate that burden. Redux is one. There are a lot of tools that can be used with React. And the Internet will have strong opinions. But I want to advocate against any change that starts with “I heard that …”

What about A? As we just discussed in the context of the search bar. It depends on how we conceive of the color update. Should dragging the sliders change the pen color immediately? Or do we want to have a specific update step? For the former, we would want to hoist state up, for the latter, we would likely want separate state within the ColorPicker component, itself.

From Dan Abramov of the React team (and creator Redux).

“However, if you’re just learning React, don’t make Redux your first choice. Instead learn to think in React. Come back to Redux if you find a real need for it, or if you want to try something new. But approach it with caution, just like you do with any highly opinionated tool.”

Recent versions of React incorporated Contexts (effectively pseudo-global variables) to reduce the “lacing” (termed “prop drilling”) burden.

What are some roles for components?

- Container vs. Presentational[1]
  - Containers implement state & logic
  - Presentational (typically) renders DOM
- Implement vs. Compose[2]
- Simple vs. Container[2] (specific vs. generic?)
  - Simple explicitly render children
  - Container offer generic composition via children prop, etc.
- ~~Stateful (class) vs. stateless (functional)~~

[1]https://medium.com/@dan_abramov/smart-and-dumb-components-7ca2f9a7c7d0
[2]https://www.developerway.com/posts/components-composition-how-to-get-it-right

As you are considering your component hierarchy, here are some potential considerations (and certainly not the only…).

The first encourages us to think about whether a component is responsible for the ”views” seen by the user (presentational) or the logic that underlies the interaction (container). Making that distinction encourages separating those two concerns.

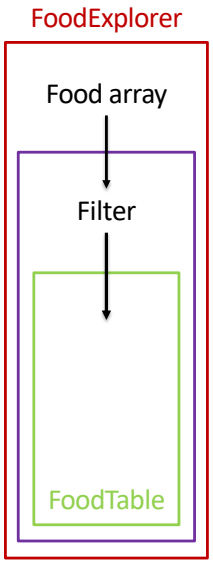
The next consideration is that components should generally either implement specific functionality or compose (group) other components together. From the blog post: ‘A component should be described either as a “component that implements various stuff” or as a “component that composes various components together”, not both.’

The third's names are terrible. Perhaps a better description is specific vs. generic. We are considering whether a component is implementing functionality specific to this use case or might be generic/reusable. An example might be a toggle feature that not is specific to any one toggling element.

The last used to be a very important technical consideration in the era of classes vs. functional components, which is less (no longer) relevant in the hook’s “era”. Now functional components (components implemented as a

function) can be stateful and we default to functional components for everything. What is a hook? They are “functions that let you “hook into” React state and lifecycle features from function components.” The useState function we saw previously is an example of a hook (the convention is to use names starting with “use”). They are mechanisms for maintain state within functional components, effectively across renders.

Container components: Separating logic from UI



Separation of Concerns:

- *Container Component (CC):* Concerned with how the application works, i.e., implements logic
- *Presentational Component (PC):* Concerned with how the application looks. Typically generates DOM.

*"Remember, **components don't have to emit DOM.** They only need to provide composition boundaries between UI concerns."* Dan Abramov

https://medium.com/@dan_abramov/smart-and-dumb-components-7ca2f9a7c7d0

In the context of the "Question Board" we discussed the potential for a `QuestionList` component to manage the ordering, etc. of the questions. We would describe that as a Container Component. We could apply the same idea to the `FoodExplorer`. The idea of the container component would be to encapsulate the filtering operation on the food items, separating it from the enclosing `FoodExplorer` component, and the "presentational" `FoodTable` that renders the food on the screen. Why might that benefit us? We can separate those two concerns, rendering the list and filtering/ordering the list. They can evolve, be tested, and perhaps now used independently.

That said, some of the role of container components has been taken over by custom hooks which can collect logic (for reuse). Dan Abramov, who proposed this notion in 2015, updated the post in 2019 with

"I wrote this article a long time ago and my views have since evolved. In particular, I don't suggest splitting your components like this anymore. If you find it natural in your codebase, this pattern can be handy. But I've seen it enforced without any necessity and with almost dogmatic fervor far too many times. The main reason I found it useful was because it let me separate complex stateful logic from other aspects of the component. Hooks let me do the same thing without an arbitrary division. This text is left intact for historical reasons but don't take it too seriously."

For example, his update would suggest a “filtering” hook that encapsulates the filtering operation. It could replace the specific filtering component, i.e., in FoodExplorer we might have
[fitleredFoods, filterString, setFilterString] = useFiltered(foods);

Personally, I think think there is value in this consideration and applying in your design process. Whether that process turns into components or hooks, the underlying considerations are similar.

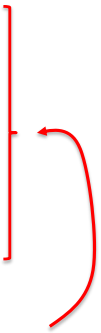
Custom hooks?

Custom hooks are a means to share stateful logic between components

For example, we want to share filtering based on some stateful search string

```
function useFilter(data, toStrings) {
  const [filterString, setFilterString] = useState('');
  const query = filterString.toLowerCase();
  const filteredData = data.filter(item =>
    toStrings(item).some(word =>
      word.toLowerCase().startsWith(query)
    )
  );
  return [filteredData, filterString, setFilterString];
}

function FoodExplorer() {
  const [foods, setFoods] = useState([…]);
  const [fitleredFoods, filterString, setFilterString] = useFiltered(foods, …)
  …
```



Here we implement a hook that encapsulates the search string state, and the filtering operation. It would replace any “FilteredList” container component we might have created before. It exposes that underlying search string state (so it can be set by the form, or some other means), and the filtered array. Each time the enclosing component is re-rendered, the current search string will be used to filter the `data` array.

As noted in the documentation, custom hooks let you share stateful logic, not state. If you invoked `useFilter` in two different components you would have two distinct filterString states (i.e., they could change independently).

Do you need to write or use custom hooks? No. But they can be a means for simplifying your code. If you find yourself duplicating logic between components, that might be a sign to create a hook. Further, there are libraries of pre-written hooks for common tasks, e.g., toggling, knowing if the user’s network is connected, etc. which you can reuse in your application.

You have implemented a `CommentList` component that fetches an array of comments from your server and renders those comments as an unnumbered list (i.e., `<ul>...</ul>`). `CommentList` is a:

A. Presentation component
B. Container component
C. Both a presentation and container component
D. Neither a presentation not container component

Answer: C

As described CommentList is both a Presentation Component and Container Component, in that it generates DOM (the <ul>) and so is concerned with how the application looks *and* is concerned with how the application works (i.e., gets comments from server). It could be split into a container component that fetches the data and a CommentList component that displays the comment list UI. Or now in the hooks era, we could use a hook to fetch the data from the server (effectively serving in the "container" role) and our component would be responsible for rendering the comments as a list.

Interlude: Sequences in React

```
function FilmTable(props) {
  const films = props.films.map(film => (
    <FilmContainer
      key={film.id}
      {...film}
      setRatingFor={props.setRatingFor}
     />
  ));
  return <div>{films}</div>;
}
```

"Arrays" need key to uniquely identify components

"Keys help React identify which items have changed, are added, or are removed. Keys should be given to the elements inside the array to give the elements a stable identity. Most often you would use IDs from your data as keys" -ReactJS Docs

https://react.dev/learn/rendering-lists

Recall that React is trying to figure the minimal number of edits to apply when updating the browser screen. If you insert an element of the array it might seem to React that all of the elements in the array have changed because now oldArray[0] !== newArray[0]. And thus, React might do a lot more work re-rendering all the elements. But in reality, the rendering of all the remaining elements can be reused. Using keys in this context helps React realize that elements just shifted (and thus can be reused).

Note that keys are powerful tools outside of sequences. For example, we can use keys when we want to "reset" a component (https://react.dev/learn/you-might-not-need-an-effect#resetting-all-state-when-a-prop-changes)

Interlude: Conditional rendering

```
function FilmContainer(props) {
  const [showDetail, setShowDetail] = useState(false);
  if (showDetail) {
    return <FilmDetail {...props} onClick={() => setShowDetail(false)} />;
  } else {
    return <FilmSummary {...props} onClick={() => setShowDetail(true)} />;
  }
}
```

A React function is code and so you can use conditionals to change views

Some other common conditional patterns:

```
{boolean && <Component … />}
{boolean ? <Component1 … /> : <Component2 … />}
```

https://react.dev/learn/conditional-rendering

The first other pattern utilizes short circuit evaluation in the and (&&) operation. If the first operand is falsy JS won't evaluate the second expression. And React will not render anything for {false}. The second pattern is the ternary operator which is effectively an inline if-else expression. If the Boolean predicate evaluates to truthy it will evaluate to Component1 (before the colon), if falsy it will evaluate to Component2 (after the colon).

Note there is a caveat to the short circuit evaluation approach. React will render some values JS considers falsy, most notably numbers. i.e., 0 && < … > will render 0. As result some developers prefer {Boolean ? <…> : null }.

https://react.dev/learn/conditional-rendering

Simple/Specific vs. Container/Generic

Functional component rendering DOM

```
const Button = ({ title, onClick }) => <button onClick={onClick}>{title}</button>;
```

What if I want a button with an icon?

```
const Button = ({ children, onClick }) =>
    <button onClick={onClick}>{children}</button>;

<Button onClick={onClickHandler}>
  <Icon />
  <span>Create</span>
</Button>
```

Special prop with all child components

children

https://www.developerway.com/posts/components-composition-how-to-get-it-right

Or more generally, should a button care what its children are? Not really…

Note that are other, even more sophisticated composition patterns, that we won't get into here.

Class vs. Functional Components

- Classes can have state! And lifecycle methods.
- Functions are suggested unless you need Class features since they are simpler and may be optimized in the future

Function components are suggested in all situations (using Hooks if stateful)

Prior to hooks, State could only be implemented in classes. Function components could only used for stateless components (for which they were recommended over classes). Now with hooks function components can be stateful and are recommended in all but a few highly specialized situations.

Adapted from Dan Abramov

Interlude: Rules of Hooks

- Only call Hooks at the top level of a function

  Don't call Hooks inside loops, conditions, or nested functions
- Only call Hooks from React functions or custom Hooks

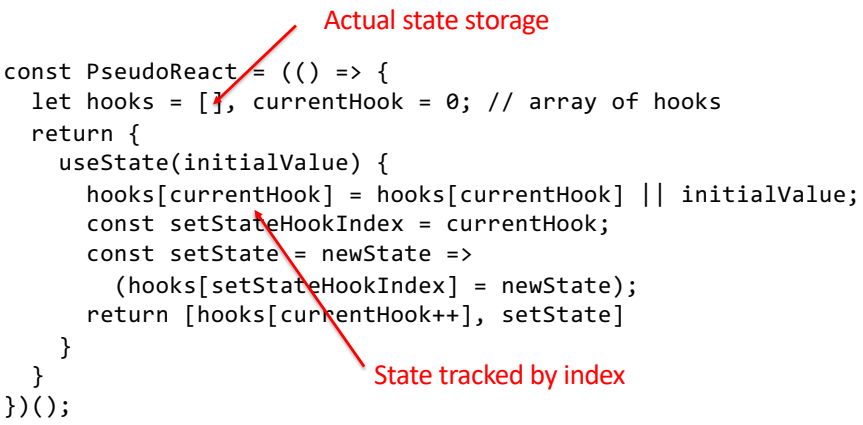
  Don't call Hooks from regular JavaScript functions
- Convention is to put hooks at start of the function

https://reactjs.org/docs/hooks-rules.html

React uses the order in which hooks are called to maintain the mapping between state and useState calls. Thus, the order needs to be same every time the React function is invoked (conditions and loops are likely to violate this assumption). The second rule ensures that all stateful logic in a component is clearly visible from its source code. There are ESLint rules included in our skeletons that will check some aspects of these rules (but no linter rule is perfect…). We go beyond these rules to also collect all hooks at the very beginning of the component function so they are clearly visible as we read the code.

https://reactjs.org/docs/hooks-rules.html

Where do these rules come from?




```
const PseudoReact = (() => {
  let hooks = [], currentHook = 0; // array of hooks
  return {
    useState(initialValue) {
      hooks[currentHook] = hooks[currentHook] || initialValue;
      const setStateHookIndex = currentHook;
      const setState = newState =>
        (hooks[setStateHookIndex] = newState);
      return [hooks[currentHook++], setState]
    }
  }
})();
```

https://www.netlify.com/blog/2019/03/11/deep-dive-how-do-react-hooks-really-work/

Here is a representative implementation of React. One question is where is React state actually stored? In a closure (here useState closes over the local hooks array in the PseudoReact function).

Notice that hooks are tracked by index. Thus, all hooks need to execute in the same order every time. Loops, conditions, nested functions, etc. all have the potential to change to order in which the hooks are invoked. And thus, we should invoke a hook inside any of those constructs.

How does React know what functions to invoke? It keeps track of all of the components you previously rendered starting with the ReactDOM.render call ”kicks” off React and inserts the results in the web page.

https://www.netlify.com/blog/2019/03/11/deep-dive-how-do-react-hooks-really-work/

What might go wrong here?

```
const [films, setFilms] = useState([]);
…
const setRating = (filmid, rating) => {
  const index = films.findIndex((film) => film.id === filmid);
  films[index].rating = rating;
  setFilms(films);
}
```

Calling setter with same object may not trigger a re-render since React doesn't think anything changed

```
films.sort(...);
return (<FilmTable films={films} … />);
```

Sorts in place so React may not know that FilmTable's props have changed, and thus not re-render

Although we mutated one of the elements in the films array, the films variable still points to the same array object. The state setter compares the new and old object when deciding if the component is "dirty" and thus needs to re-render. The comparison rules are lengthy, but generally simple values like integers are compared via equality while objects are compared by reference. In this case, since it is the same object (old films and new films point to the same array in memory), React may not trigger a re-render.

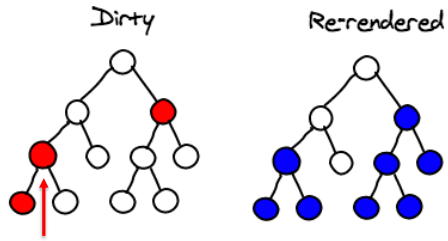
[click]

What about the lower snippet? `sort` is in place. If `FilmTable` compares its new props to previous props it may think nothing as changed. This last one is more subtle and motivates us to learn more about what re-rendering means in React.

[click]

https://react.dev/learn/updating-objects-in-state
https://react.dev/learn/updating-arrays-in-state

Re-rendering in React



Components where state changed

https://calendar.perfplanet.com/2013/diff/

Recall this image from last time. The red circles are components where a state update occurred. Notice in the right image that those nodes – and all of their children, children's children, etc. – are re-rendered.

A change to state is the only thing that causes re-renders, that is why the empty nodes didn't re-render. They weren't the children of components with state changes. That is why we want to be careful to be sure React recognizes state has changed. If not, the desired nodes may be not be re-rendered.

But what about props? In the second snippet, we were concerned about a change to a prop not getting recognized as such and re-rendering get cut-off before reaching the leaf node(s), (e.g., the right-hand side leaves). By default, that is not a concern, React re-renders all children because it may not know what has changed. But there are some obvious optimization opportunities. If a component is "pure", i.e., only depends on its props, and those props haven't changed we don't need to re-render. Historically React could employ that optimization automatically for certain components and now it is an opt-in (and may become automatic in the future again). We may not know if a child has that optimization employed and so want to be conservative to minimize the possibility for subtle bugs.

In general, operations on JS objects are cheap compared to re-rendering and so should measure before we attempt to optimize JS manipulation that may lead other

problems. We also shouldn’t automatically reach for those opt-in optimizations (`useMemo` and `useCallback`) hooks unless we have profiled (i.e., measured the performance) and know they are needed. They don’t magically fix performance problems and introduce a cost of their own.

Take home message: Don’t mutate state or props, create new objects

- Assigning to state does not trigger a re-render
- Mutated state/props will not compare as different objects and so may not trigger a re-render

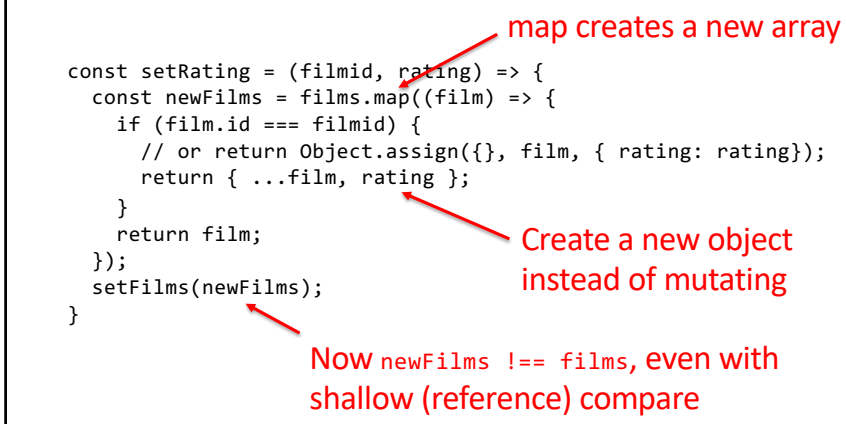
```
// Typical hook pattern prevents reassignment
const [comments, setComments] = useState([]);
comments = ['Hello']; // Javascript error


// But doesn’t prevent mutation
const [comments, setComments] = useState([]);
comments.push('Hello'); //modifies array in-place
setComments(comments); // new and old comments are shallow equals
```

Assigning to state used to be more of an issue in the class era. Now JS variable declaration rules can help use avoid that issue with hooks, by preventing us from re-assigning state. But they don’t prevent missed updates due to mutating state. So, what do we do instead? Make copies.

https://react.dev/learn/updating-objects-in-state

Make copies instead of mutating



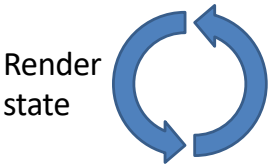
Instead, we make copies. Here we are making a copy of the films array with map. Further we making a copy of the specific object we are modifying. As a result, everything that has changed, the array and the modified film, point to new locations in memory.

To make a copy of the object, we are using the spread operator. The spread operator (the ellipses) works by populating the new object literal with all the properties of the film object and then overwrites that with rating (this concise syntax is short for `rating: rating`). The comment shows how to do the same with Object.assign.

[How does Object.assign work in this context? assign overwrites the properties of its 1st argument with the remaining arguments (in order). Thus, this create a new empty object, overwrites with the properties in film and then overwrites the rating property with the new rating.]

Wait, wait I hear you saying. Isn't this inefficient (and verbose/awkward)? Yes, but it may not matter. First, and most importantly, we don't want to start optimizing unless we know something is a problem. In many cases, it won't matter. For us, updating the screen is much more expensive that manipulating objects; minimizing/optimizing re-renders can be more important. If we do observe performance problems, we can look towards caching techniques (e.g., useMemo hook) or immutable data structures to speedup and simplify updates for complex objects.

Recall: React controlled components




```
function Example(props) {
  const [title, setTitle] = useState('');

  return (<input
    type="text"
    value={title}
    onChange={(event) => setTitle(event.target.value})}
  />);
}
```

Input value determined by React state

Change updates state, which re-renders input with new value

By default, HTML input components have their own internal state and ”update” loop, i.e., dragging the slider updates that internal state. Controlled components override that internal update loop with React’s update loop. Dragging the slider triggers the onChange event which updates the states which triggers a re-render which moves the slider, … The motivation is to maintain that single source of state, that is everything (the logic and the UI) is ”controlled” by the same React state. Doing so makes the component “predictable”, we know it will always show the state we specified and enables us to access those values for validation and other uses.

React: Controlled vs. Uncontrolled

+ Single source of truth
- Lots of callbacks

(Familiar?) Controlled component:

```
<input type="text" value={…} onChange={…}/>
```

Uncontrolled component:

Reference to real DOM element

```
<input type="text" ref={(input) => this.input = input} />
```

Feature	Controlled	Uncontrolled
One–time retrieval, e.g., on submit	✓	✓
Validating on submit	✓	✓
Instant validation	✓	✗
Conditionally disabling submit	✓	✗
Several inputs for one piece of data	✓	✗
Dynamically modify data (e.g., capitalize)	✓	✗
<input type="file" />	✗	✓

The ”con” for controlled components is lots of callbacks because we need to implement onChange and other handlers to update value (triggering the re-render). But there are a lot of advantages that come from being able to act on the input state in the component logic.

In React, an <input type="file" /> is always an uncontrolled component because its value can only be set by a user, and not programmatically.

https://goshakkk.name/controlled-vs-uncontrolled-inputs-react/