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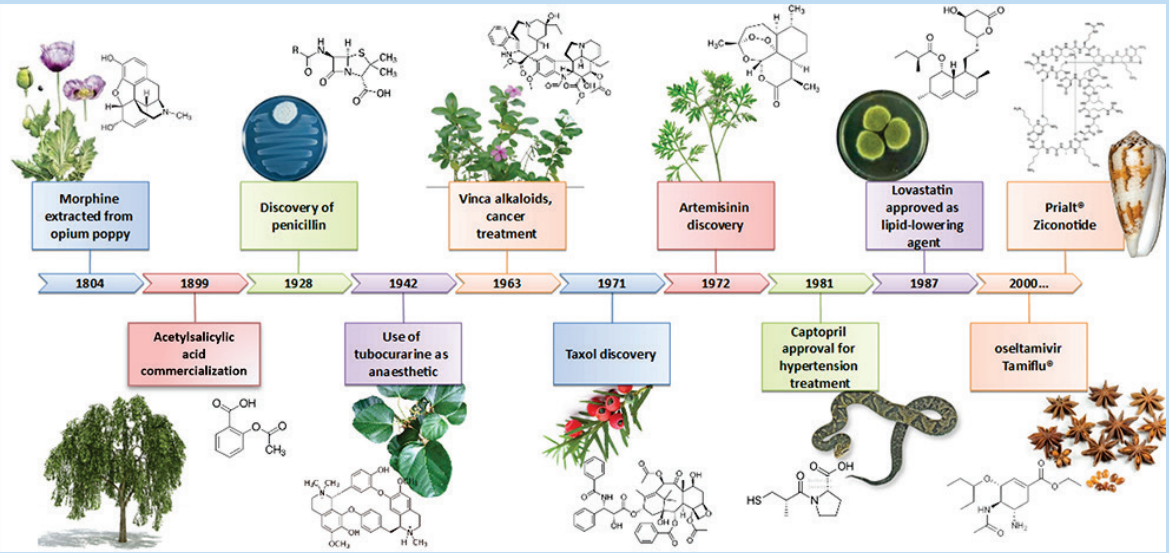
Worksheet 3: Developing new medicines

Microbiology: Discovering antibacterial agents

Medicines from natural products

Many living things produce natural antimicrobials to defend themselves against bacteria or kill competing bacteria. These can be found in different sources like plants, such as fruits, vegetables, seeds, and spices; animal products, such as eggs and honey; and microorganisms, such as fungi and bacteria. In fact, the first antibiotic, penicillin, was discovered in moulds from the genus *Penicillium*. Modern antibiotics are often based on such natural products, although most are synthetically modified to improve their properties.



Natural products identified during the last century and used as medicines
*From Valli M, Bolzani VS (2019) Perspectives and challenges for use of Brazilian plant species in the bioeconomy. Anais da Academia Brasileira de Ciências **91**.*

However, drug development is a complex process. Testing a substance for the desired activity in the lab is just the very first step.

What makes a medicine?

To be used as a medicine, it's not enough for the substance to have the desired action, like killing bacteria; it also needs to be **nontoxic to humans at an effective dose**. This is the key challenge, because many substances that kill bacteria or cancer cells, for example, kill healthy human cells too or cause dangerous side-effects in other organs.

As well as having the desired activity, a potential medicine should ideally also:

- Not be toxic to humans or cause serious side-effects at the effective dose
- Not be broken down by the liver into toxic products
- Be active at reasonable concentrations that can be achieved in patients – even if it's very nontoxic, you don't want them to have to take 20 pills a day
- Be easy to synthesize or isolate from an abundant producer organism
- Be chemically stable, so that it can be stored
- Be water soluble – if it is fat soluble, it may not get to where it needs to in the body or could accumulate in the body fat, which can be dangerous
- Be stable to stomach acid and enzymes and absorbable through the gut, so that patients can take it themselves instead of having to get injections
- Be relatively stable in blood and body fluids, so that it doesn't break down before it can have an effect, but not so stable that the body can't get rid of it
- Have a wide therapeutic window – this means that the gap between the effective dose and the toxic dose is large, so you can give the effective dose without the risk of accidental overdose

Chemical modifications can be made to change some of these properties, but these often lead to a loss in effectiveness, new side-effects, or worsening of other properties. Developing substances that meet all these criteria is very challenging and is the reason why drug development is so slow and expensive and why many drug candidates fail during the development process. This is why you should be very sceptical of media headlines claiming a natural substance could cure or prevent diseases based on the fact that it shows an effect in a petri dish.

1. Fill out table 1 for the substances you're intending to test. You can leave any answers you don't know blank. Note that it should be easy to look up the active substance in a product like mouthwash or cleaning products, but this can be very challenging for natural sources like plants, which may contain many potential active substances.

Substance	Proposed active compound	Do you expect antibacterial activity?	Why?	Is it toxic?

Table 1

2. Fill out table 2 with your experimental results.

Substance	Dilution	Antibacterial activity?	Diameter of bacterial inhibition (cm)

Table 2

Discussion questions

Answer the following questions for the substances you tested. If you don't know the answers for questions 6–8, then just say so. In science, recognizing what you don't know is as important as what you do know.

1. Are the results similar to what you hypothesized?

_____

_____

_____

2. Which substance has the highest antimicrobial activity? And the lowest?

_____

_____

3. What effect did different dosages have? Are the inhibition zones similar or different?

_____

_____

4. For the foods, how do you think the concentrations you used compare to the concentration in your body after eating a normal portion of this food (even if it is all absorbed)?

_____

_____

5. Could some of the nontoxic food substances be toxic if dosed in the body at the high concentrations you used?

6. Do you know if the active substance is absorbed into the blood if ingested?

7. Is the active substance soluble in water?

8. Is the active substance broken down by the digestive system or liver?

9. Based on the above answers, do you think the substances tested could be used as antibiotic medicines? Explain your reasons.