Creating Science – Balance and the Australian Hopping Mouse

Few animals can manage to stand balanced on their back legs all day, but we take it for granted! So just how do we do it? *#CreatingScienceBalanceMouse*

Suggested outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity, and you may find cross curriculum links you can and should use.)

Science understanding

- Biological sciences 5: Living things have structural features and adaptations that help them to survive in their environment

Science inquiry skills

- Science Inquiry Skills, Planning and conducting F: Participate in guided investigations and make observations using the senses.
- Science Inquiry Skills, Questioning and predicting 4: With guidance, identify questions in familiar contexts that can be investigated scientifically and make predictions based on prior knowledge (ACSIS064)

Science as a human endeavour

- Science as a human endeavour 7, Use and influence of science: Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

Cross curricular outcomes

Health and physical education

- Contributing to healthy and active communities 4: Discuss and interpret health information and messages in the media and internet (ACPPS039) though exploring balance, ear and body health, and kinaesthetic movement with some fun science activities.

Science vocabulary words

Tier 1 (Everyday words) – Balance

Tier 3 (Specialised vocabulary)

- Equilibrioception – a technical name for our sense of balance.
- Proprioception – the technical name for knowing where your body is, and how it is shaped and how it is moving, without having to look at it.
- Tactile – the name for our sense of touch.

Warning

- Cutting and gluing required, please exercise appropriate caution.
- Also, don't let kids fight over coloured crayons, etc.

Preparation

- A ring of water, perhaps in a circular lid or bucket, with a float to help illustrate movement (such as a ping pong ball).
- Prepare the balance toys mentioned in the appendix. You'll need:
    - Thick card for printing on.
    - Scissors for cutting.
    - Pens or crayons for decorating.
    - Paperclips or coins (with sticky tape) for added weight.
    - Some good paper glue – small amounts required only.
- Several blocks of wood for balancing – each one smaller than the last.
- Various shapes for illustrating the centre of space (see section on centre of mass).

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students' questions can and should guide student learning, more material is presented for your convenience. Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

The activities of cutting and gluing can be challenging, please prepare appropriately for your group.

Children at this age can have difficulty with focus. Avoid tangents if you're attempting to make a key point.

Middle:

This activity is usually well suited to this group.

Teen:

Added challenge can be found in attempting to build the balance bird. Also, developing a model of the semicircular canals with their flowing fluids can present an enormous challenge.

Learning Intent (student friendly)

'We are learning to' (WALT) – appreciate our sense of Balance

Success criteria

'What I'm looking for' (WILF) – students who can understand stability by building a balancing bird or mouse, which has its centre of mass beneath its base.

Student learning goals

Help students make a self-monitored learning goal for this lesson, such as 'learn how we stay balanced', or 'make a self-balancing toy'.

Evidence of learning

How will you know when the learning goal is achieved? For example,

- Students built a balancing mouse or bird, and can explain why it works.

Engage

- ⇨ Make sure all students write down any questions they may have generated during this phase regarding the topic for today.
- ⇨ Play with marble runs and ask – why do the marbles roll?

Explore

- ⇨ Encourage and validate student explanations of this phenomenon. You may like to ask students to write or draw their explanation personally to avoid embarrassment to students unfamiliar with this material. Remember, 'I don't know' is a valid explanation in science – it is the beginning of learning new things!

Why marbles roll:

- Gravity pulls the marbles and the earth together, we know this.
- The run's slope and the shape of the marble helps.
- But why do things roll? Well…

Explain

Objects that are rolling are really just under a controlled fall.

Every physical object has two important, mathematical points.

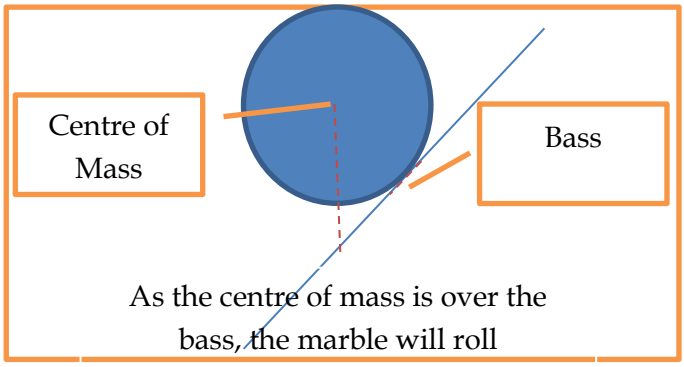
- A Centre of Mass – this is the mathematical point at the very centre of the object's weight.
    - It is the point which, if you spun the object wildly in the air, all the rest of the object would spin around it, and the centre of mass would stay still (or if you throw the object up into the air, the centre of mass follows a smooth, curved path). Try making a large letter c or o. When you spin it in the air it spins around the invisible middle part. Other letters, such as I or H, will spin around a middle part that still has part of the letter in there.
    - It is the balancing point of the object. If you can hold underneath the centre of mass, and keep it there, the object will not fall down.
- A base – the shape formed by the part of the object in contact with solid ground. If you're sitting on a chair, the base is the square made by the four legs acting as the corners. If you're standing up, it's the rectangle made by your feet at either end. If you're running or standing on one foot, your base is the footprint you make.

This leads us to two simple yet profound rules. When compared with the direction of gravity:

1. If your centre of mass is over your base, you are stable, and you will not fall over.
2. If your centre of mass goes over the edge of your base, you are unstable and will start to fall.

For example:

A marble will roll around until its centre of mass is over the base. As soon as you put it on a sloped surface the base moves to one side, and thus the marble will roll in the opposite direction.



Self-stabilising

Now for the third nifty rule:

3. If your centre of mass is UNDERNEATH your base, you will self-stabilise.

For example, see the balancing mouse or bird in the appendix.

So what are some ways lower your centre of mass till it is beneath your base? Any attempt to lower your centre of mass will also help you to be more stable.

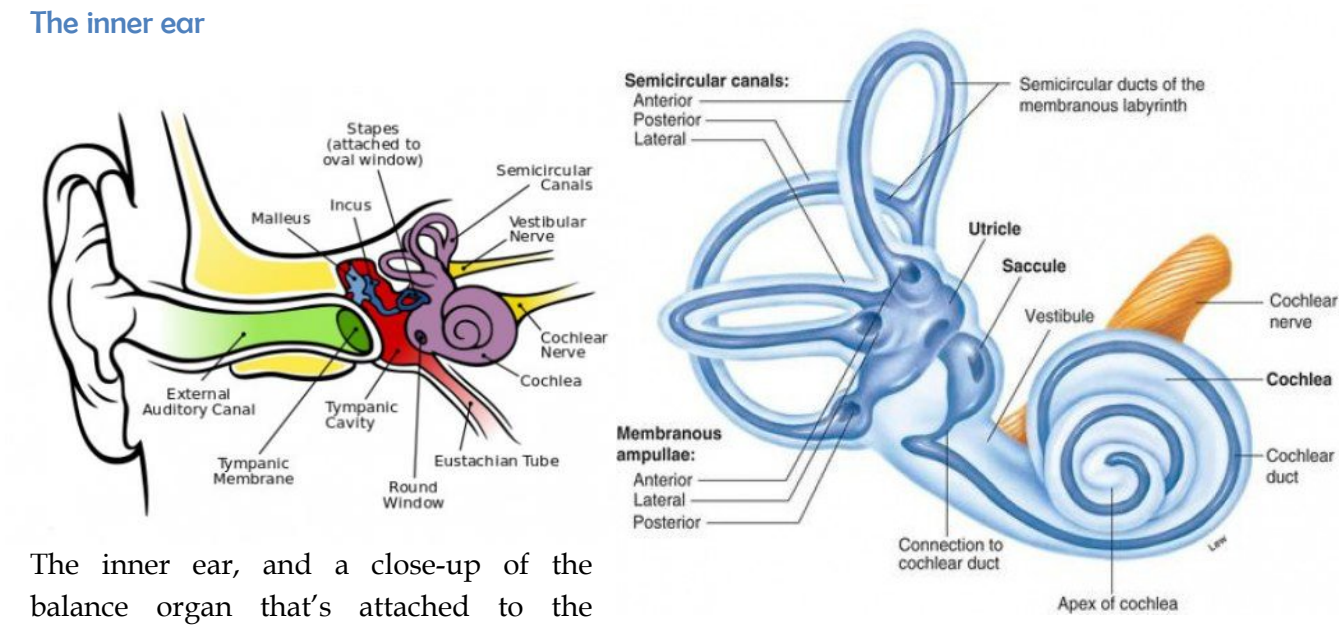
- Crouch down lower, towards the base.
- Hold onto something heavy, the lower the better, if you can lower it to beneath your base, even better!

Our sense of balance

Balance (AKA, "equilibrioception") is made up of:

- The movement of liquids in the semicircular canals, utricle and saccule which are attached to the inner ear, but do not help with hearing.
- Touch, the feel of the floor on our feet, for instance.
- Proprioception (which senses the relative location of the rest of the body to the head) but it's an INTERNAL sense so it's not included in this discussion.
- Vision, most often the line of the horizon to tell us which way is up.

The inner ear



The inner ear, and a close-up of the balance organ that's attached to the hearing of our body (in blue).

How do the semicircular canals detect signals?

The semicircular canals are filled with a fluid called *endolymph*. Each one of the semicircular canals has an enlarged cuplike structure called the *cupula*. The cupula has tiny cells with long strands running form them, known as *hair cells*.

Whenever your head moves, the fluid in the canals moves too. When the fluid in the canals moves, the hair cells move in the direction of the fluid and generate signals that detect the changes in the position of the body.

How does the vestibule detect signals?

The *vestibule* connects the semicircular canals to the cochlea. The *utricle* and the *saccule* inside the vestibule are lined by hair cells that help to detect linear acceleration or movement of the body in a straight line.

The utricle and saccule are covered by a jelly-like layer that has tiny calcium crystals. When the head tilts or changes in position with respect to gravity, the calcium crystals are displaced, and this displacement makes the hair cells bend and detect signals regarding the changes in the position of the body.

The signals that are detected by the hair cells of both the semicircular canals and the vestibule are changed into nerve impulses and sent to the brain through the vestibular nerve. The brain coordinates all three signals from the inner ear, visual system and skeletal system to maintain balance and equilibrium of the body.

Adapted 1 June 2017 from https://owlcation.com/stem/How-does-the-ear-help-to-balance-the-body

- ⇨ Do you think balance is part of our hearing? Or our sense of touch? Or is it a completely difference sense altogether?

Stability

Sometimes we simply can't lower our centre of mass to underneath our base. In these cases, we need stay stable. What are some tricks to increasing our stability? Most people try to do these activities automatically when presented with a problem of balance.

- Again, get down lower.
- Fling your arms out to the sides will move your centre of mass around, helping you to keep it over your base.
- Have a larger base. Stepping out sideways increases our base.
- Move forwards. With practice, it can be easier to keep our balance when moving than when sitting still. Riding a bike is a really good example of this.

Stability activity

Try keeping your balance on a smaller base than usual, such as a small block of wood. Then get an even smaller block of wood and try that. What tricks do you use to help stay upright?

Elaborate

- ⇨ Ask students if they can design new ways to test this explanation, is it really sufficient? Can they think of further or better explanations, and the experiments needed to test them?

Equilibrioception illusion

This one is easy! One of the oldest bodily illusions available – but take care you don't overdo it!

- ⇨ Spin around in a circle until you are dizzy.

Why it works:

Acclimatisation is at work again! In order to keep you functioning while spinning around, your body compensates. Once you stop spinning, this compensation is still running, making you feel like you are still spinning around when you are not!

MYTH BUSTING: Some folks think the fluid in your inner ears is still spinning, and that's what makes you dizzy – **not entirely so**, it's an acclimatisation issue, not momentum. Just as your eyes stop seeing if you stare long enough, and your nose acclimatises to a strange smell after a while, so your sense of balance can acclimatise to a constantly enough stimulus.

Evaluate

- ⇨ Review with students what they felt they learnt from this lesson. Did they have any questions at the start that they feel were answered?

Success criteria

- ⇨ Review the Learning Intentions of this lesson with students. Was it met?

At the end of each class, review the learning objective and see how we did. Ask:

- Did you achieve your learning goal?
- What might you do better next time?
- (If needed) where can you go for extra help or information?

Assessment

Prior learning:

Try to get students to balance a difficult item, such as a bottle or cup. Ask them what stability is, and how things are able to stay balanced.

Be sure to watch out for the following common alternative conception, that balance is a bodily function rather than a sense in the true sense of the word:

Formative:

As students are learning, help them self-monitor their own learning and achievements.

Summative:

Help students consider ways they can communicate their new understanding to others, just as scientists need to do. Can they teach another student the tricks to:

- Staying balanced?
- Why marbles roll?
- How to become self-stabilising?
- What part of our body detects our balance?

So what?

Balance is made up of:

- Touch.
- Proprioception (which senses the relative location of the rest of the body to the head) but it's an INTERNAL sense so it's not included in this discussion.
- Vision.

In keeping balance:

- Things fall over when their centre of mass is **no longer over** their base.
- And they're self-stabilising when their centre of mass is **below** their base.

And when we explore the physical structures which help us stay balanced, we saw that;

- Biological sciences 5: Living things have structural features and adaptations that help them to survive in their environment – as we explored our sense of balance.

Balance is fun! Also, knowing how to keep our balance can help to keep us safe.

Creating science

Science understanding

As we learnt about our sense of balance, in humans and in other species, we learnt that;

- Biological sciences 5: Living things have structural features and adaptations that help them to survive in their environment

Science inquiry skills

As we built a balancing toy, and found ways to explain the science within, we had the chance to;

- Science Inquiry Skills, Planning and conducting F: Participate in guided investigations and make observations using the senses
- Science Inquiry Skills, Questioning and predicting 4: With guidance, identify questions in familiar contexts that can be investigated scientifically and make predictions based on prior knowledge (ACSIS064)

Science as a human endeavour

As we learnt about keeping upright, we had the chance to;

- Science as a human endeavour 7, Use and influence of science: Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

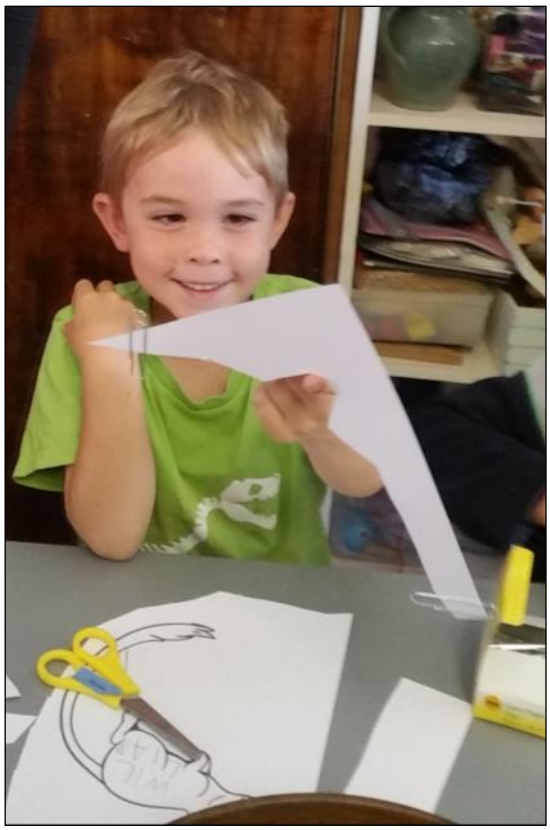
Cross curricular outcomes

Health and physical education

Learning about how balance helps us to stay healthy, and upright, we could;

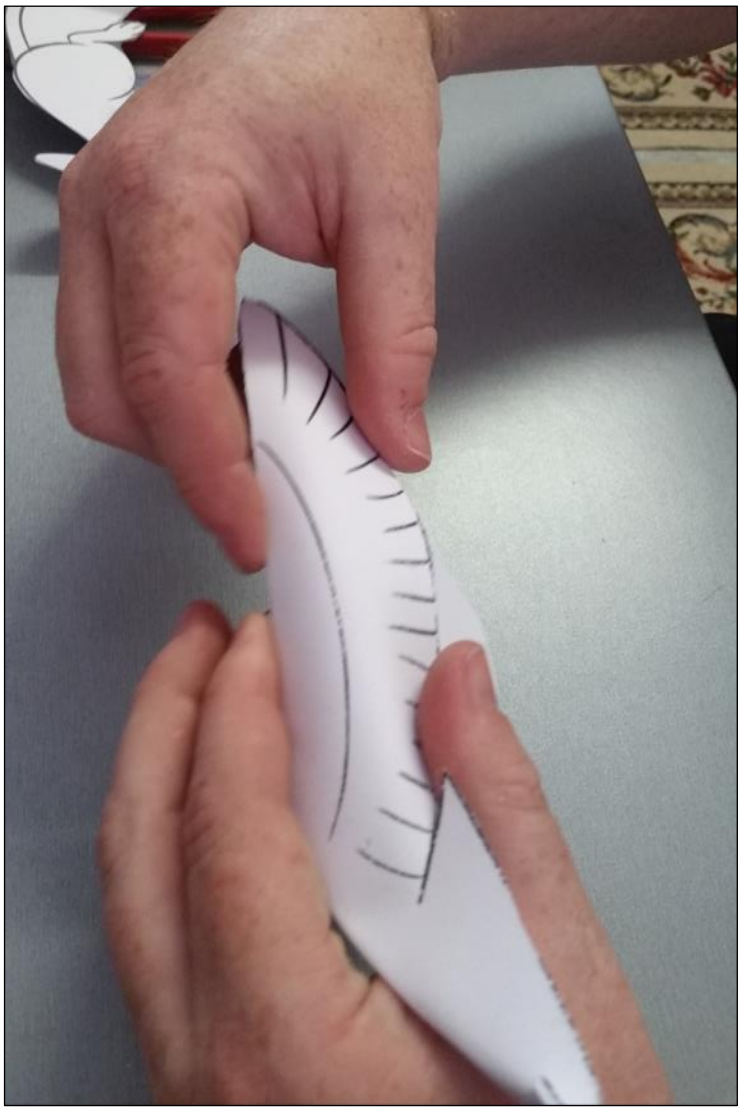
- Contributing to healthy and active communities 4: Discuss and interpret health information and messages in the media and internet (ACPPS039) though exploring balance, ear and body health, and kinaesthetic movement with some fun science activities.

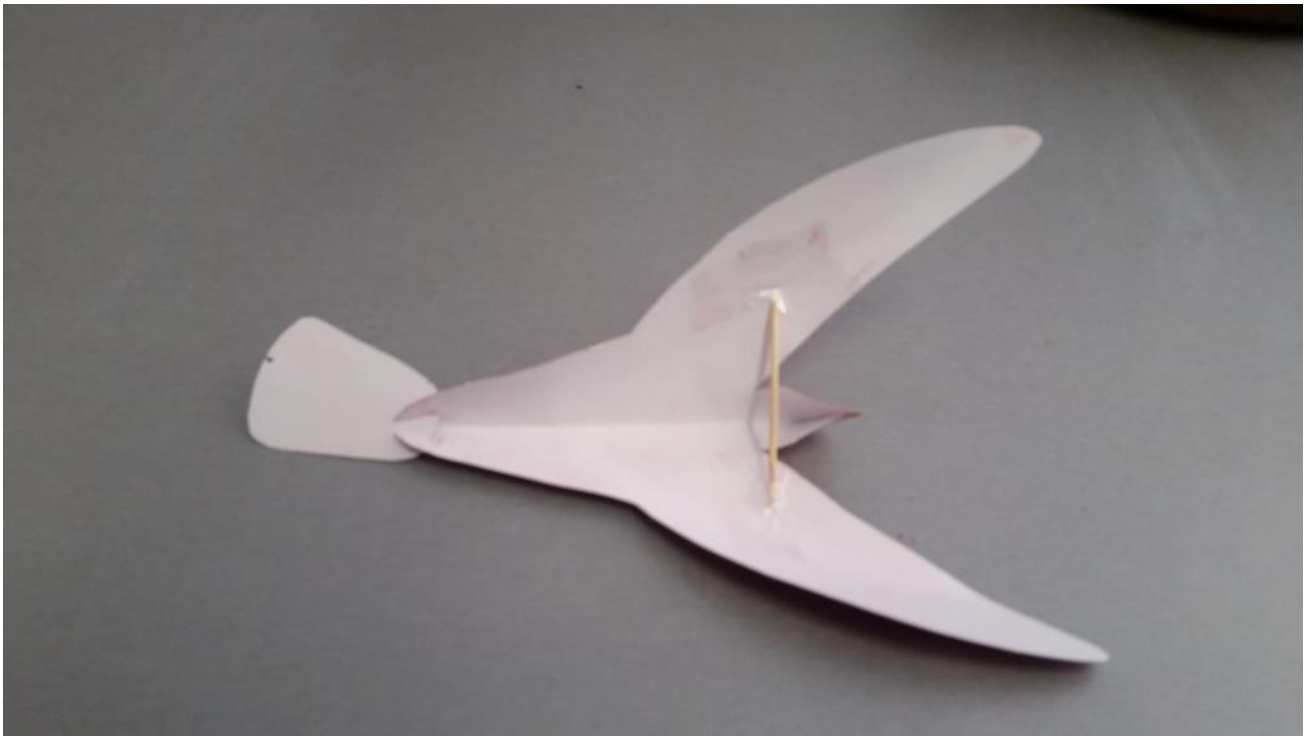
Tips from the masters



Balancing birds are quite fussy! Be sure to bend the wings for extra strength.

Even an unusual shape will balance quite nicely if the centre of mass is below the bass – note the heavy paper clips are used to lower the centre of mass.





Be sure to support the balancing bird with a toothpick.

Balancing birds – challenging, but a treat!

Appendix: The Hopping Mouse

Print on thick card, colour and cut out. Then place paper clips on the tail to make her balance.

Kindly made by Emily Joy Ireland, 2017

Appendix: Build your own balancing bird

This is a tricky activity that takes precision building, go gettum!

1. Print the image page over onto thick card (or normal paper and then glue it onto thick cardboard, but use glue sparingly or it will get all crinkly).
2. Colour in the image however you would like – though don't make it too heavy with extra decorations or heavy ink!
3. Cut out the bird and its tail – make sure you cut out the wings from the body exactly as drawn so that they can separate out. Be precise, it's important.
4. Fold the bird in half along its horizontal symmetry axis (i.e., longways, wingtip to wingtip). Exactly in half!
5. Put a little glue in the beak and eye area so that the bird's head can stick together. You can reinforce it with sticky tape if it bends too easily.
6. Gently put a small curve down in the wings. This helps to strengthen them.
7. Place a small toothpick in the bird's body between the wings (on the underside) to strengthen the wings, just like a toy kite has. Tape it in.
8. Slide in the tail piece and tape in carefully.
9. Temporarily stick a large paperclip to each wing. Move them around as necessary to help your bird stay balanced.
10. Your bird is ready to go – photograph, play, and share online!

Image credit to Emily Ireland, 2016.


The Balance Bird
Download your instructions from
www.CreatingScience.Org/activities
www.DrJoe.id.au