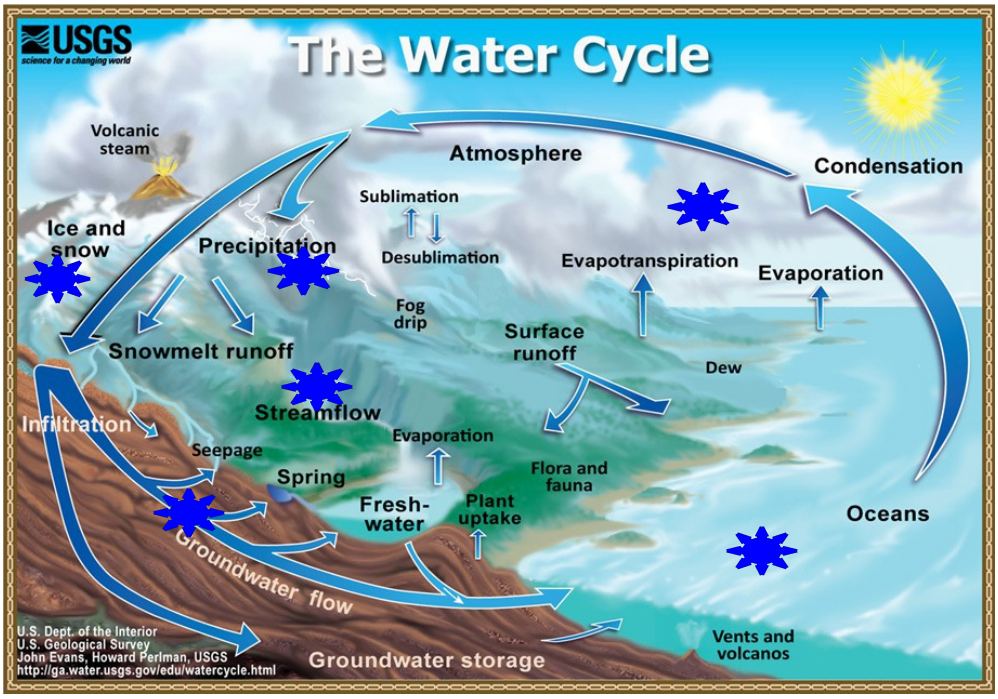
‘Tagging’ water molecules – to explore the water cycle
A thought experiment to investigate the water cycle

Scientists can ‘mark’ genes with different glowing colours to find out how they work, and so can produce mice that glow bright green. Meanwhile other scientists ‘tag’ moving organisms to find out where they go. Help your pupils to understand the water cycle by carrying out a thought experiment on what we would see if we could ‘tag’ water molecules to give them bright colours and make them visible.

Breathe onto a mirror or other piece of glass so that water droplets condense on the surface. Then tell your pupils that with your special ‘molecule tagging pen’ you can touch one of the molecules to make it glow bright blue – so you can watch what happens to it. Use your ‘special pen’ (any pen will do) to touch a water droplet – tell them it is glowing bright blue. Then ask them to make up stories of how this blue water molecule could move and change in the future.

These points will help.

- The molecule will disappear from the glass as the liquid water droplets become molecules of water vapour – they can ‘watch’ the blue molecule leaving the glass and floating around in the room.
- When you open the window, they would see the blue molecule escaping and floating up into the sky – from there it could do all sorts of things:
  - float up so high that it condenses again to form a cloud; more condensation would form rain drops and their blue molecule would fall in a raindrop; it might flow over the ground and into a nearby lake; there it might evaporate and start the cycle again.
  - … it could fall onto the soil, soak into the ground and be absorbed by the roots of a tree; you would ‘see’ it rising up the trunk to the leaves and then being released back into the atmosphere – by transpiration.
  - … it could flow from the pond into a river and then the sea; you could ‘see’ it floating around, moved by waves, tides and ocean currents; it might end up in polar regions and become frozen into ice, then break off into an iceberg with a blue spot, before melting, evaporating and moving on around the water cycle.
  - … it could sink into the ground and into the rocks beneath, and then be pumped up for our water supply; they could drink it and the blue molecule might shine through their skin until they lost it from their bodies in some way – and the journey continued.
- The ‘adventures’ of the bright blue shining molecule are constrained only by their imaginations.



From: http://ga.water.usgs.gov/edu/watercycleprint.html

The back up

Title: 'Tagging' water molecules – to explore the water cycle

Subtitle: A thought experiment to investigate the water cycle

Topic: An activity to help pupils to visualise the movement of water through the water cycle

Age range of pupils: 8-18 years

Time needed to complete activity: This depends upon how many times the activity is run with pupils.

Pupil learning outcomes: Pupils can:
- describe the movement of water through various parts of the water cycle;
- link the different elements of the water cycle together.

Context:
Pupils carry out a thought experiment to visualise the movement of an imaginary 'tagged' bright blue water molecule as it moves through various parts of the water cycle. Molecules can actually be 'tagged' and traced using radioactive isotopes, so the principle is used – if not the bright blue colour.

If pupils ask 'How long will it take?' – estimated average 'residence times' (the time that water molecules remain in that part of the water cycle) are given in the table below.

Element of water cycle	Estimated average residence time
Biosphere	1 week
Atmosphere	1-3 weeks
Rivers	2 weeks
Swamps	1-10 years
Lakes and reservoirs	10 years
Soil	2 weeks-1 year
Ice caps and glaciers	1000 years
Oceans and seas	4000 years
Groundwater	2 weeks-10,000 years
Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and UNESCO, Paris, 1999; Max Planck, Institute for Meteorology, Hamburg, 1994; Freeze, Allen, John, Cherry, 'Groundwater': Prentice-Hall, Englewood Cliffs, NJ, 1979.	

Following up the activity:
Ask pupils to 'visualise' what would happen if other atoms or molecules could be 'tagged' in bright colours and observed as they cycled around systems.

Underlying principles:
- Water molecules 'flow' around the water cycle in solid, liquid and vapour form through a wide range of processes.

Thinking skill development:
Visualising the movement of a water molecule through various elements of the water cycle involves creativity and imagination as well as the use of bridging skills to apply the water cycle diagram to reality.

Resource list:
- unlimited imagination

Useful links:
See the other Earthlearningidea 'watery' activities at:
http://www.earthlearningidea.com/home/Teaching_strategies.html

Source: Devised by Chris King of the Earthlearningidea Team.

The progression of thinking skills shown by the Earthlearningidea Water Cycle activities

Earthlearningidea	Strategies and skills developed
Changing state – transforming water: practical activities to change the state of water; solid, liquid, gas	Demonstrations of the change of state of water in a tactile way, enabling language skill development
Mini-world water cycle: a water cycle demonstration model in a box	Demonstration of key water cycle processes in a simple model, allowing bridging to the more abstract water cycle and the development of higher level thinking skills through discussion
Water cycle world: a discussion activity on the natural water transformations on Earth	Extended discussion about the different elements of the water cycle and the many different products of the cycle
'Tagging' water molecules – to explore the water cycle: a thought experiment to investigate the water cycle	A 'thought experiment' to encourage creativity and imagination in pupils in the context of the water cycle
Cycling water and heat in the lab – and the globe: demonstrating the water cycle, latent heat and global energy transfer	A lab demonstration of the water cycle, extended to promote higher level thinking skills and an understanding of the abstract process of latent heat transfer