



St PAUL'S
CATHEDRAL

Schools & Families Department

Building the Building

The Science of St. Paul's

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Contents

| | |
|-------------------------------------|----|
| The History of St. Paul's Cathedral | 4 |
| Beginning at the bottom | 7 |
| What's it made of? | 9 |
| Holding up the Roof | 11 |
| Sounds Interesting | 13 |
| Questions | 14 |

The History of St. Paul's Cathedral

There has been a Cathedral dedicated to St. Paul in London since 604, when Mellitus, one of a group of monks sent from Canterbury, arrived in the city and built his new Cathedral. Although Restitutus had been the first bishop of London, his Roman cathedral had been abandoned and lost when the Romans left Britain, and Mellitus came as a missionary to a largely non-Christian community.

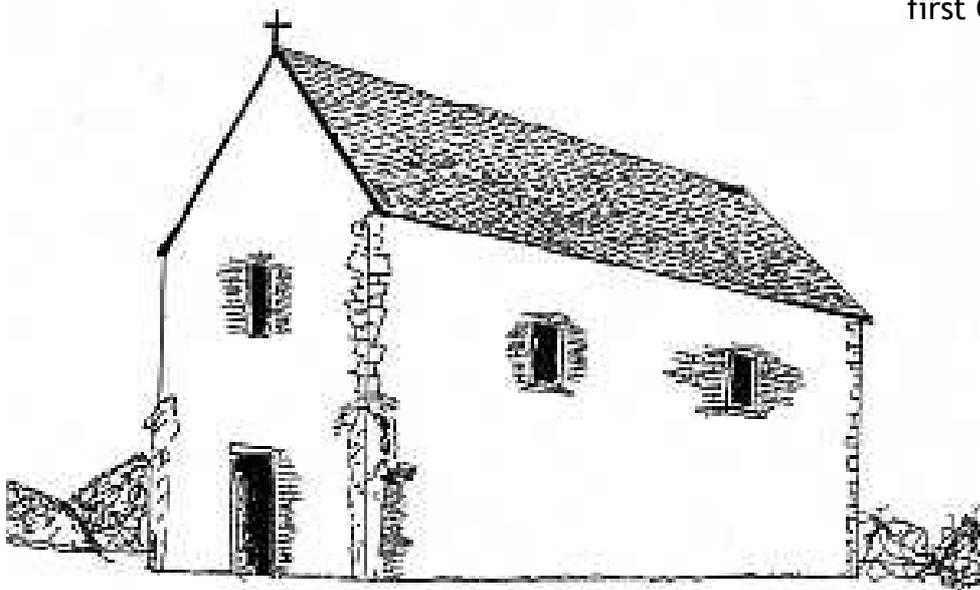
Although no one knows what the building looked like, it was likely to have been simple, made of stone and wood.

Erkenwald, Bishop of London, was made a saint on his death, and his shrine in the first St. Paul's became a place of pilgrimage for Christians from all over Europe.

Unfortunately, St. Paul's suffered the first of several fires in 675 and had to be rebuilt. It was destroyed again in 961, by the Danes who were in the process of attacking and invading England. Each time, however, St. Erkenwald's shrine was rescued and rebuilt.

The next Cathedral, rebuilt in the tenth century was made of stone. However, once again, it suffered in a large fire which swept through London in 1087.

Artist's impression of the first Cathedral



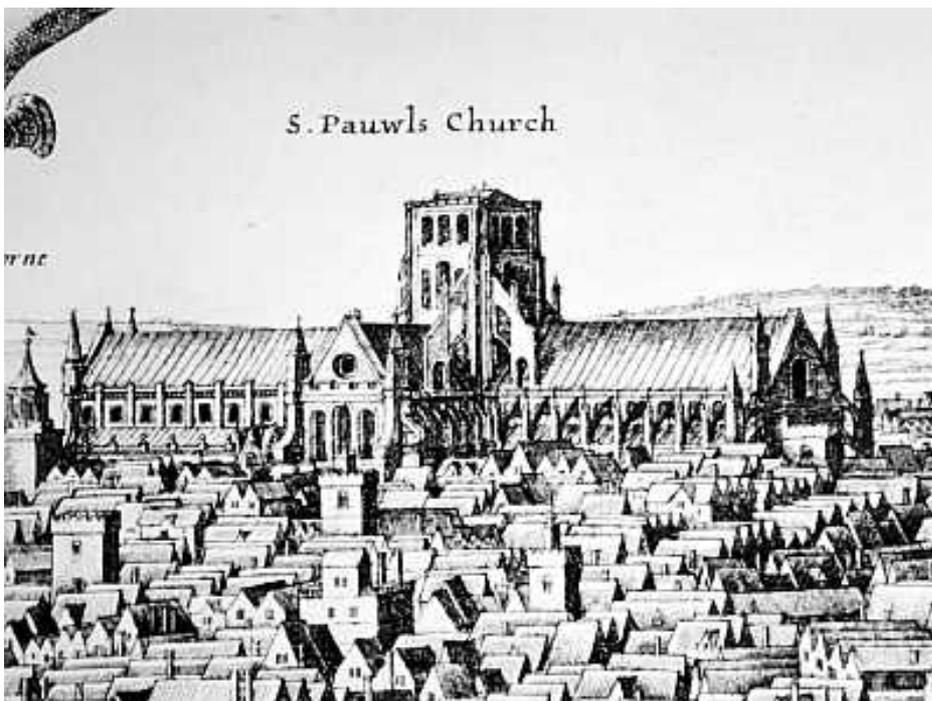
The Medieval Cathedral

The next building was designed by Maurice, chaplain to William the Conqueror. Over the next hundred years the Cathedral was made to be one of the largest and grandest buildings in Europe. It continued to expand until the mid fourteenth-century. On top was a magnificent spire and the building was even larger than the one you can see today.

Although the people of London were proud of their cathedral, they did not always treat it with the respect it deserved. It was a public building, paid for by the ordinary people and as a result never had much money for repairs. During the Reformation, St. Erkenwald's great shrine was taken apart and its gold and jewels taken by King Henry VIII. The great bells were cut down and gambled away by the King, before being sold as scrap metal.

During the reign of Queen Elizabeth I (1558-1603), the spire burnt down, but was not replaced as there was no money. By the end of the sixteenth century there were cracks in the masonry and the roof leaked.

Charles I asked the great royal surveyor, Inigo Jones, to do some repairs. But work stopped, yet again, when the Civil War broke out in. During this time, the Cathedral was used as a stable for 800 horses!



The Medieval Cathedral after the spire burnt down.

By the time Charles II was restored to the throne in 1660, the Cathedral was a wreck, and it was at this point that a young architect, Christopher Wren was consulted for his ideas. Wren's plans were impressive and new, but came to nothing on the night of Sunday 2nd September 1666.



The Great Fire

The Great Fire of London swept through the city from its starting point in a bakery on Pudding Lane. The Cathedral, with its lead roof patched up with wooden boards, caught fire on the Tuesday night. The lead melted and ran in rivers down Ludgate Hill. In total, the fire destroyed 13000 homes, and 85 churches. St. Paul's itself was so unsafe that it had to be knocked down.

Wren immediately began to plan a new London, with wide, straight streets and all centred on his brand new St. Paul's. Although the street plans were not adopted, Wren's designs for the Cathedral were.

The Cathedral today

The Cathedral today is a beautiful building, made from Portland stone, decorated with beautiful, glittering mosaics inside, and delicate baroque garlands and cherubs outside. Seating 2500 people it has been the site of many important national services. In 1981 it was chosen as the venue for the marriage of HRH Prince of Wales and Lady Diana Spencer. In 2000 it hosted Millennium services and in 2003 it was the place where the nation celebrated the Queen's Golden Jubilee.

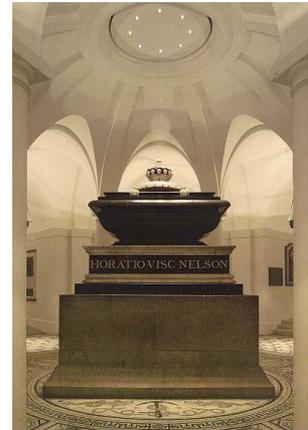
The Churchill Gates: one of the newest additions to the Cathedral. Sir Winston Churchill was Prime Minister during World War II.



Beginning at the bottom: Foundations and Gravity

The Crypt

Underneath the floor of the Cathedral is the Crypt. It contains the remains of hundreds of people who have died. Many are important figures from British history, such as Admiral Horatio Nelson, and Arthur, Duke of Wellington. Sir Christopher Wren himself is buried in the South East corner close to where the first stones were laid.



The Crypt was also vitally important for without Nelson's tomb in the Crypt it, Wren's whole design would have been useless.

When building any building it is important to have FOUNDATIONS.

(fig. 1)

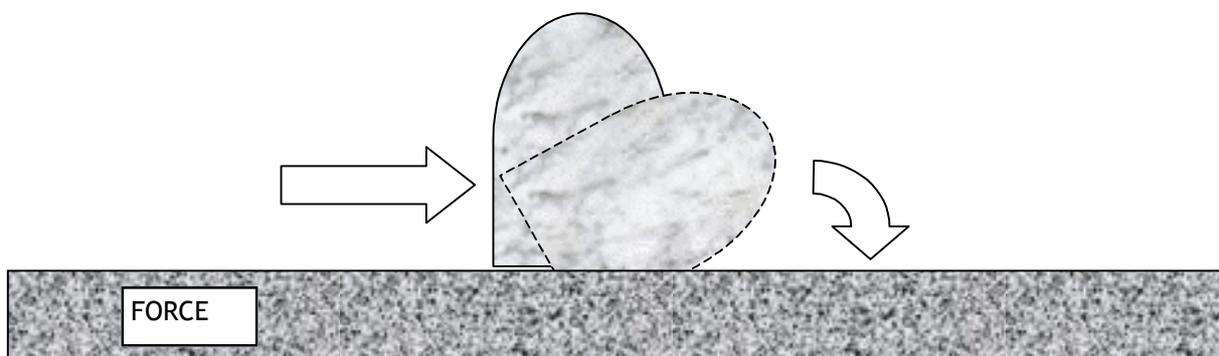
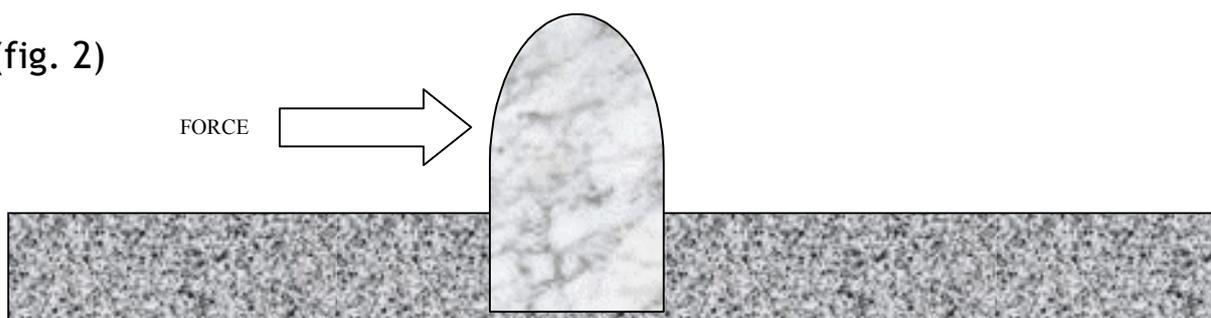


Fig. 1 shows a building without foundations. As soon as a force (perhaps a strong wind or buildings built up against it) is applied to the side, the structure would be unstable. It would probably topple down. Gravity is also always trying to pull it down.

(fig. 2)



The building in fig 2 has foundations which go deep into the ground. This makes it much more stable when a force is applied. It is much harder to topple the building and much harder for gravity to pull it down.

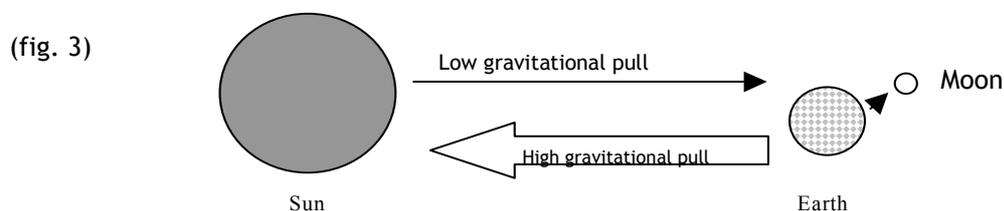
The larger the building, the deeper the foundations need to be to support it. The foundations stop the building from falling down!

At St. Paul's, it was also important that people could be buried in the Cathedral. It wasn't practical to continually dig up the floor, so the Crypt served as both foundations and a graveyard!

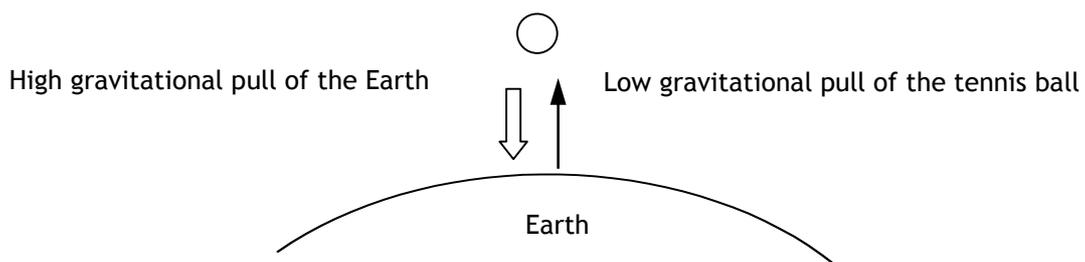
Nowadays, we don't bury bodies in the Crypt. Instead we accept the ashes of people who have been cremated.

Gravity

The force that makes things fall down is called GRAVITY. Whenever you get two objects near each other, they actually attract each other. The more massive the object, the stronger the force of attraction. In outer space, the Sun attracts the planets and as a result we orbit the Sun which is much more massive than Earth. (If the Earth was bigger than the Sun, then it would orbit us!). (fig 3)



Because the Earth is much bigger than a tennis ball, when we drop one, it looks as if the ball is falling down. This is the force of Gravity attracting the small ball to the massive earth. (If we had sensitive equipment we would actually find that the earth actually moves a little bit closer to the ball as it is dropped, too, but we only notice the big movement of the ball being attracted to the Earth).



What's it made of? Materials

The building materials

When Wren designed the building he thought about three things in his design:

1. Beauty - the building should look lovely
2. Stability - the building would have to be strong and stable
3. Usefulness - the building would have to be big enough to fit in lots of people to worship God.



- Imagine if St. Paul's had been made of flowers:

A Cathedral made from flowers would be very **beautiful** and very **useful**, but would not be **stable** and would blow down in the wind!



- Imagine if St. Paul' had been made of a block of concrete.

A solid block of concrete is **stable**. You could also decorate it to make it look **beautiful**, but it wouldn't be **useful** as you couldn't get inside it to worship God.



But there are also other things to consider when designing a building:

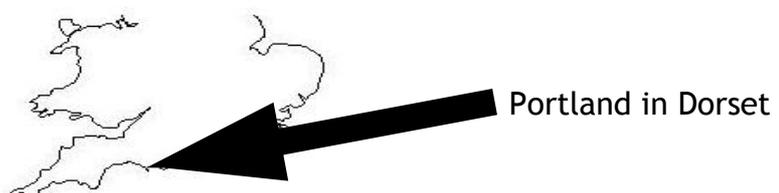
- Imagine if St. Paul's had been made of wood:

It could be carved to make it look **beautiful**. It would be quite **stable** and many buildings were made out of wood in Wren's time. It would be **useful** as you could get inside to worship God.

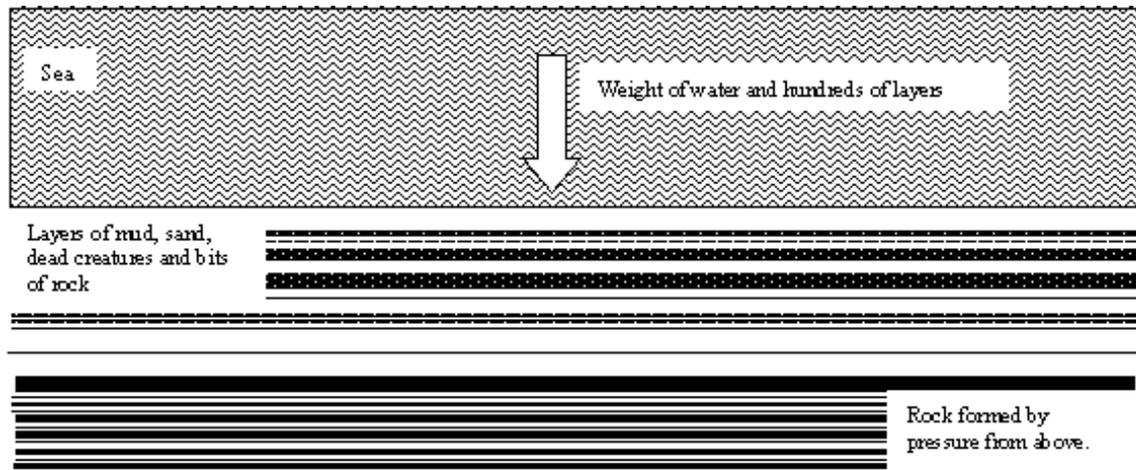
BUT

Wood burns and rots so it is not a very good building material if you want it to last for many hundreds of years. Think about what happened to the other St. Paul's Cathedrals! Wren chose to build the main structure of the Cathedral from stone. He used Portland Stone which is limestone from Portland in Dorset.

(fig 4)



Portland limestone is pale white in colour. It is a **Sedimentary rock**. This means it was formed when layers of old eroded rocks and dead organisms were laid down at the bottom of a river or sea. Over millions of years they were squashed solid and became rocks. (fig 5)



Portland stone was very good to use inside the Cathedral because it is so light in colour. However, the level of pollution in London over the centuries has meant that the stone got very dirty. We have just spent millions of pounds cleaning the outside and inside of St. Paul's Cathedral!



Different methods were used to clean the stone, but the main way was to spray a kind of latex 'face pack' on to the stone. This drew out all the dirt and pollution deep inside the stone. When it was peeled off, the dirt came with it, leaving the Portland stone a lovely creamy-white colour.

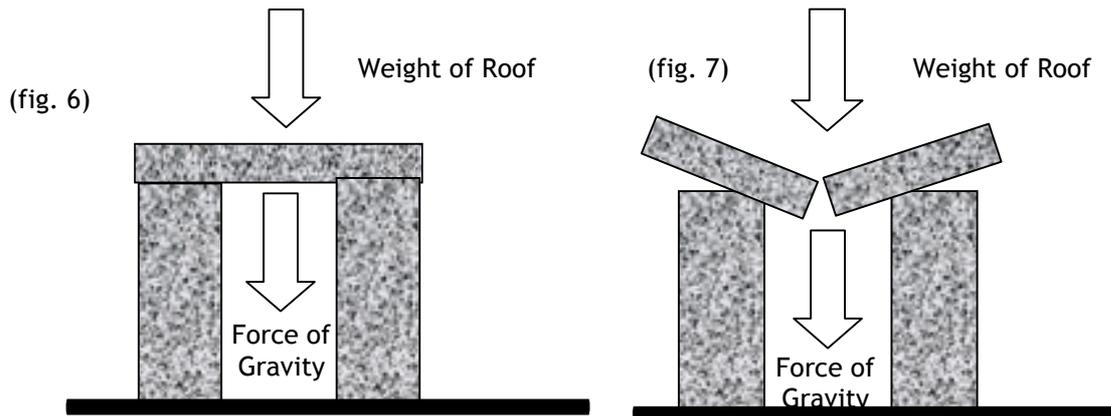
When the Cathedral was built, London was even more dirty than it is today as people had coal and wood fires which sent lots of smoke and soot into the air. Until the roof was put on, the inside of the Cathedral was open to all this pollution. Christopher Wren himself would never have seen the Cathedral looking as clean as it does today!

Portland stone is very expensive and the whole Cathedral cost over £700,000 in Wren's time. Today that would be about £50 million! To pay for it and the rebuilding of the City of London after the Great Fire, the coal brought into London by the merchants was taxed. It took 35 years to build St. Paul's, partly because it was always running out of money!

Holding up the Roof

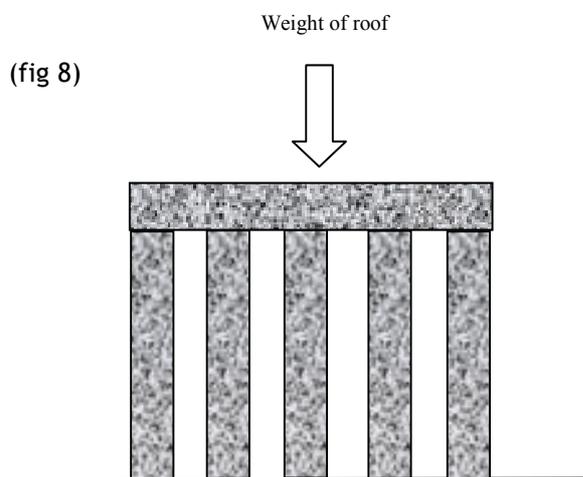
Building an Arch

If you look at the structure of St. Paul's you cannot help but notice the number of arches it has, from down in the Crypt to up in the Dome! Architects like Wren have always been fascinated by arches as they are beautiful, mathematically interesting and able to support great weights.



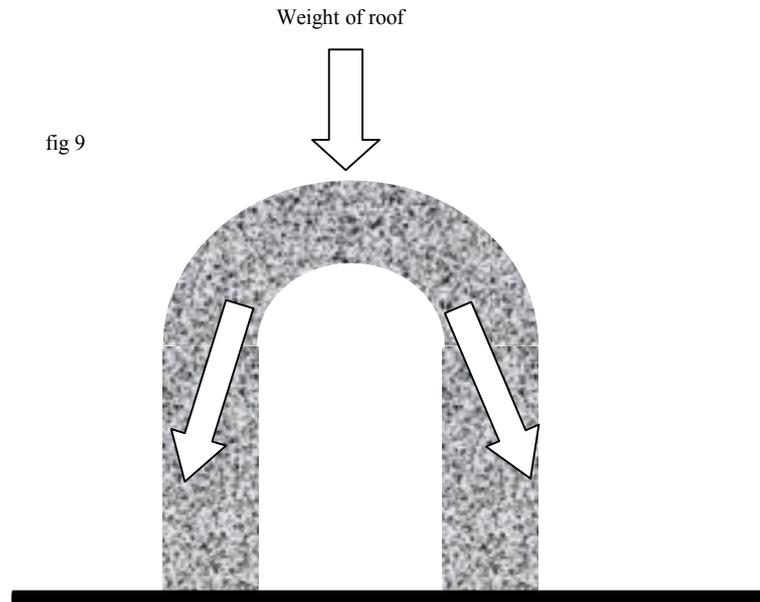
In fig.6, a doorway has been created by putting a flat stone lintel across the top. The arrows represent the forces acting on the stone lintel. The weight of the roof above the lintel would cause the lintel to crack and the roof to collapse (fig 7).

One way to solve this problem is to put the pillars closer together. This means that more of the lintel is supported and it is less likely to crack. (fig 8)



The problem with this, of course, is that there wouldn't be room for any people to go through the door!

However, if instead of a stone lintel, an arch is used, the weight of the roof is more evenly distributed and the roof remains supported.



Wren believed that certain shapes were more beautiful than others and used these a lot in his designs. He thought that straight lines and semi-circles were particularly beautiful and used them throughout the Cathedral.

Wren used the rounded Romanesque arch rather than the pointed Gothic or Saracen arch which had been part of Old St. Paul's. The simple shape was more beautiful to Wren's eye.

The Great Model

When you consider the strength of an arch, it is easier to understand why Wren was so keen on having a Dome on the Cathedral. A Dome is actually a series of arches. Even his earliest plans for the restoration of Old St. Paul's before the Great Fire, show that he was keen to replace the central tower and spire with a small dome.



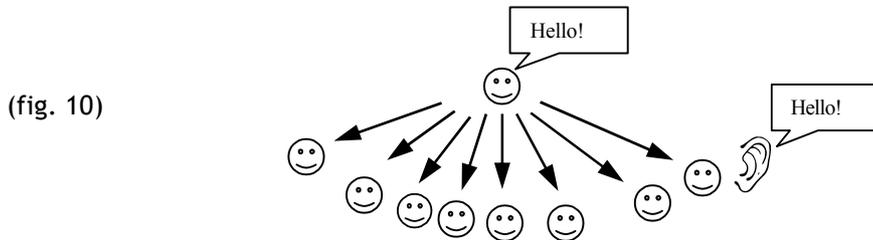
The Great Model shows Wren's preferred design. Having the model made was very expensive. It cost about the same as a London house in Wren's time!

The design was rejected, partly because the Nave was not considered long enough for grand processions!

Sounds Interesting! The Whispering Gallery

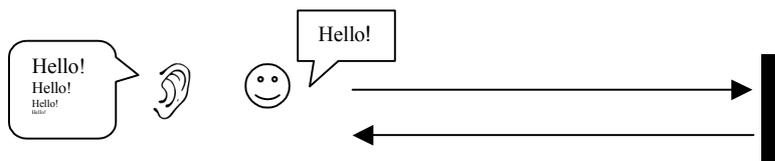
Echoes

When you speak, your voice goes out in all directions. If there is someone nearby, they will hear the words you said. (fig 10).



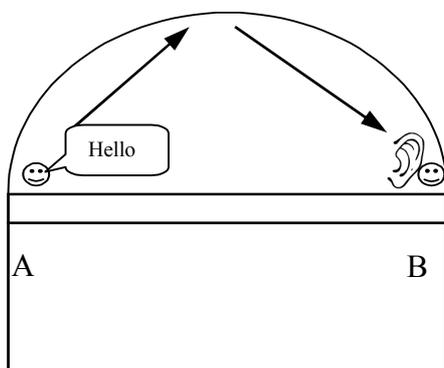
When you go into some spaces with shiny or hard surfaces (like a cave) , the sound of your voice bounces back to your own ears, and we call this an echo.

(fig. 11)



Sometimes this happens several times and we hear our voices reflected back, getting fainter and fainter.

One of the unexpected bonuses of the Dome is the Whispering Gallery. When it was completed, it was discovered that this gallery, running around the inside of the Dome had amazing echo properties. This was a result of the angles of the Dome.



When person A speaks on the Whispering Gallery, the sound travels all around. Some travels up into the Dome and is reflected back down. This means that person B can hear what A has said, even if they have spoken really quietly!

Questions

The History of St. Paul's

1. How many years ago was the first St. Paul's Cathedral built in London?
2. How many different St. Paul's Cathedrals have been built in London?
3. What happened to the Shrine of St. Erkenwald?
4. True or false? St. Paul's Cathedral was burnt down in the Great Fire of London.
5. Why was Sir Christopher Wren's first cathedral design rejected?

Beginning at the bottom.

1. Explain why it is important for a building to have deep foundations.
2. What is gravity?
3. True or false? The moon stays going around in the Earth because it is held there by Earth's gravity.

Materials

1. Explain why Sir Christopher Wren did not use the following materials to build the Cathedral. Make sure you think about Beauty, Stability, and Usefulness.
a) Gold b) Cotton Wool c) Plastic
2. Why was Portland Stone a good choice as a building material?
3. Building St. Paul's was completed in 1710 and took 35 years. When was the building started?

Holding up the roof

1. Explain why Sir Christopher Wren used arches to support the weight of the roof of St. Paul's
2. What reason did Wren give for using rounded arches rather than pointed ones?

Sounds Interesting

1. Explain why we sometimes hear echoes.
2. How does the Whispering Gallery at St. Paul's get its name?

