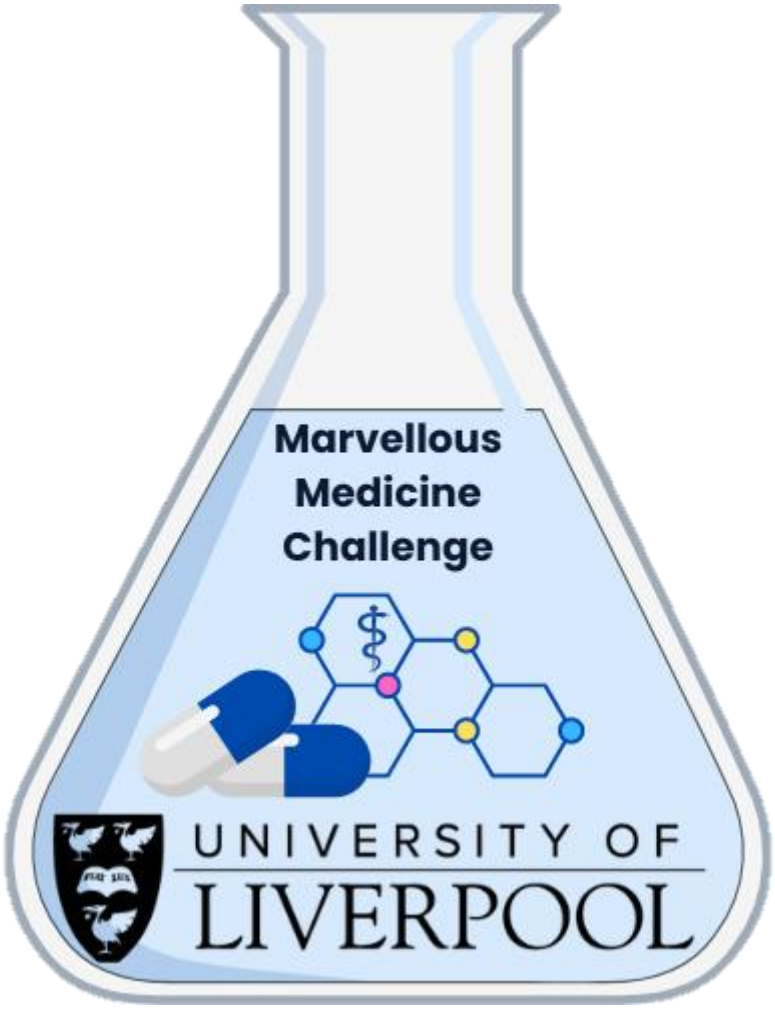
Marvellous Medicine Badge



Pharmacology and Therapeutics
The University of Liverpool

5-10 years old

Table of Contents: 5-10 years old

 **Experiment**  **Paper based**  **Game**  **Craft**

 **Demonstration**

The Marvellous Medicine Challenge

Hi my name is Professor PaT and I will help to guide you through our marvellous medicine challenge badge.

To complete the challenge badge you must complete at least one activity per section

We would love for you to share your activities with us, or you'd just like to say hi. You can find us on Bluesky @@drlaurarandle.bsky.social and @livuniengagehls.bsky.social or on Instagram @livunipharma. Don't forget to tag us #MarvellousMedicineBadge.

Thanks to 5th Widnes girl guides, 16th Widnes Rainbows, and Cronton CE primary school for being our wonderful badge testers!

Important Safety Message

What is Pharmacology??

Firstly, it has nothing to do with farms or farmers! Pharmacology is the study of how medicines and other substances interact with our bodies. It helps scientists and doctors understand how drugs work, how they can treat illnesses, and what side effects they might cause.
Pharmacology looks at how drugs affect different organs in our body, how they are absorbed into our blood stream, and how the body breaks them down for removal. This knowledge is key to developing new medicines and making sure they are safe and effective for people to use.

Modern medicine is improving our health and wellbeing by fighting infections, managing everyday illnesses, and helping to prevent the spread of diseases worldwide, all of which contribute to extending our lifespans.

What is the difference between a pharmacologist and a pharmacist?
Pharmacologists and a pharmacist both work with medicines but have different roles.

A **pharmacologist** is a scientist who studies how drugs work in the body, researching how medicines interact with biological systems to develop new treatments and improve existing ones. They focus on drug discovery, testing, and understanding the effects of drugs at a scientific level.

A **pharmacist** is a healthcare professional who dispenses medicines to patients and provides advice on how to use them safely. They work in pharmacies or hospitals, ensuring that people receive the right medications and understand how to take them properly.

What do pharmacologists do?

- **D**iscover new medicines to help treat diseases.
- **R**esearch their unwanted side effects and effectiveness to improve medicine safety.
- **U**nderstand why people have different responses to medicines, and why some work better for some people than others.
- **G**ain an understanding of why some drugs cause addiction.

Professor PaT

Welcome to Pharmacology & Therapeutics

Pharmacology and Therapeutics at the University of Liverpool is world leading Department, with a reputation for excellence in teaching, research and innovation. In 2017, we were awarded a prestigious Queen's Anniversary Prize in recognition of our work to improve the safety and effectiveness of medicines. We offer undergraduate (BSc.), post graduate taught (MSc.) and research based (MRes. and PhD) degree programmes. Our research strengths

include personalised medicine, antimicrobial resistance, drug safety and long-acting therapies with the priority of developing new medicines for the benefit of patients.

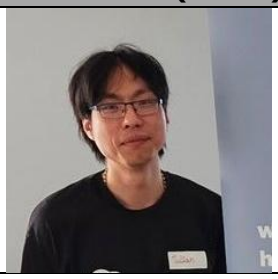
Scan the QR codes below to visit:

1. Our research labs
2. A lecture theatre

You can also visit:
https://www.liverpool.ac.uk/virtual-tour/
https://bit.ly/UoLivPharmacology

SCAN ME

Meet the Marvellous Medicine Team

Laura Randle	**Owen McGreevy**	**Tsun Ho Chan (Julian)**	**Amy Chadwick**
			
Role: Senior lecturer	*Role*: PhD student	*Role*: Post doctoral researcher	*Role*: lecturer
Research: making new medicine for liver cancer and understanding how some medicines can damage our liver.	Research: Owen looks at improving our understand of liver cancer and which medicines will work best for treatment.	Research: Julians works helps us to understand the genetic basis for drug toxicity and side effects.	Research: understanding how drugs can injure our mitochondria. The power stations in each cell of the body
Danae Jessel	**Rebecca Jensen**	**Carol Jolley**	**Parveen Sharma**
			
Role: PhD student	Role: Post doctoral researcher	Role: Core Technical Staff	Role: Senior lecturer
Research: Danae explores how we can use our immune cells to fight liver cancer.	Research: Becky's research explores how genetic differences can alter drug safety.	Research: Carol has worked on better understanding adverse drug reactions.	Research: making new medicines for the heart.

What do we know about medicines?

To introduces the session and the badge it is a good idea to begin by asking the young people what they know about medicines. Ask your trainee pharmacologist the following questions…

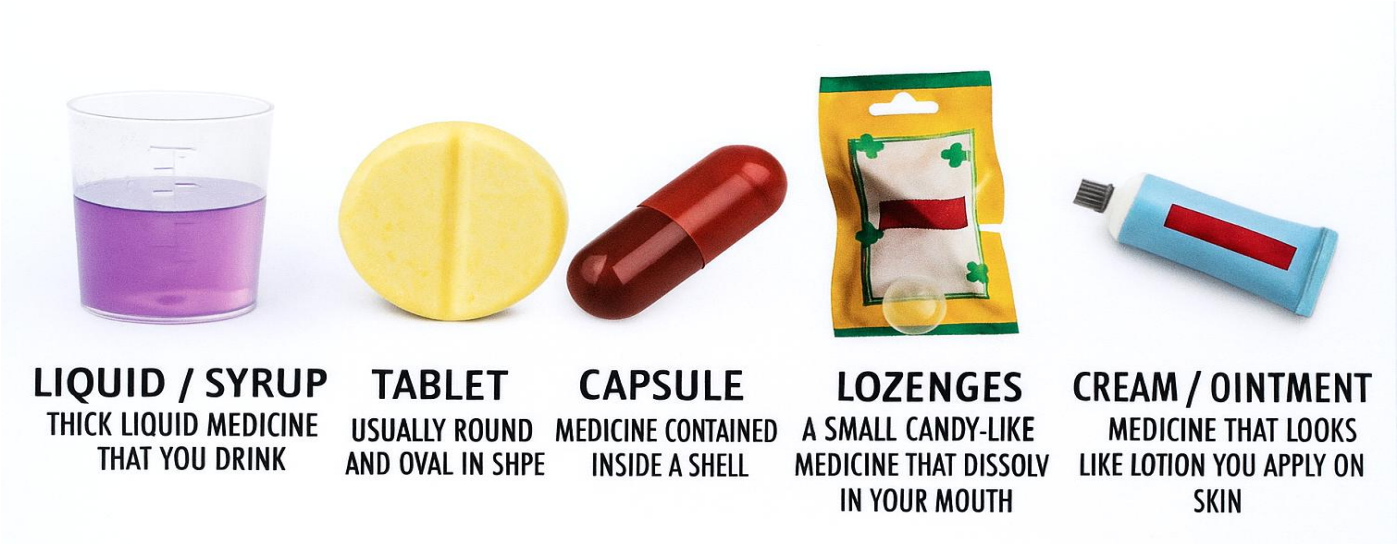
Question 1: When do we take medicines?
Possible answer: when we feel poorly / sick

Photo: horizontal photo unknown hand pouring liquid into spoon from little bottle with syrup person caring about child lying bed with flu.jpg https://www.freepick.com/author/user18526052

Question 2: What different types of medicines are there?
Possible answer:

Illness	**Type of medicine**	**Example – Trade name (active medicine)**
An ear infection	Antibiotic	Amoxicillin (amoxicillin)
Pain or a high temperature	Pain relief	Calpol (paracetamol) Nurofen (ibuprofen)
A cough	Cough syrup	Benylin (guaifenesin) Tixylix (glyecerol)
Hayfever or animal allergy	Anti-histamine	Piriton (cetirizine) Calrityn (Loratidine)
Snotty nose	decongestant	Sudafed (pseudoephedrine hydrochloride)
Tummy bug	Oral rehydration solution	Dioralyte (glucose and electrolytes)

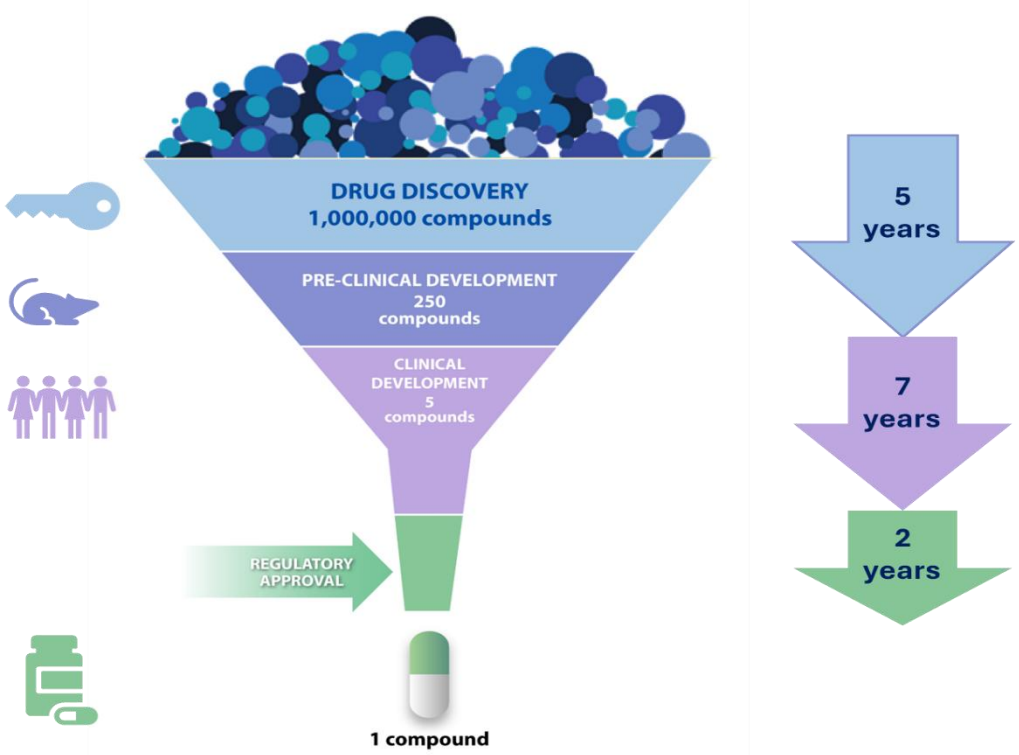
Question 3: What different forms of medicine are there?
Possible answer:



Professor PaT Colouring

Drug Discovery and Development Maze

The drug discovery and development process is a step-by-step journey to turn an idea for a new medicine into a product that can help people. It takes a team of scientists usually around 15 years and up to £1.5 billion to take a medicine from an initial idea to being approved as a treatment. It starts with more than 20'000 potential substances that might treat a disease, which are tested in the lab in models and on animals to check if they're safe and effective which reduces this number to only a few candidate compounds. If a substance looks promising, it moves on to clinical trials, where it's tested on people in different phases to figure out the right dose and ensure it works safely. Only one candidate medicine will make it through all these stages to get approved and sold. This process takes a lot of time, effort, and money.



Aim: Can you figure out which medicine will make it to market and be given to patients.

Materials:

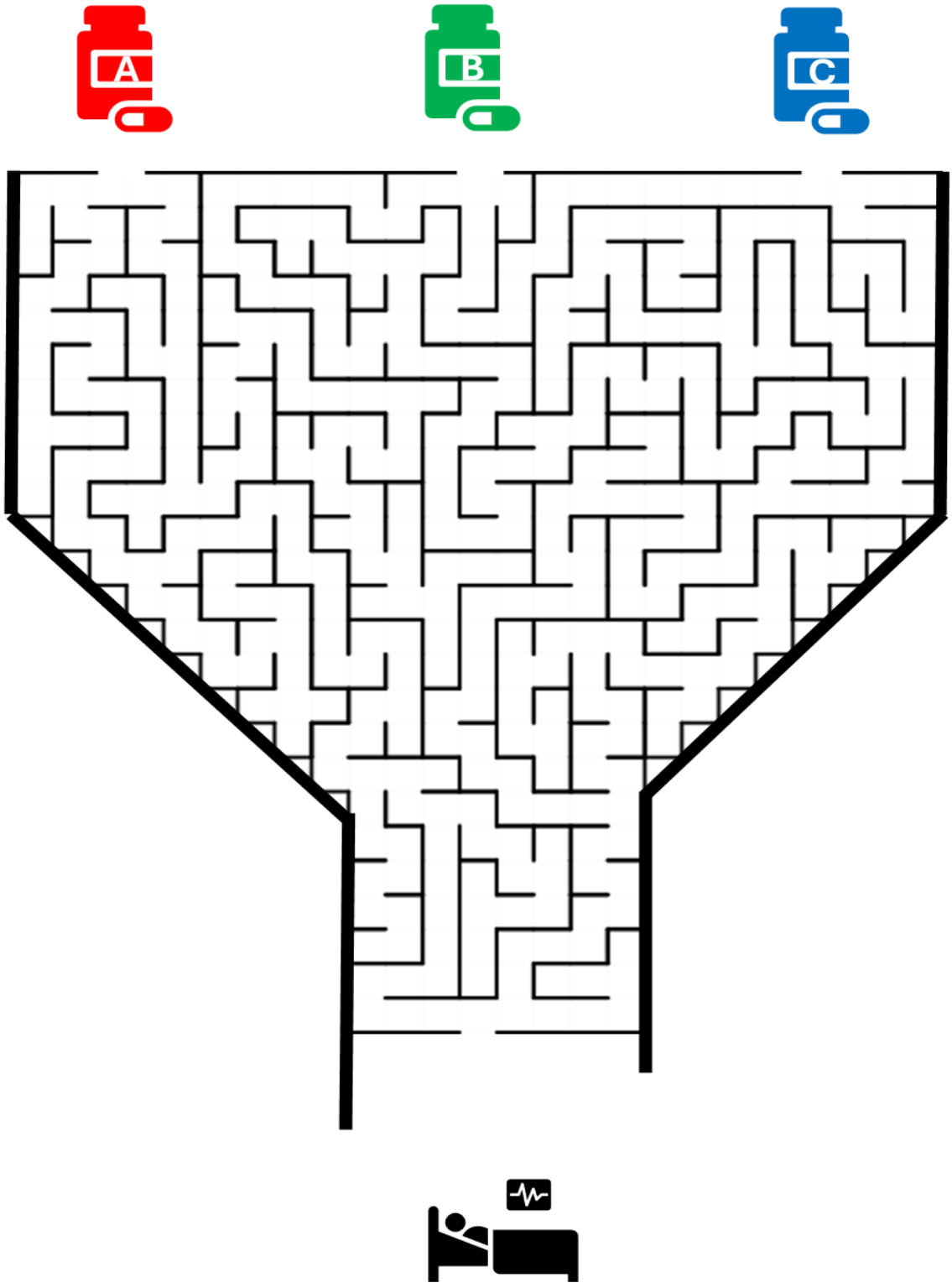
- Print out the maze (page 20)
- Pen / pencil

What to do:

1. Begin at the top of the maze by choosing a potential medicine A, B or C.
2. Trace your way through the maze until you reach the patient at the bottom. Try different paths to see if they lead you closer to the patient at the finish. If you hit a dead end, go back to where the path splits and try a different route.
3. Keep trying until you successfully find your way out of the maze!

Drug discovery and development Maze

Which medicine will make it to market and be given to patients?



Accept or reject - Pharma snake and ladders

This game is based on the original board game: Snakes and Ladders. However, we are going to use this to demonstrate the full process of drug development, from the drug design stages to the drug being given to patients as part of their treatment. At each stage, the new drug or "medicine" will either be approved/accepted or rejected/ withdrawn depending on the results
from that stage.

What do participants need to take part:

- Dice
- Board game counters
- Printed board game

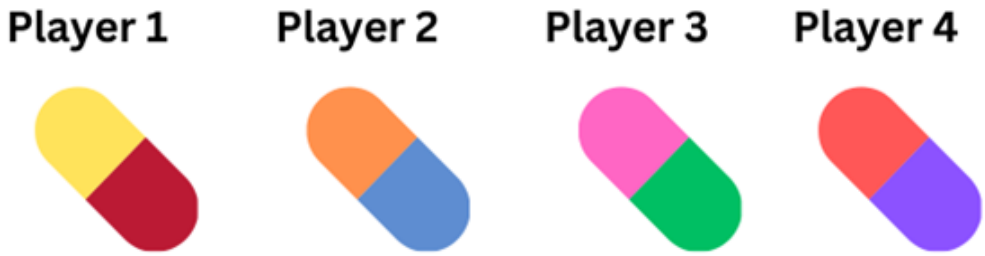
How to play the game of Approve or Reject

- Place your counter on the starting point.
- Roll the dice to see how many places you can move from the starting point.
- If you hit a strand of DNA, then your drug has been accepted to move onto the next stage of development and can climb up to where it takes you.

- If you hit a pipette, then your drug has been rejected and you need to move backwards to where the droplet lands.

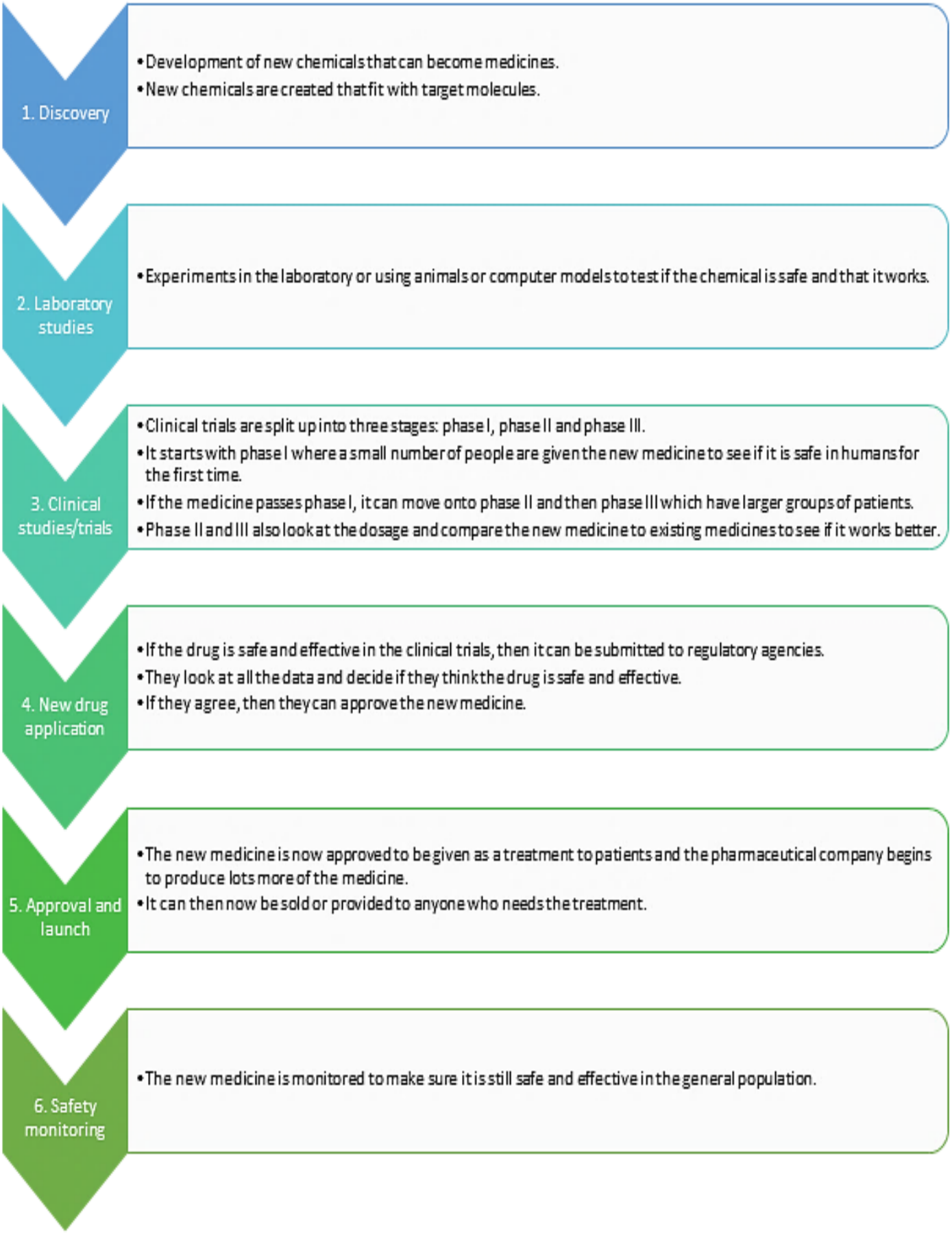
Player counters:

- Either print the pill shaped counters below or use small objects you have to hand to mark your position on the board.




FINISH
40
WINNER!
39
38
Removed from the market after reports of major side effects
36
31
32
No side effects reported after medicine is put onto market
34
35
30
Medicine is not as effective as other medicine on the market
28
Side effects in patients during a clinical trial
Approved by the government to give to patients
Approved as safe after given to patients in clinical trial
22
23
24
Toxicity seen in laboratory and animal testing
20
19
18
Medicine doesn't work good enough to treat the patients
16
11
Medicine is safer than other medicines already available
Chemical doesn't react with target for treatment
14
15
10
Approved as safe in laboratory and animal testing
8
7
1
START
2
3
4
Chemical selected from a group of multiple chemicals

An overview of how we discover and develop new medicines



Famous Medicine Makers Jigsaws

Aim: To learn about some famous pharmacologist and how they have helped to make some new medicines.

What to do:

1. Print and laminate the photos.
2. Cut along the jigsaw piece lines.
3. Mix up the piece and get your trainee pharmacologists to complete the jigsaw. You could try running this as a relay race!
4. Share the names and interesting facts about the people they reveal

Tu Youyou

1. **Discovered a life-saving medicine** – Tu Youyou found a special medicine called *artemisinin* from a plant. It helps cure malaria, a sickness caused by mosquito bites.
2. **Helped save millions of lives** – Her discovery has helped sick people all over the world get better, especially children in Africa and Asia.
3. **Inspired by nature** – She studied old Chinese medicine books and plants to find new ways to heal people.
4. **First Chinese woman to win a Nobel Prize in Medicine** – In 2015, she won the Nobel Prize, one of the most important awards in the world, for her discovery
5. **Chief Scientist -** Youyou became the chief scientist of the China Academy of Chinese Medical Sciences in 2023.

Tu Youyou | Biography, Malaria, Nobel Prize, & Facts | Britannica

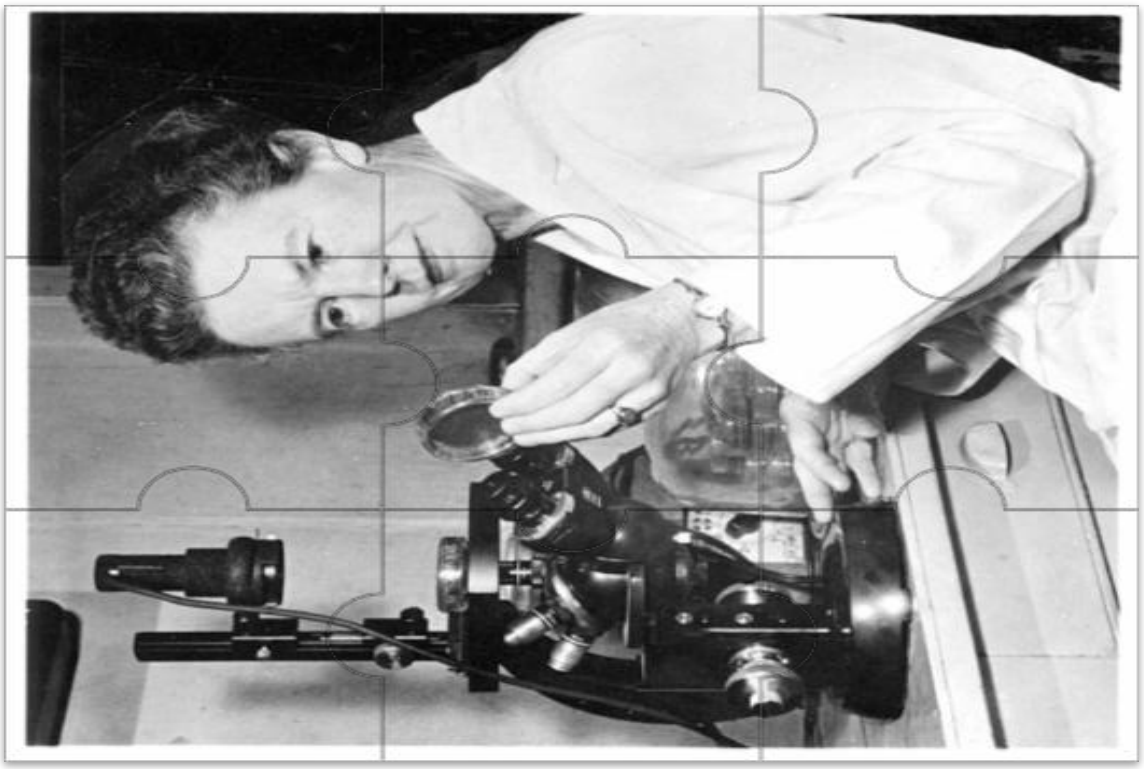
Sir Prof. Munir Pirmohamed

1. **Leader in Pharmacogenetics**: Professor Munir Pirmohamed studies how our **genes** affect how we respond to medicines. Since 2007, he has worked at the University of Liverpool to help make medicines safer and more personal for each person.
2. **Long Career in Medicine and Teaching**: He studied medicine at Liverpool University and became an expert in pharmacology (the study of how medicines work). He has worked as a doctor and led special centers focused on drug safety and personal medicine.
3. **Making Medicines Safer**: Munir's research helps doctors understand how **genetic testing** can help them choose the best medicine for each person. This helps reduce side effects and makes medicines safer and more effective.
4. **Helping Improve Healthcare in the UK**: He has helped advise the UK government on how to make medicines safer. He helps doctors use genetic testing to make better decisions for patients.
5. **Awards and Recognition**: Professor Pirmohamed has written over 600 research papers and is known around the world as an expert in his field. In 2015, he was knighted (which means he got a special honor from the Queen) for his work in medicine, and he has received many other important awards.

Professor Sir Munir Pirmohamed announced as Chair of the Commission on Human Medicines - News - University of Liverpool

Dr Hattie Alexander

1. **Pioneering Paediatrician and Microbiologist:** Hattie was a doctor who worked with sick children and studied how to treat infections. She worked at a hospital where she became very important in researching bacterial infections.
2. **Developed Treatment for Meningitis**: She created the first treatment for **Haemophilus influenzae** (Hib) meningitis, a dangerous disease that affected children. Her treatment helped save many lives by lowering the death rate from almost 100% to less than 25%.
3. **Pioneer in Antibiotic Resistance Research**: Hattie was one of the first people to study **antibiotic resistance**. She discovered that some bacteria could change and become stronger against medicine, which helped scientists understand how to fight these stronger bacteria.
4. **Trailblazer for Women in Medicine**: Hattie was the first woman to become president of the **American Paediatric Society** in 1964. She helped open doors for more women to become doctors and scientists.
5. **Legacy of Excellence and Recognition**: Throughout her life, Hattie won many awards for her work, including the **E. Mead Johnson Award** in 1942 and the **Elizabeth Blackwell Award** in 1956. Even after she passed away, her work continues to help doctors treat infections in children.



Archive | Notable People of Goucher College

Dr Gertude Elion

1. **Nobel Prize-Winning Scientist**: Gertrude Elion won the **Nobel Prize** in 1988 for her amazing work in creating new medicines. She changed how drugs are made by focusing on the disease itself, instead of just trying different medicines until something worked.
2. **Pioneered Life-Saving Drugs**: Gertrude helped create some important medicines:
   - **AZT**, the first medicine for **HIV/AIDS**,
   - **Azathioprine**, the first medicine to help people who get **organ transplants**,
   - **Acyclovir**, the first medicine for **herpes**.
3. **Overcame Gender Bias in Science**: Even though many people didn't think women should be scientists, Gertrude didn't give up. She kept working hard, and later joined a company where she made some of her biggest discoveries.
4. **Innovator in Drug Design**: Gertrude worked with another scientist, **George Hitchings**, to come up with a new way to design medicines that work better for specific diseases, like **leukemia**, **malaria**, and **lupus**.
5. **Mentor and Advocate for Women in Science**: After she retired, Gertrude still helped teach and guide students. She worked to inspire more women to become scientists and never stopped working to make new medicines.

Gertrude B. Elion - Wikipedia
Deed - Attribution 4.0 International - Creative Commons

Dr Alexander Flemming

1. **Discoverer of Penicillin**: Alexander Fleming is famous for discovering **penicillin**, the first antibiotic, which has saved millions of lives by treating infections.
2. **Accidental Discovery**: He discovered penicillin by accident in 1928 when he noticed that a mold called **Penicillium** killed bacteria in a petri dish.
3. **Helped Stop Infections**: Before penicillin, many people died from simple infections. Penicillin helped doctors treat these infections and saved countless lives.
4. **Worked in a Hospital**: Fleming was a doctor and a scientist. He worked at **St. Mary's Hospital** in London, where he made his important discovery.
5. **Won a Nobel Prize**: In 1945, Fleming received the **Nobel Prize** in Medicine for his discovery of penicillin, which changed medicine forever.

SYNTHETIC PRODUCTION OF PENICILLIN | Imperial War Museums (iwm.org.uk)

Professor B. Kevin Park

1. **Leader in Drug Safety**: Kevin worked for almost 50 years to make medicines safer for people. His research helped doctors and scientists figure out how to make medicines that work better and are safer for everyone.
2. **Leader at Liverpool University**: Kevin helped make the Pharmacology Department at Liverpool University one of the best in the world. He worked there from 1999 to 2021 and helped the department win a special Queens Prize award in 2018.
3. **Innovative Research**: Kevin did important research to help scientists better understand how medicines work in the body. He helped make a new, safer medicine for malaria and improved how doctors test for dangerous side effects of medicines.
4. **Great Teacher and Mentor**: Kevin helped 135 students earn their PhD and always had an open door for them. He taught them how to be strong and confident in science, inspiring many of them to follow in his footsteps.
5. **Awards and Lasting Impact**: Kevin received several important awards for his work and continues to influence the world of science through his students. Many of his students now lead important projects in science and medicine.

Obituary: Professor Kevin Park - News - University of Liverpool

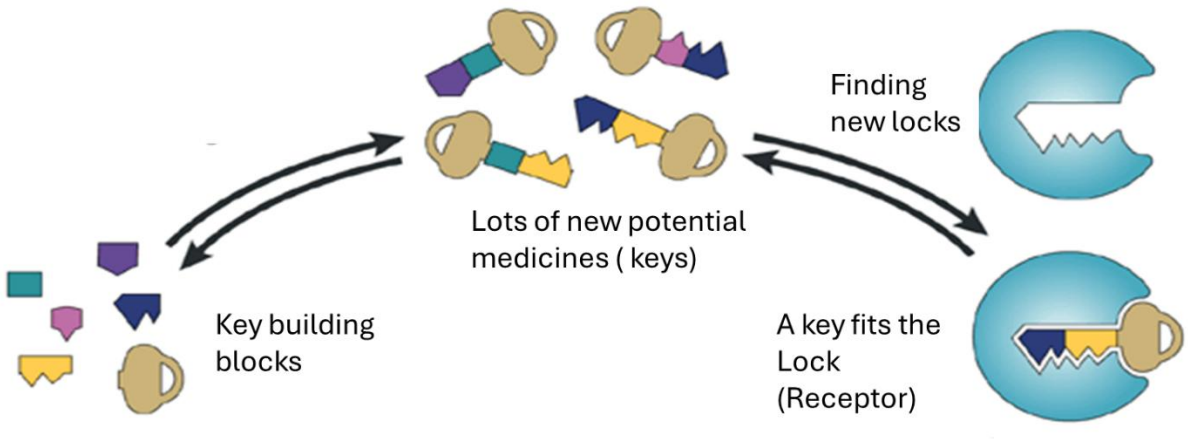
Discovering New Targets and Designing New Medicines

When scientists create new medicines, one of the first steps is figuring out what in the body the medicine should act on. These are called drug targets. A drug target might be a protein, a gene, or even a tiny switch inside cells that plays an important role in how a disease develops.
The idea is simple: if we can find the right target, we can design a medicine to change how it behaves — for example, blocking it if it's causing harm, or boosting it if it's not working well enough.

Lego Drug receptors

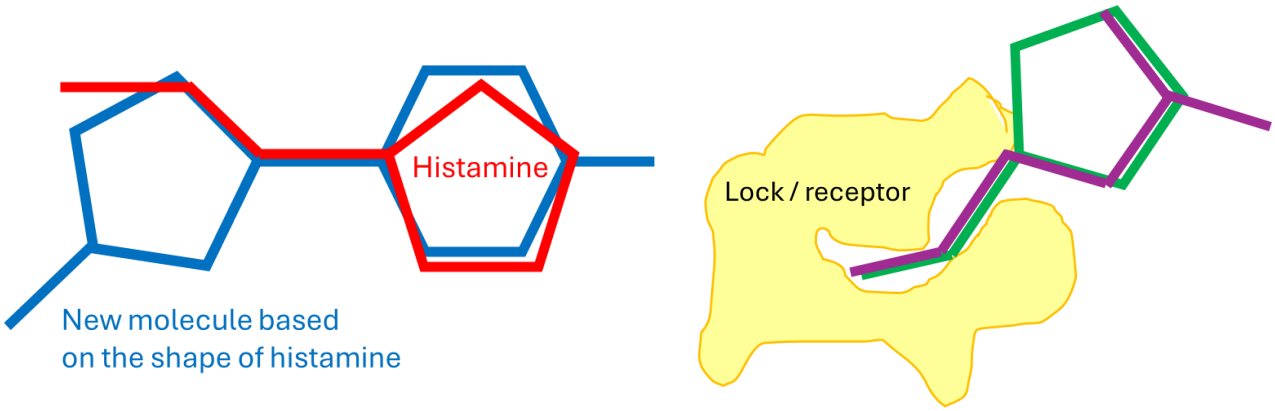
Designing new medicines is like designing a key to fit a lock.

Scientists have to make and test lots of keys to find the one that fits the locks.



Adapted from https://doi.org/10.1038/nrd704

Sometimes it is easier to change an existing medicine for example making new hayfever medicines. Histamine (key) can enter the histamine receptor (lock) which in turn can make you sneeze and your eyes run. The potential new medicines (blue, green and purple) are designed to stop the histamine (red) from accessing the lock (receptor) as they have similar shape. The new medicines (key) fits in the lock and stop you from sneezing.



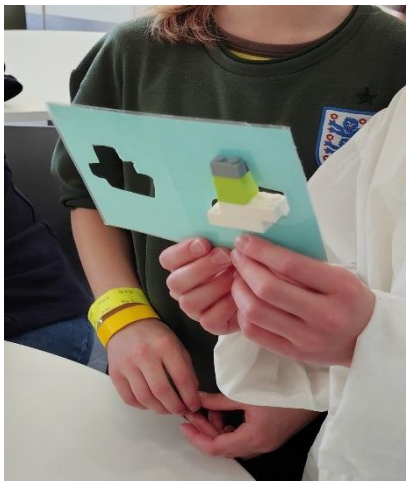
Aim: To understand that the same building blocks can make very different shapes (keys). Through trial and error you will find a shape that will fit the lock.

Materials:

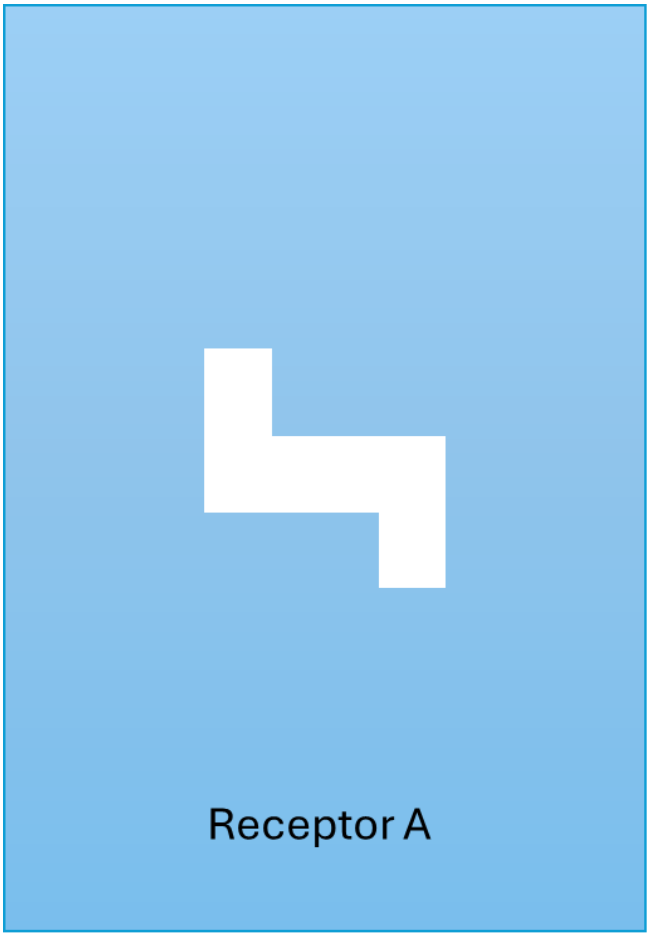
- Lego building brick
- Receptor / Lock template (page 23)

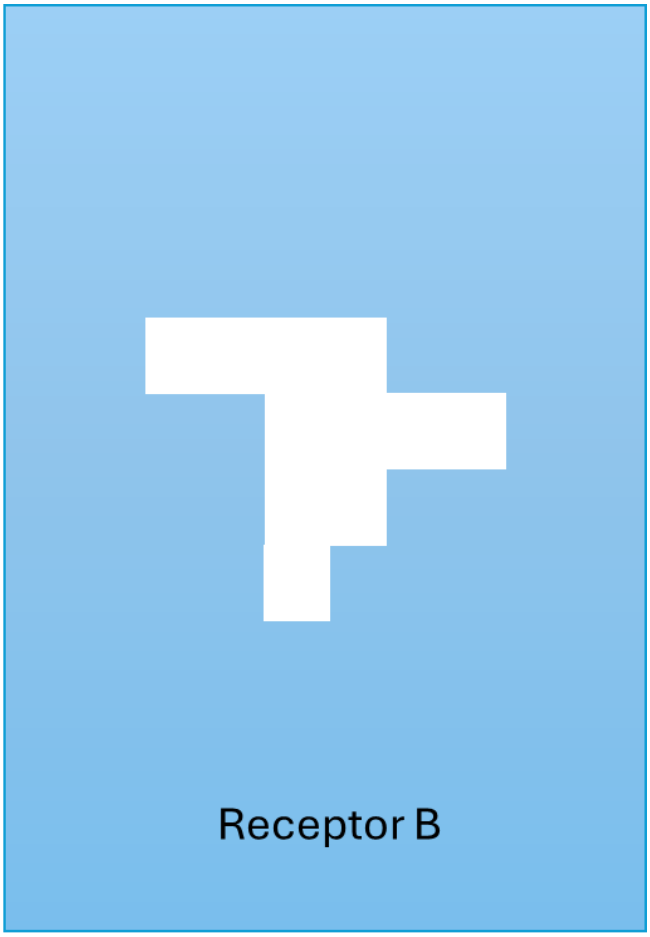
What to do:

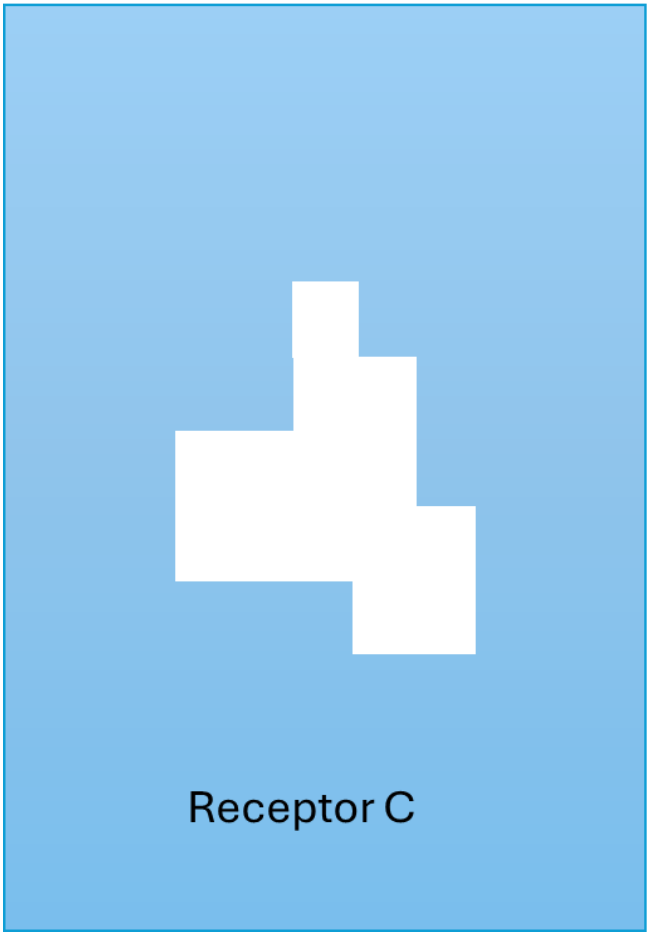
1. Choose 8 lego building bricks. You must use at least:
   a. 2 x 8 brick
   b. 2 x 4 brick
   c. 1 x 2 brick
   d. 3 x 1 brick
2. Combine your bricks together to make a new medicine.
3. Does your medicine fit in the lock?

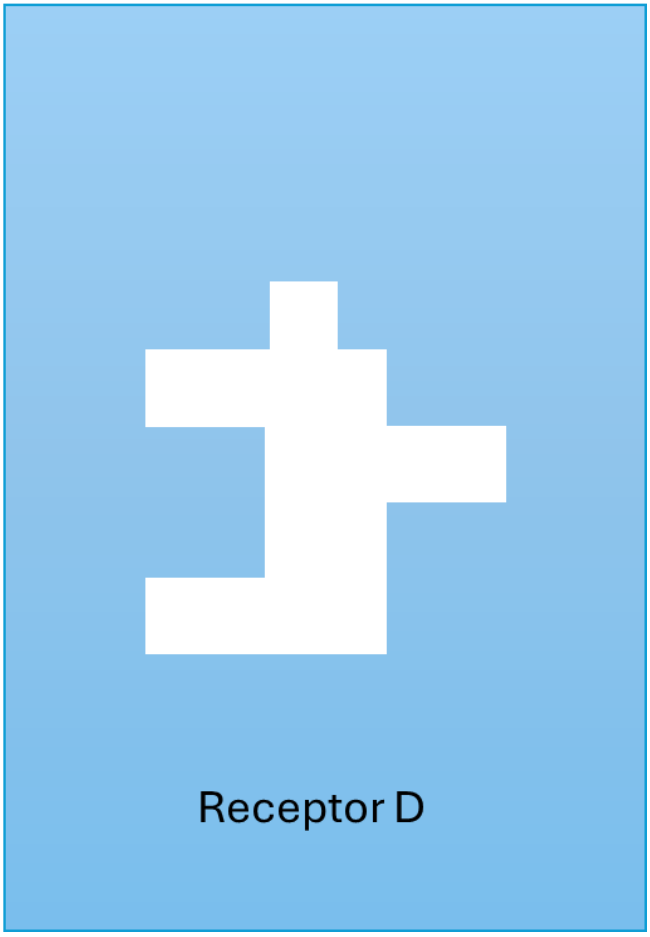


Receptor / Lock Template - print, laminate and cut out white template









Medicinal Plant Top Trumps

Many of the medicines we use today trace their origins back to plants. For thousands of years, people have relied on leaves, roots, seeds, and bark as natural remedies for illnesses. Even in modern times, scientists study plants to discover and develop new drugs, since they produce powerful chemical compounds that can fight infections, ease pain, or treat chronic conditions. Common examples include aspirin, originally derived from willow bark, and morphine, which comes from the opium poppy. This shows how closely human health is connected to the natural world and highlights the importance of plants in medicine.

Aim:
To learn that some medicines come from plants. Each medicinal plant card includes the name of the drug, source plant name and photo, the chemical structure, molecular weight, toxicity and cost.

Materials:
Print out and cut out the medicinal plant top trump cards from Science and Plants for schools. https://www.saps.org.uk/teaching-resources/resources/871/medicines-and-drugs-from-plants-trumps-card-game/

What to do:

1. Deal out all the cards between the players. Each player should hold their cards in a pile, face down, without looking at them.
2. The first player takes the uppermost card from their stack. They read aloud the name of the drug and the plant the drug comes from. They then choose a category (e.g. toxicity) and state the value of that category for the card (e.g. 3.4).
3. The other players then pick the uppermost card from their stacks. Each one reads aloud the name of the drug and the source plant, and then the value of the selected category.
4. The person with the highest value for that category is the winner, and claims their opponents' cards. These cards are then put to the bottom of the winner's card pile.
5. This is repeated, with the winner of each round choosing the next category.
6. The game continues until one person holds all the cards and is declared the winner.

Take it further:
Can you think of any medicines that come from plants? You could do some research on the internet.

Wordsearch

Marvellous Medicine Word Search

N T Y H M A S T D N M O O I Y
C U R X E F J S A F E P P U W
O B U Q D C X Y C S M Z O E T
U U H Y I B L O R D E F O G W
G L S T C D I S E H W U R R D
H P F X I R V N A G X M L H O
S I K Z N U E S M W Q V Y N C
Y L J B E G R N E M K H J R T
R L K T X V P K S P O O N A O
U H G H M V O T H W X P U U R
P Z Q E U L O C M O E R N Z X
F P P G K F L L L C I D S H R
I P H A R M A C Y Z B U C B R
U G A N T I B I O T I C S O X
T Q X U C F V W B E M E V S N

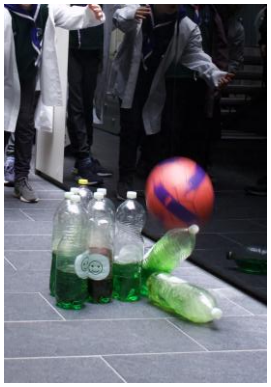
Can you find the words below in the word search?

Antibiotics	Cough syrup	Liverpool	Pill
Medicine	Pharmacy	Safe	Spoon
Poorly	Cream	Doctor	Drug

Drug Development: Do they work?

Drug development is the journey of turning a scientific idea into a medicine. At the start, scientists look for molecules that interact with a part of the body linked to a disease. A good medicine should be **selective**, meaning it works mainly on the target we want, without causing too many unwanted effects elsewhere. We also study how the body responds to different amounts of the drug — this is called the **dose–response relationship**. From this, we learn about the drug's **potency** (how much is needed to work) and its **efficacy** (how well it can work at its best). To find good starting points, researchers use **high-throughput screening**, a powerful method that tests thousands of possible molecules very quickly. The most promising ones, called "lead compounds," are then improved and tested further, step by step, on the way to becoming safe, effective medicines.

Selectivity skittles



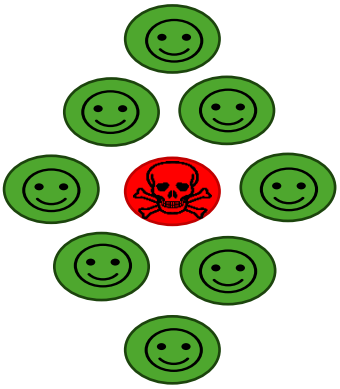
Aim: To understand that medicines are designed to be selective so that they will only target the cause of the illness e.g. bacterial, virus or remove the diseased cell, without accidentally damaging the surrounding healthy cells.

Materials:

- 10 Empty 2L pop bottles
- Labels to denote good and bad bottles (see template page 27),
- Green and red food colourings
- Water.
- Range of throwable 'novel drug' items e.g. tennis ball, beanbags, football, ping pong ball.

What to do:

1. Decorate 9 bottles as 'healthy cells' bottles and 1 bottle as the diseased cell.
2. Quarter fill the healthy bottles with green water and the disease bottle with red coloured water, the amount in the diseased bottle can be varied to make it easier or harder to knock over.
3. Arrange bottles in a diamond or triangle formation (see below). Move the bad bottle into different positions as the game progresses, to make it easier or harder to target.
4. Participants will select an item and try to knock over the 'diseased' bottle without damaging the healthy bottles. The ball size is a balance between power and ability to target disease and is a metaphor for medicine effectiveness of the novel drug/ treatment *vs*. the side effects. The winner is the one who knocks over the 'diseased' bottle whilst limiting the damage to the fewest 'healthy' bottles.



Health cell and diseased cell skittle formation.
Green – healthy,
Red - diseased

5. Take it further:
   a. Make the diseased bottle harder to knock over by adding more water. This could represent the development of drug resistance.
   b. Reduce the amount of water in the diseased red bottle making it easier to knock over or swap It for a bigger bottle. This means the diseased cell is becoming sensitive to the drug and will respond better to treatment.

Throughout the games participants should consider which 'drug' item they can control most accurately and how this may need to change according to the position or weight of the 'diseased' bottle. For example, if the 'diseased' is in the top position of the triangle formation this could representative an eye infection where the drops can be easily placed directly on the eye with little chance of hitting any other area. However, if the 'diseased' bottle is placed in the middle of the diamond formation this could represent a virus in the heart where a very powerful medicine may damage the surrounding areas.

Selectivity Skittles labels – print, cut out and stick to 2L pop bottle skittles.

Testing new medicines

Background: Imagine a robot in a laboratory that can test hundreds of thousands of chemicals very quickly. Instead of checking one by one, it uses special plates with tiny wells (like miniature ice cube trays) to run thousands of tests at the same time. We simply want to know at this stage Does this chemical compound show any sign of working? These experiments or screens are trying to narrow down a huge library of chemicals into a small list of "hits." Robots can help us to do this quickly and efficiently. This is called High throughput screening.

Aim: You are developing a new antibiotic to kill purple germs. Screen your new medicines to identify those which work and kill the germs and can go on for further safety testing.

Materials:

- A red cabbage, cut in to pieces
- hot water
- ~ 30ml capped tubes/ small beakers
- bowl
- ice cube tray/ 12 well spot plate
- pipettes/syringe / small spoon
- A selection of 'new medicines (*e.g. clear vinegar, lemonade, water, lemon Juice, baking powder mixed with water, bleach, washing powder mixed with water*.)
- Tray (optional to contain spillages)

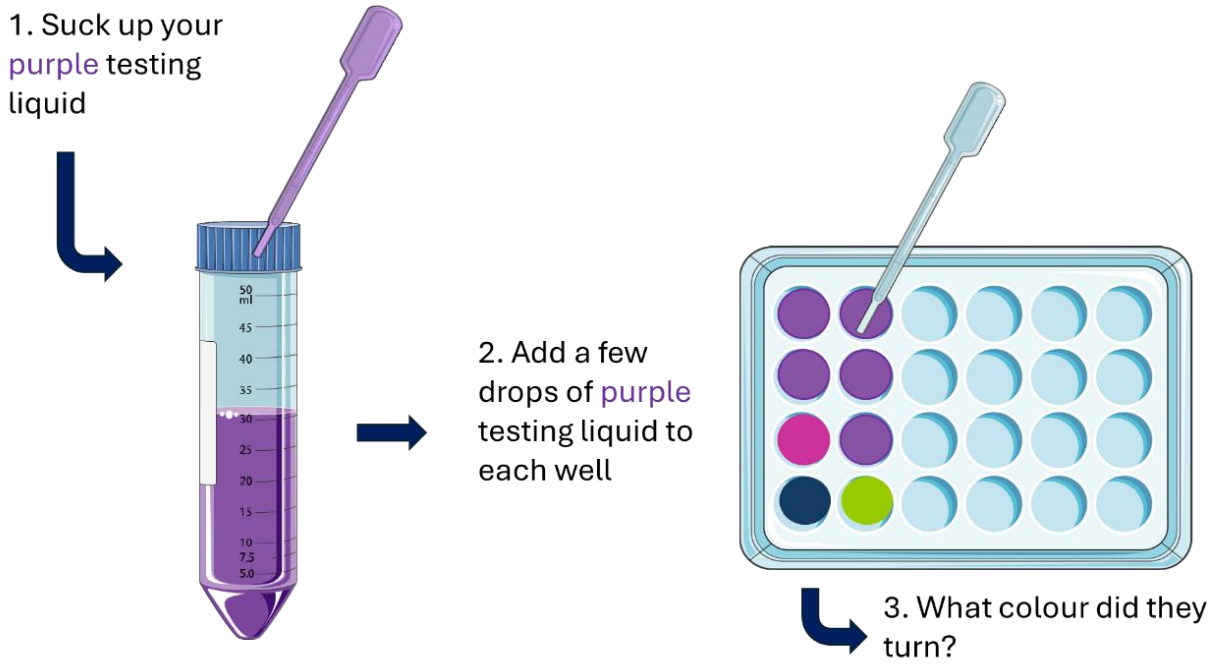
Methods:

Ahead of the session

1. Prepare you reagent - chop the red cabbage into pieces and add to bowl of hot water. Leave for 10 mins, or until cooled. Strain and collect the liquid. Decant into individual tubes/ beakers. It should turn a purple-blue colour. *This can be made the day before and stored in a fridge.*
2. Prepare your new medicine testing plate - using the pipette, spoon or syringe, add 3-4 drops of each of the 'new medicines' to your ice cube tray / spot plate. You can repeat your compounds.

During the session

1. Explain that the chemistry department have sent some potential new compounds that you need to test. Participants are provided with a plate with the test molecules. They are to add purple testing reagent
2. Ask participants to add the cooled 'testing reagent' (cabbage water) to the testing plate using the pipette, spoon or syringe.



3. Observe the colour change against the chart below and identify which compounds are positive and should go forward to be tested further. The greater the colour change the more potent or stronger the response.
    a. The new compounds which have turned pink, have worked they have killed the purple germs, these would then undergo further testing to ensure that they are safe.
    b. The compounds which have turned green have not worked, the germs have continued to grow. This compound development would be stopped.

Positive Response = works well	No change	Negative Response = does not work
☑		☒
Will undergo further experiments to see if they are safe		

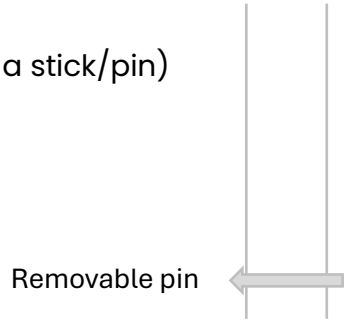
Coke and Mentos demo and understanding dose-response.

When scientists develop new medicines, they need to understand how the **dose** of a drug (how much you take) relates to the **response** in the body (how strong the effect is). To make this idea fun and visual, we can use a Coke & Mentos experiment. The number of Mentos we drop into the bottle is like the drug dose, and the height of the soda fountain/ geyser is like the body's response. By testing different doses, we can see how the response changes — just like scientists do when they study medicines.

Aim:
To demonstrate potency and dose -response by dropping different numbers of mentos (the dose) into identical bottles of diet coke and measure the height of the geyser (the response).

Materials:

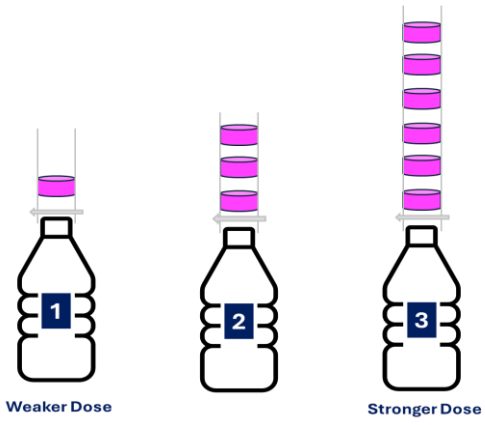
- Pack of mentos
- Medicine delivery tube (geyser tube or open ended tube with a stick/pin)
- 3 x Small bottles of diet pop (e.g. diet cola, diet lemonade)
- Large tray
- Ruler



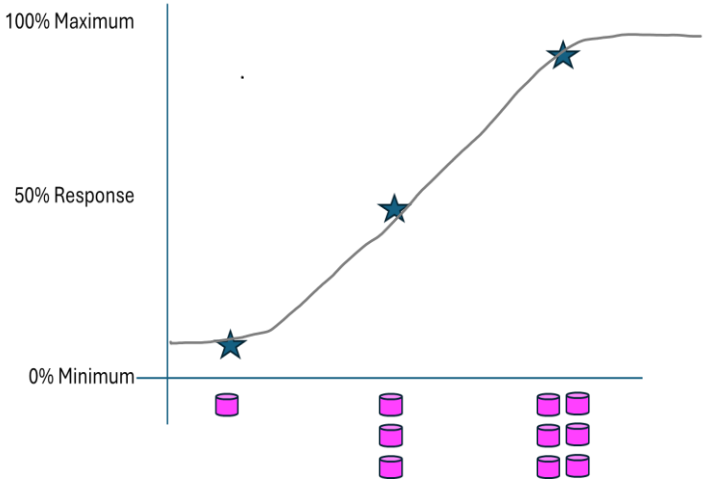
Note to supervising adult: it is possible to run this demo without the delivery tube, open the lid and drop mentos into the bottle directly but the geyser is not as impressive.

What to do:

1. Remove the lids, set up 3 bottles on a tray with a medicine delivery tube.
2. Add 1 mento to bottle one, this is a low / weaker dose.
3. Add 3 mentos to bottle two.
4. Add 6 mentos to bottle three, this is a strong dose.
5. A bottle at a time, pull the pin to release the mentos into the pop and stand back. Measure the height of the geyser. What difference does adding more mentos make?



The more medicine you take, the bigger the effect until you reach the maximum effect. There is no benefit to adding more at this point as you will not get a bigger effect



Take it further: You could try comparing different types of mints to see difference in potency.

Glossary of Terms

- **Potency (Poh-ten-see):** Potency is the concentration or dose of a drug required to produce 50% of that drug's maximal effect. i.e **how much** you need to get an effect (fewer Mentos = more potent)

- **Dose–response**: As the dose increases, the response usually increases too — up to a limit.

- **Efficacy (EH-fih-kuh-see):** The ability of a medicine to produce the desired beneficial effect. The maximum effect possible from a medicine, no matter how much you add i.e. **how big** the biggest effect can be (the tallest geyser in our experiment)

- **EC_{50}:** The dose that gives **half the maximum** effect — a handy number scientists use to compare compounds which we estimate from the dose response graph.

Making Medicines

Medicines come in many forms, from tablets for headaches, liquids such as cough syrups, to creams for skin rashes and inhalers for asthma. They all contain an **active ingredient**; the part of the medicine that does the job of treating or preventing illness. The way a medicine is put together, known as its formulation, is designed so that this active ingredient reaches the right place in the body, at the right time, and in the right amount. To help make this work, medicines also contain inactive ingredients or excipients. These don't treat the illness directly but make the medicine safe and effective. For example, by holding a tablet together, giving a syrup its taste, or controlling how quickly a drug is released.

Different formulations are chosen depending on the condition to be treated, how quickly relief is needed, and what's easiest or safest for a patient to take.

Have you ever looked at a medicines ingredients label?

Calpol (Patient information sheet)

https://www.medino.com/product/calpol-infant-oral-suspension-colour-and-sugar-free-100ml

There is often a long list of ingredients but what are they and what do they do?

Active Ingredients: These are the chemical compounds that have a direct effect on the body, *e.g cough medicine, pain relief.*

Inactive Ingredients:

- **Fillers:** Help a tablet or capsule hold its shape.
- **Binders:** Help ingredients stick together.
- **Dispersants:** Help the medicine dissolve or spread out.
- **Colourings and flavours:** To make the medicine more appealing.
- **Preservatives:** To prevent spoilage or microbial growth.

Herbal medicine Formulation

Many of the medicines we use today, like aspirin (pain killer) or cough syrup, originally came from plants. Scientists learned how to take the special compounds (active ingredient) from plants and make them into medicines that are then tested to make sure they are safe. **Herbal remedies** are made directly from plants, often without testing. **Medicines** are scientifically tested for safety and to make sure they work properly.

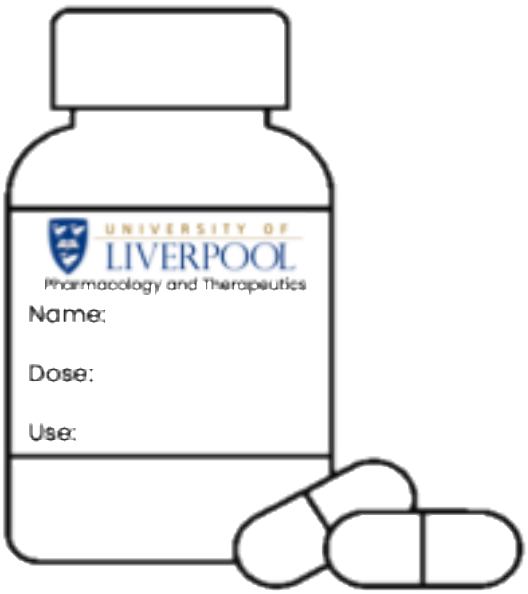
Aim: To extract the active ingredients from a plant and make a medicine.

Materials:

- Dried medicinal planets e.g. lavender, camomile, peppermint
- White binding powder (cornstarch)
- Bowl
- teaspoons
- pestle and mortar
- ice cube tray / sweet mould.
- Glass of water
- Microwave (optional)
- paper bag

What to do:

1. Crush 1 teaspoon of your herb / plant in a pestle and mortar in a bowl using the back of a spoon.
   What can you smell? This is you're active ingredient.
2. Add 2 teaspoons of the white binding powder, this is one of your inactive ingredients.
3. Add a few drops of water using the teaspoon.
4. Mix together to form a paste and add the paste to your tablet mould.
5. Leave the mixture to dry (a few seconds in the microwave works well, otherwise air dry).
6. Unmould your tablets, package and label. (Do not eat).



Drug Safety: Are they safe?

Drug safety, they mean making sure a medicine **helps more than it harms**. Every medicine has effects we want (the benefit) and sometimes effects we don't want (side effects). Drug safety is about carefully testing and checking to make sure that the benefits outweigh the risks.

In the lab, new medicines are first tested in cells (the building blocks of the body) and in animals (e.g. mice and rats) to spot any obvious dangers. We then conduct small clinical trials where a few healthy volunteers take the potential new medicine under close supervision to see if it's safe. We then run much larger trials where the new medicine is tested in patients to confirm safety and check how well it works. Even when a medicine has made it to marker and is being used, doctors and scientists keep monitoring it, because rare side effects sometimes only appear after many people have used it.

Poorly tummy demo

Aim: to demonstrate that some medicines can make you feel poorly, which is why we only ever take a medicine given to us by a trusted adult.

Materials:

- 2 clear glasses / beakers
- Clear vinegar
- Baking powder
- Teaspoon
- Water.

What to do:

1. Fill one glass hallway with water. Half fill the other glass with clear vinegar. This represent the liquid inside our tummy.
2. Add a teaspoon of baking powder to the water and give it a stir. This demonstrates if we take a medicine prescribed to us, then our tummy is settled.
3. Add a teaspoon of baking powder to the vinegar and give it a stir. It should fizz, this represents an unhappy, poorly tummy. This is what happens when we take a medicine not prescribed to us.

Clinical trials

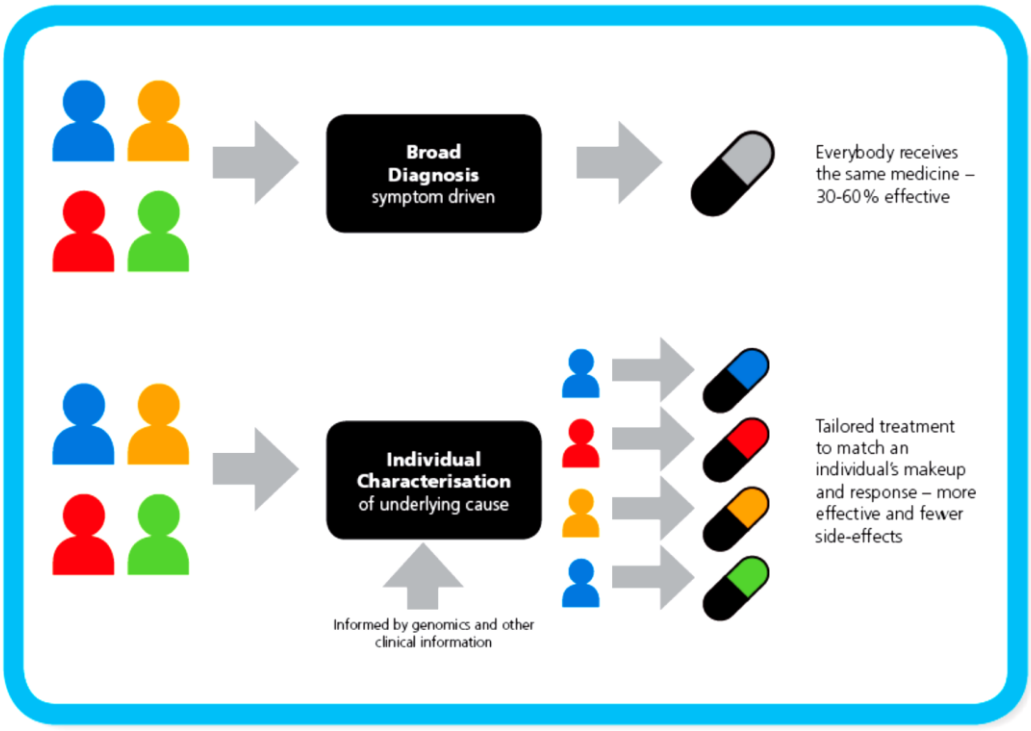
Aim: To introduce drug safety, personalised medicines and why they are important.

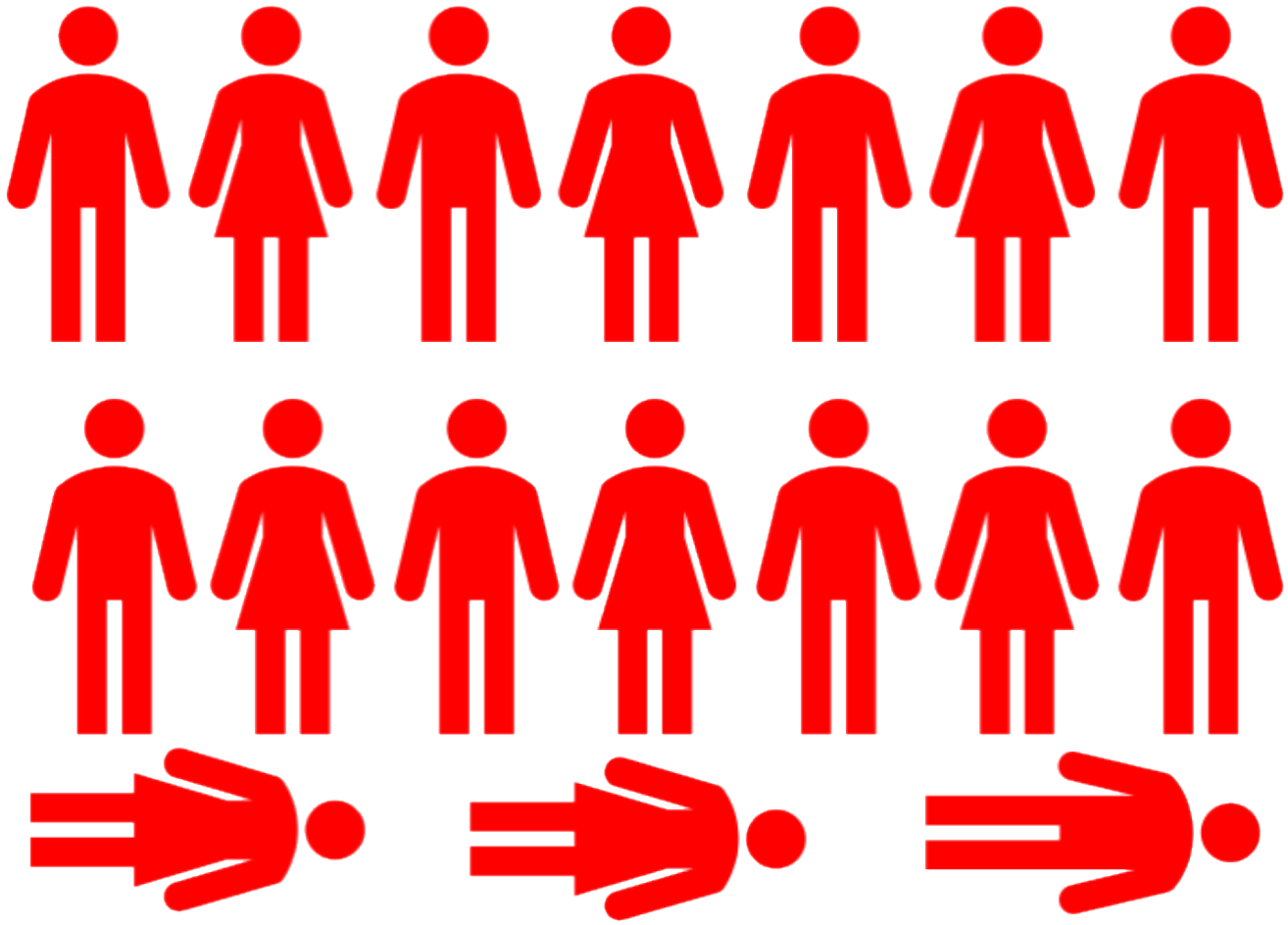
Materials:

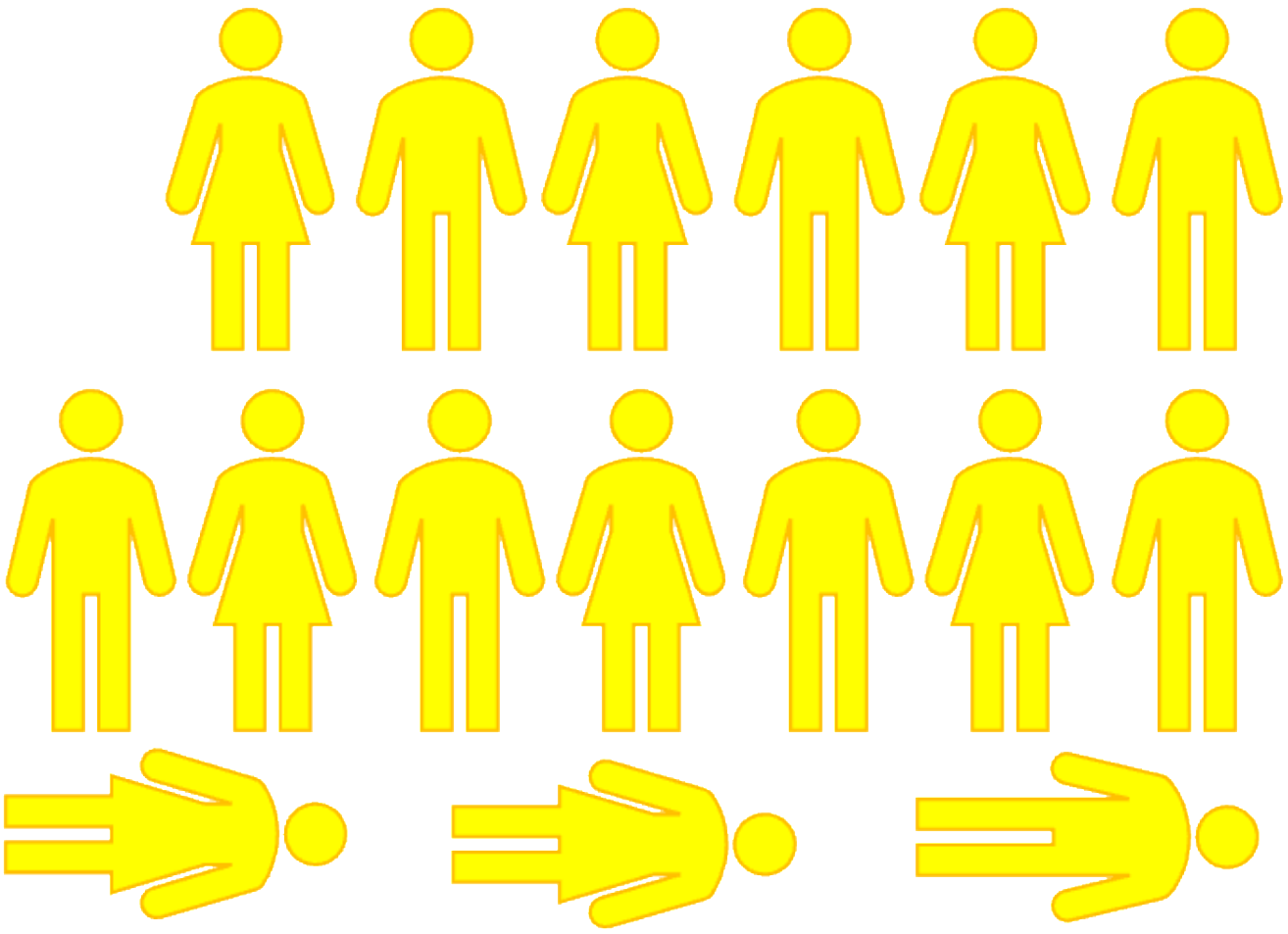
- Learning resources family counters *or* red, blue, green and yellow people printed and cut out (page 36-37)
- UV pen and torch

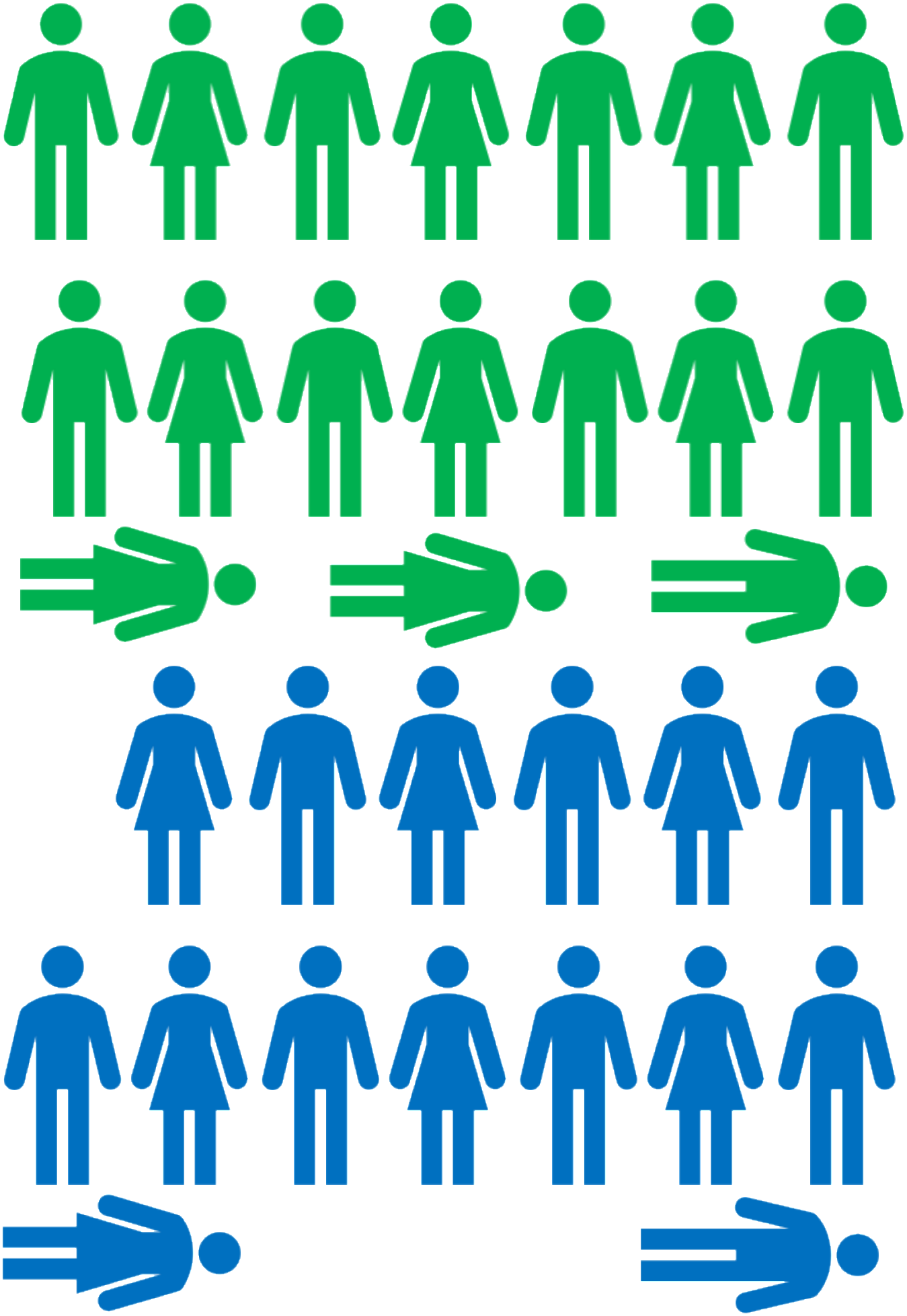
What to do:

1. Print and cut out the red, blue, green and yellow people.
2. Mark a random handful of people with a few different shapes using the uv pen e.g star, circle, square etc.
3. Ask the group to sort the people into different types of groups. You can repeat this a few times by considering different characteristics e.g Different Colours, sex, adult/ child
4. Explain that when a doctor diagnoses someone with a disease they consider their signs and symptoms. Everyone diagnosed with a disease or condition will receive the same medicine. However, this will not work for everyone. It may only be effective in 30-60% cases. For some people it will even make them more poorly.
5. Mix the people up and give the participants a UV torch and explain that scientists look for special invisible markers called biomarkers in your blood to group people together. Can they find any? Hopefully they will find each group now has people of different colour, sex, size etc. Explain that by sorting people using these special invisible markers we can better match medicines to their disease / illness meaning that the medicines will work better and have fewer side effects. This is called personalised medicine, where we individually tailor medicines to the person.









Medicines of the future: My Personalised medicine

Hospitals and GPs spend approximately £19 billion (£19,000,000,000) on medicines each year but they do not work properly in 50-70% patients. Why?

Everyone's body is different, and not all medicines work the same for everyone. The genes which code instructions inside your body that make you unique. This means that the same medicine might work well for one person, but not so well for another, or even cause side effects which can make you feel ill. With personalized medicine, scientist and doctors look at your genes, your lifestyle, and other things about you to find or design the best medicine for you. This helps treat your illness more effectively and reduces the chances of side effects, making it safer and better for your health.

Aim: to understand that understanding of genetic variation may one day lead to personalised medicines being developed.

What is DNA? Cells are the basic unit of life and make up all plants, animals and bacteria. Deoxyribonucleic acid, or DNA, is the molecule that controls everything that happens in the cell. DNA contains instructions that direct the activities of cells and, ultimately, the body. The DNA Is made of 4 base units - adenine, thymine, cytosine and guanine which join together to form a DNA helix, which Is then further twisted into a chromosomes and stored in a cells nucleus to stop It from getting tangled.

What are Genes? Genes are made up of DNA sequences and are located on chromosomes in the nucleus of cells The genetic information in DNA contains instructions for the development, growth, reproduction, and functioning of organisms. Some genes provide instructions for making proteins, which are essential for the body to function

What are Chromosomes? Chromosomes are long strands of DNA that contain the blueprint for the body. The DNA helix Is further twisted into a chromosomes and stored in a cells nucleus to stop It from getting tangled. In humans, the nucleus of each cell contains 23 pairs of chromosomes, for a total of 46 chromosomes

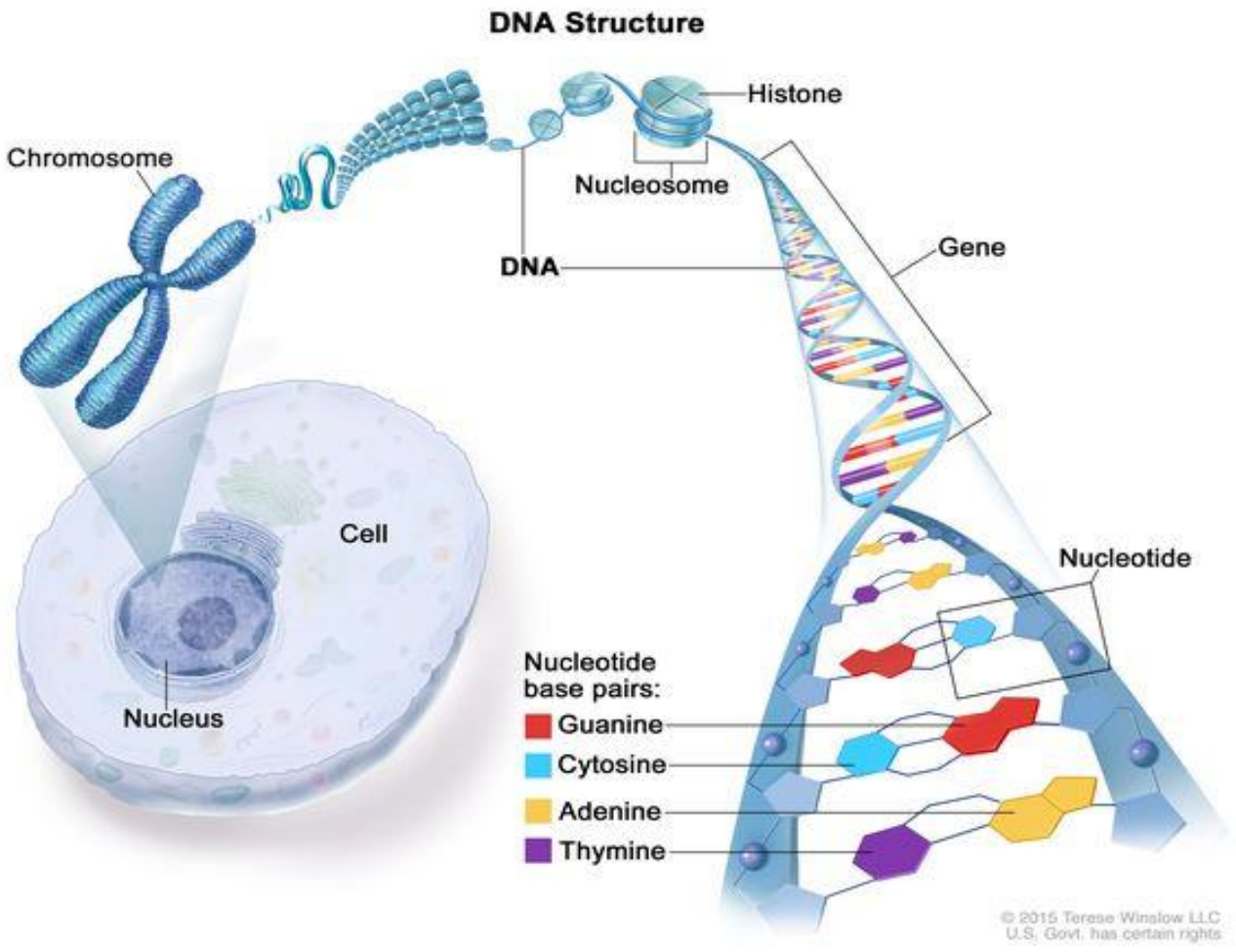


Image: https://www.cancer.gov/publications/dictionaries/genetics-dictionary/def/chromosome

DNA Extraction Demo

We can easily extract DNA from fruit by following the instructions below or you can watch a DNA extraction demonstration video: https://youtu.be/zMw44VDqf2s

Materials:

- A few strawberries/ a kiwi / half a banana
- Dish soap
- Table salt
- Tap water
- Ice-cold Rubbing alcohol / surgical spirits
- Zip lock plastic bag
- clear glass x2
- measuring spoons
- small sieve
- coffee filter / clean dishcloth

What to do:

1. Measure out 100mL water into a glass. Add 1 tsp salt and 2 tsp dish soap and mix (try and avoid bubbles).
2. Place 3 strawberries/ chunk of banana into a zip lock bag and mush into a paste.
3. Add the solution, mix and leave for 5 mins.
4. Add a coffee filter/ clean dish cloth into the sieve resting over a clean glass and pour in the mixture into the filter. You may need to twist the filter just above the liquid and gently squeeze the remaining liquid into the cup.
5. Pour ~ 100mL ice cold alcohol down the side of the glass, do not mix. The alcohol will float on top of the fruit/soap mixture.
6. After a few minutes, the white tangled mess of DNA will float as a separate layer in the alcohol. You can fish It out with a spoon.

Genetic Testing - Are you a supertaster?

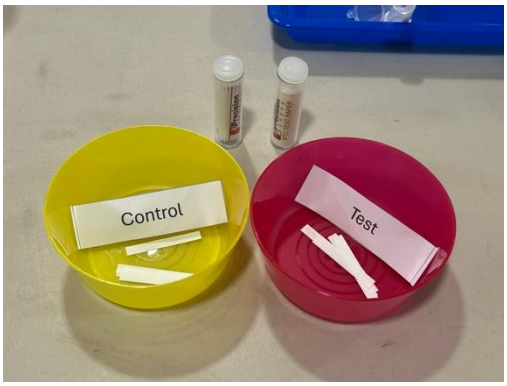
Taste buds on your tongue allow you to taste 5 major flavours - savoury, salt, sweet, sour and bitter. But are you a supertaster? Just like DNA carries instructions that decide things such as eye colour or height, it also influences how we experience taste. A simple way to see this is with a PTC taste test. PTC is a harmless chemical that some people find unpleasant, while others taste nothing at all. This difference comes from variations in a gene on our chromosomes that controls taste receptors on the tongue. So, by testing whether you can taste PTC, you're actually seeing your DNA in action!

Aim: To determine your taste ?? using Genetic Taste Testing.

Materials:

- PTC (Phenylthiourea) test paper*
- Control test paper
- Clean forceps
- Drinking water and cups
- Pot with dilute bleach (10%).

  **Classroom Genetic Taste Testing experiment kits are easily available online.*



Note to supervising adult: PTC can taste very bitter to a few people (supertasters). The majority will taste something but are not sure what it is, some people will not taste anything at all. We do not tell the participants what to expect, as this can influence the results. We have a glass of water available for supertasters. We also try and make everyone put the test strips on their tongues at the same time. Do not give to anyone with a thiourea allergy.

What to do:

1. Using the forceps, hand out a control paper to each participant, ask them to place it on their tongue for a few seconds.
2. Participants then puts their used strip into the discard pot.
3. Using the forceps, hand out the PTC test paper to each participant, ask them to place It on their tongue for a few seconds. Record their response!
4. Participants then puts their used strip into the discard pot.
5. Leave the strips to soak for a little while, pour the bleach away, transfer the used strips into a plastic bag and put into the refuse bin.

How It works:

Bitter tasting, phenylthiourea (PTC) can only be tasted by 75% of the population as it is linked to the TAS2R38 gene, which codes for the bitter taste receptor on your tongue. Your ability to taste PTC is inherited from your parents (1 copy from each) as it depends upon whether you have 2 strong (dominant) copies of the genes (TT), 2 weak (recessive) copies of the TAS2R38 gene (tt) or a mixture of both, 1 dominant copy and 1 weak copy (Tt). This will then determine If you are a bitter supertaster (TT), standard taster (Tt), non-taster (tt).

♂	T	t
T	TT	Tt
t	tT	tt

If you were a non-taster (tt) and the medicine you are given only works for supertaster (TT) or standard taster (Tt) then it will never work for you, in fact It may cause you more harm than good. Knowing this information, a doctor can give you a different drug or alter the dose (the amount) of drug you need. It may work really well for TT supertaster, but you may need to take more If you are a standard (Tt) taster.

My personalised marvellous medicine (sand art)

By knowing about your genetics, scientists can use this information to tailor make medicine to suit you which should mean that they work better and have fewer side effects.

Aim: To create a 'medicine' as unique as you!

Materials:

- Empty clear container with lid. *This can be a small capped universal tube/ small sand art bottles from Baker Ross etc.*

- Dry pre-coloured sand / rice (red, yellow, green, blue) Sticky 'medicine' labels
- Small Funnel / paper cone.
- Trays
- Bowl
- Spoons
- Prescription printout

What to do:

1. Fill your bowls with the coloured sand, add a spoon to each bowl.
2. Provide each participant with an empty container and lid.
3. Working over a tray, the participant should answer the genetic questions below filling the container with a layer of sand (using the spoon and a funnel) to represent their answer.
   For example, if you have blonde hair you would add a thin layer of yellow sand. You should add enough sand so that the container Is full by the time you have answered all the questions and put the lid on.

4. If you shake/ knock the bottle while it is not full, then you will lose the layers. You can add extra mixed coloured sand to the top to ensure the tube is completely full if needed.
5. Create a medicine label and stick it onto your bottle.
6. Print out and complete your prescription. *What does your medicine do? how often should you take It and how much should you take?*
7. Compare your personalised medicine with someone else's. You will each have slightly different combinations of sand, the layers may be in an entirely different order, this Is because your medicine has been made especially for you. If there are genetic siblings/family members in the group they may notice that their bottles are very similar.

All potential new medicines have to be tested in patients during controlled experiments called clinical trials. They check how safe the new medicine will be and how well it works compared to other medicines on the market. If the new medicine successfully passes these tests, then It can be sold and prescribed by clinicians and nurses.

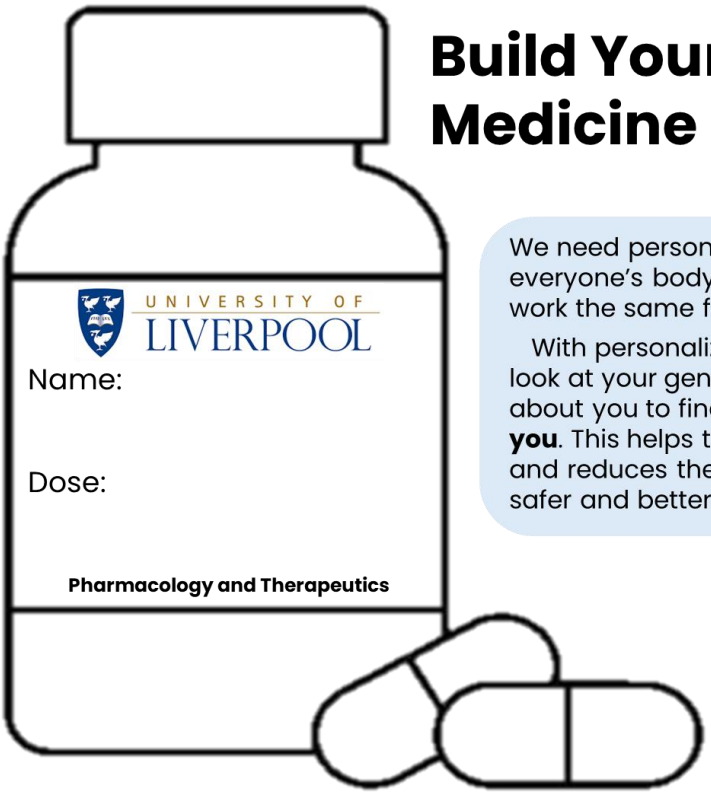
8. Make a big announcement! The results of medicine testing have been collected and analysed. The clinical trials have shown that it works best in following groups:
   a. Good responders = 4 or more yellow layers
   b. Mid-range responders = 3 blue layers
   c. No response = mixed up layers

   Are you a good responder?

Genetic Questions

Question	Option 1	Option 2	Option 3	Option 4
What is your sex?	**Male = blue**	**Female = Red**	**Other = green**	
What is your hair colour?	**Blonde = yellow**	**Brown = Blue**	**Black = Green**	**Red = red**
Are you colour blind?	**Yes = Red**	**No = Yellow**		
What is your eye colour?	**Blue = blue**	**Brown = Red**	**Green = green**	**Grey = Yellow**
Can you roll your tongue?	**Yes = Red**	**No = yellow**		
Hair personality	**Straight = Blue**	**Curly = Green**		
What hand do you write with?	**Left = red**	**Right = yellow**	**Both = Blue**	
Do you have dimples	**Yes = green**	**No = blue**		
Is your ear lobe attached?	**Yes = red**	**No = Yellow**		
Do you have freckles?	**Yes = green**	**No = blue**		

Prescription for printing out

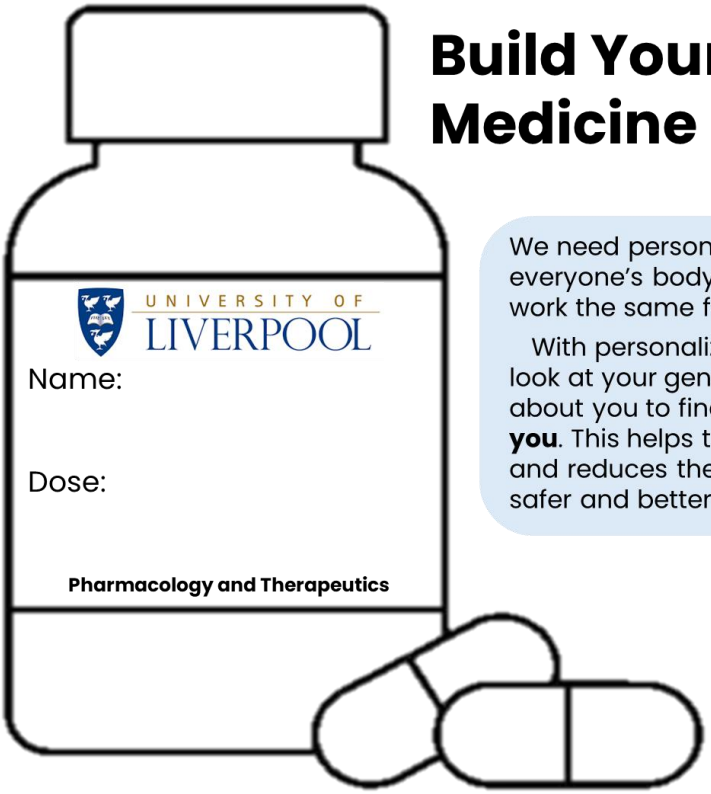


Build Your Own Medicine

We need personalized medicine because everyone's body is different, and not all medicines work the same for everyone.

With personalized medicine, scientist and doctors look at your genes, your lifestyle, and other things about you to find or design the best medicine for **you**. This helps treat your illness more effectively and reduces the chances of side effects, making it safer and better for your health.

Professor PaT



Build Your Own Medicine

We need personalized medicine because everyone's body is different, and not all medicines work the same for everyone.

With personalized medicine, scientist and doctors look at your genes, your lifestyle, and other things about you to find or design the best medicine for **you**. This helps treat your illness more effectively and reduces the chances of side effects, making it safer and better for your health.

Professor PaT

Appendix

Badge Ordering Form

Unit / Class:	
County / School:	
Leader's / Teacher's Name:	
Address (for delivery):	
Email:	
Total number of badges @ £1.00 each	
Add postage* depending on number of badges ordered**: 1 - 40 badges £2.50 40 – 100 badges £3.50	
Total Amount Paid	

*For international orders and those with larger numbers, please contact for postage costs.

Payment Method:

Via cheque

Cheques should be made payable to 'The University of Liverpool'

Please add reference **JXG13727 MARVMEDBADGE to the back of your cheque**

Please return this order form and cheque by post to *Dr Laura Randle, Pharmacology and Therapeutics, ISMIB, The University of Liverpool, G/081 Lower Ground Floor Sherrington Building, Ashton Street, Liverpool, L69 3GE.*

Via bank transfer

Account Name: **University of Liverpool**

Sort Code: **20-51-01** Barclays Bank, Account No: **60908533**

Reference JXG13727 MARVMEDBADGE

Please return this order form and confirmation of BACs payment by email to Laura.Randle@liverpool.ac.uk

Image use and permissions

Images have been appropriately credited. Photo permission has been sought from each person included in the pack. For more information, please contact the M*arvellous Medicine* team. Cartoon images of Professor PaT have been generated using GAI. Additional graphics have been created by the staff at the University of Liverpool using Microsoft Office and are used under the University's copyright.

Generative artificial intelligence use

GAI has been used to help introduce challenging concepts and simplify the language at the beginning of each section. Cartoon images of Professor PaT have been generated using GAI.

Social Media

We would love for you to share your activities with us, or you'd just like to say hi. You can find us on Bluesky @@drlaurarandle.bsky.social and @livuniengagehls.bsky.social or on Instagram @livunipharma. Don't forget to tag us #MarvellousMedicineBadge.

Funding

Dr Laura Randle would like to thank The University of Liverpool, Faculty of Health and Life Sciences and The National Centre for the Replacement, Refinement and Reduction of Animals in Research (NC3Rs) for their generous public engagement awards that enabled the generation of this badge pack and on campus badge days.

Badges

Proceeds from the badge sale will be used to purchase additional badges and run further inclusive badge days to support widening participation in science.

Badges measure 10 cm x 6.8 cm

Copyright