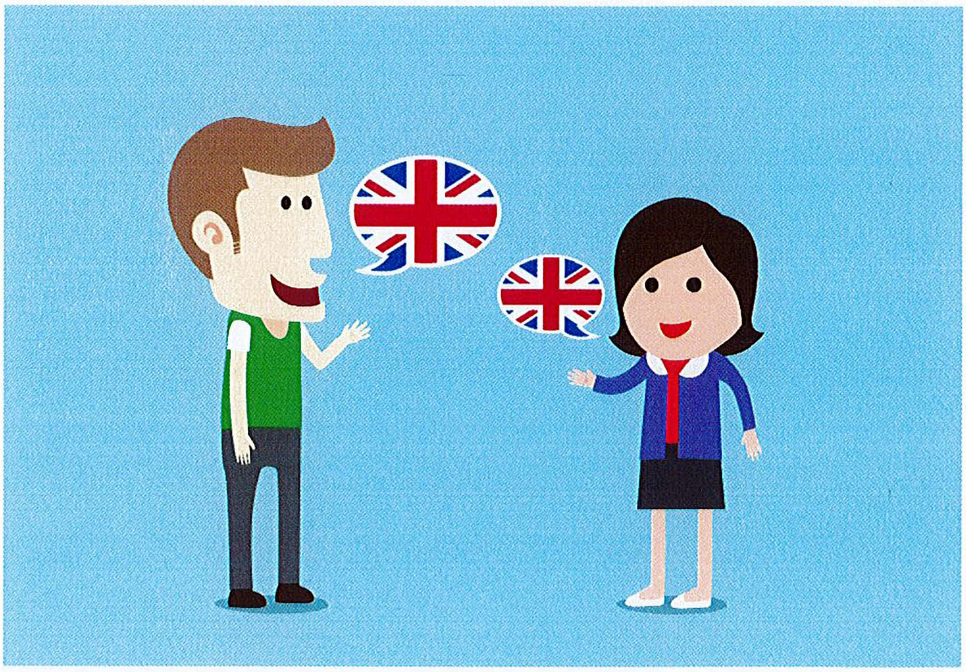
UNIVERSITE DE MONTPELLIER

Faculté des Sciences

Département Des Langues

L2 Info A – B – C – D + CMI

COMPUTER SCIENCE



ENGLISH

ORGANISATION DES ENSEIGNEMENTS

Volumes horaire : 21 heures

Les cours d'anglais auront lieu au premier (S3) et second semestre (S4) à raison de 3 heures hebdomadaires :

Le lundi de 16h45 à 20h00 pour les L2 Info B

Le jeudi de 09h45 à 13h pour les L2 Info A + CMI

Le jeudi de 13h15 à 16h30 pour les L2 Info D.

Le vendredi 09h45 à 13h pour les L2 Info C

Vous aurez donc 7 séances de TD (7x3h).

Les salles de cours **ne** sont plus au DDL, au bâtiment 5, mais il faut se aller à la salle de TD indiqué sur le planning.

Objectifs :

Acquérir une connaissance générale de l'anglais afin de pouvoir s'exprimer aussi bien à l'écrit que à l'oral, améliorer sa capacité de compréhension et de production afin de pouvoir mieux répondre aux besoins du monde informatique. Au semestre 4 (S4) l'accent est mis sur la compréhension et production orale.

Contenu des cours :

Les cours seront axés sur l'étude de documents authentiques en lien avec les nouvelles technologies :

- Textes et articles
- Documents audio
- Documents vidéo
- Consolidation des bases grammaticales

Contrôle continu des connaissances : ceci implique une totale **assiduité** !

Jeux de rôle, simulations, activités en classe : /40

Présentation, exposé : /40

Test écrit (compréhension orale) : /20

RESPONSABLE DE L'ENSEIGNEMENT : Jahangir FARAZMAND

Adresse email : jahangir.farazmand@umontpellier.fr

Adresse email du responsable de TD : ....

Introduction

EVERYDAY ENGLISH

Social expressions 1

In everyday situations we use a lot of social expressions.

Hi, Anna. How are you?

I'm fine, thanks. How are you?

1. Match an expression in **A** with one in **B**.
Which are more formal?

A	B
1 Good morning!	a Bye! See you later.
2 See you tomorrow!	b Of course I can. No problem.
3 How do you do?	c Never mind. Perhaps another time.
4 Thank you very much indeed.	d Thanks! Same to you.
5 Excuse me!	e Good morning! Lovely day again.
6 I'm sorry. I can't come tonight.	f Yeah! About nine, in the coffee bar.
7 Can you help me with this exercise?	g It doesn't matter. You're here now.
8 Can I help you?	h Not at all. Don't mention it.
9 Bye!	i No, thank you. I'm just looking.
10 Bye! Have a good weekend!	j How do you do? Pleased to meet you.
11 Sorry I'm late.	k Cheers!
12 Cheers!	l Yes. Can I help you?

2. Test your partner. Say an expression from **A**.
Can your partner give the correct response from **B**?

3. Decide which replies are OK. (Sometimes more than one is possible.)

1 It's great to see you again!
a It's great to see you, too.
b Nice to meet you.
c Thank you.

2 Thanks, that's very kind of you.
a Not at all.
b Please.
c You're welcome.

3 I'd love a cup of coffee.
a I get you one.
b I'll get you one.
c I'm afraid I only have tea.

4 How are you doing?
a Not too bad, thanks. And you?
b Fine, thanks. I've nearly finished.
c I'm painting the garage door.

5 Oops! I'm sorry!
a That's OK.
b You're welcome.
c No problem.

6 Is this your screwdriver?
a Yes, it is.
b Yes, of course.
c Yes, do you want to borrow it?

7 Can I borrow your torch?
a Yes, go ahead.
b Yes, help yourself.
c Yes, I can borrow it to you.

8 What do you do?
a How do you do?
b I'm in computers.
c I'm replacing the disk drive.

9 I'll be getting along then.
a Go ahead.
b It was nice meeting you.
c Thank you for coming.

10 Thanks for showing me around the plant.
a Goodbye.
b It was a pleasure.

EVERYDAY ENGLISH

Social Expressions 2

1 Complete the conversations with the correct expressions.

1 | I'm sorry | Excuse me | of course | Pardon |

A ________ ! Can I get past?
B ________ ?
A Can I get past, please?
B ________ . I didn't hear you. Yes, ________ .
A Thanks a lot.

2 | That's right | Oh, what a pity | Congratulations | Never mind | I hear |

A ________ you're getting married soon. ________ !
B ________ , next July. July 21st. Can you come to the wedding?
A ________ ! That's when we're going away on holiday.
C ________ . We'll send you some wedding cake.
A That's very kind.

3 | Good luck | See you later | Same to you | Good idea | What about you | No, of course not |

A ________ in your exam!
B ________ . I hope we both pass.
A Did you go out last night?
B ________ . I went to bed early. ________ ?
A Me, too. ________ after the exam. Let's go for a drink.
B ________ .

4 | Well | Don't worry | Bye | Safe journey | Thank you for having me | You're welcome |

A Here's my train!
B ________ . It doesn't leave for another five minutes.
A ________ , I'd better get on, anyway, and find my seat.
It was lovely staying with you. ________ .
C ________ . It was a pleasure.
A Goodbye, then. See you again soon, I hope.
B and C ________ ! ________ !

2. Practice the conversations with a partner.
Remember stress and intonation!

3. Make more conversations for these situations.

* being sympathetic to a friend who's just failed an exam
* trying to get off a crowded bus
* leaving a friend's house where you've just had dinner
* saying goodbye to teachers/friends when you leave school
* meeting a colleague on your first day in a new job

➲ CULTURAL DIFFERENCES

On English spelling and pronunciation:

- Americans: Spell words differently, but still call it "English"
- Brits: Pronounce their words differently, but still call it "English".
- Canadians: Spell like the Brits, pronounce like Americans.
- Aussies: Speak with such a heavy accent no one can be sure it's English at all.

On economic success:

- Americans: Seem to think that poverty and failure are morally suspect.
- Canadians: Seem to believe that wealth and success are morally suspect.
- Brits: Seem to believe that wealth, poverty, success and failure are inherited things.
- Aussies: Know that none of this matters after several beers.

On sports:

- Americans: Jabber on incessantly about football, baseball and basketball.
- Brits: Jabber on incessantly about cricket, soccer, and rugby.
- Canadians: Jabber on incessantly about hockey, and how they beat the Americans twice, playing baseball.
- Aussies: Jabber on incessantly bout how they beat the Poms (Brits) in every sport they play them in.

On patriotism:

- Aussies: Are extremely patriotic about their beer.
- Americans: Are flag-waving, anthem-singing, and obsessively patriotic to the point of blindness.
- Canadians: Can't agree on the words to their anthem, when they can be bothered to sing it.
- Brits: Do not sing at all but prefer a large brass band to perform the anthem.

WHAT THE BRITISH SAY	**WHAT THE BRITISH MEAN**	**WHAT FOREIGNERS UNDERSTAND**
I hear what you say	I disagree and do not want to discuss it further	He accepts my point of view
With the greatest respect	You are an idiot	He is listening to me
Oh, incidentally/ by the way	The primary purpose of our discussion is	That is not very important
Very interesting	That is clearly nonsense	They are impressed
I'm sure it's my fault	It's your fault	Why do they think it was their fault?
Could we consider some other options	I don't like your idea	They have not yet decided

Quiz : Britain's Great !

1. Where is the tennis player Andy Murray from ?

- Scotland
- Ireland
- Wales

2. Who is Britain's wealthiest woman?

- The Queen
- J.K. Rowling
- Amy Winehouse

3. Which city did the Beatles come from?

- London
- Manchester
- Liverpool

4. Who won the Best Actress oscar in 2009?

- Kate Winslet
- Helen Mirren
- Judi Dench

5. How many James Bond films has Daniel Craig starred in?

- 1
- 2
- 3

6. Who has played most often for the England football team?

- Bobby Charlton
- David Beckham
- Peter Shilton

7. Before Lewis Hamilton, who was the last British Formula 1 world champion?

- Nigel Mansell
- Damon Hill
- James Hunt

8. When was Margaret Thatcher elected Prime Minister?

- 1974
- 1979
- 1981

9. Which sport originated in a famous English boarding school?

- Rugby
- Cricket
- Polo

10. Which monarch reigned over an empire on which "the sun never set"?

- Queen Victoria
- Henry VIII
- George III

11. Who wrote about "Big Brother" in a famous novel?

- Salman Rushdie
- George Orwell
- John Le Carré

12. Who first obtained a real television picture?

- John McAdam
- James Watt
- John Logie Baird

13. Which animal completes the name of the famous comedy team? Monty ...

- Donkey
- Python
- Mouse

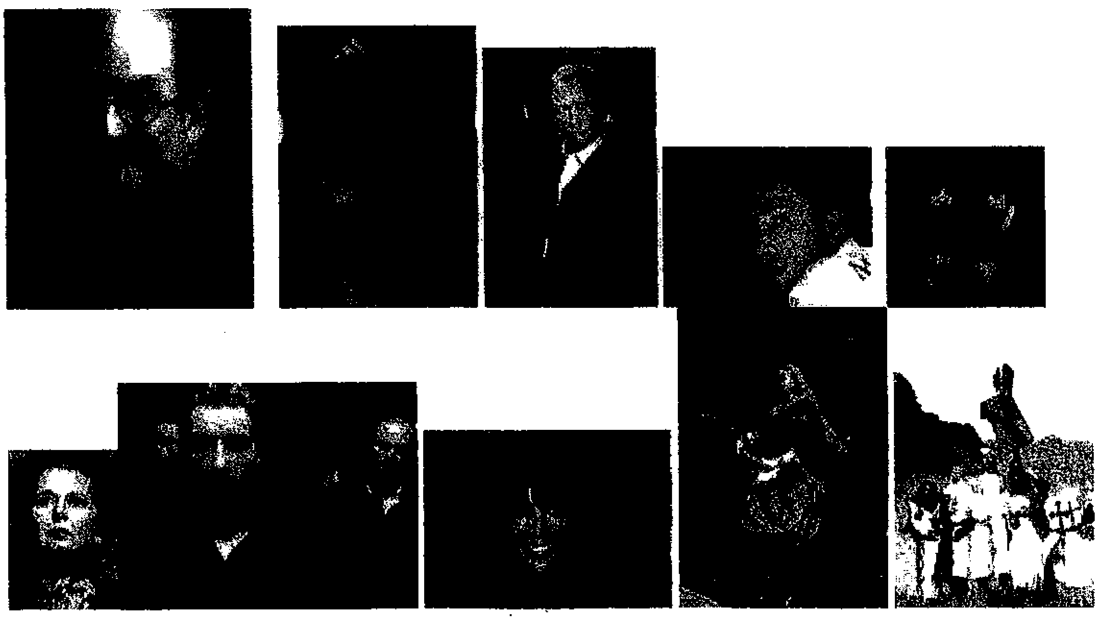
14. **Which famous model has a notoriously bad temper?**

- Kate Moss
- Agyness Deyn
- Naomi Campbell

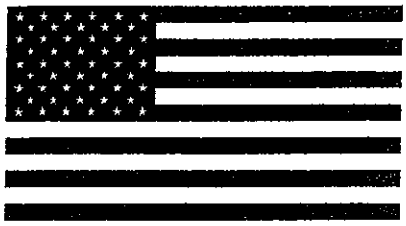
15. **Which of these bands is not actually British?**

- Coldplay
- U2
- The Police

Do you recognise them?...



US GEOGRAPHY QUIZ



1. San Francisco is located in _________.

○ California ○ Texas ○ New York

2. Bryce Canyon National Park is in _________.

○ Montana ○ California ○ Utah

3. The capital of Missouri is _________

○ Jefferson City ○ St. Louis ○ Kansas City

4. Lake Placid, home of the 1932 and 1980 Olympic Winter Games, is located in _________.

○ Minnesota ○ New York ○ Michigan

5. How many Great Lakes are there?

○ 5 ○ 7 ○ 9

6. Las Vegas is located in _________.

○ Nevada ○ California ○ Arizona

7. San Diego borders _________.

○ Canada ○ Mexico ○ Arizona

8. The capital of Florida is _________.

○ Miami ○ Tallahassee ○ Palm Beach

9. The capital of Illinois is _________.

○ Springfield ○ Chicago ○ Illinois City

10. "Lake Okeechobee" is found in the state of _________.

○ Minnesota ○ Utah ○ Florida

11. The two-letter abbreviation for the state of Montana is _________.

○ MO ○ MT ○ MN

12. Which of these states is NOT in the Midwestern U.S.?

○ Iowa ○ Colorado ○ Wisconsin

13. Which of the following states was once a monarchy?

○ Texas ○ California ○ Hawai'i

14. The "Four Corners Area" is where the boundaries of the states of _________ meet.

○ Arizona, New Mexico, Colorado, and Utah

○ Idaho, Utah, Wyoming, and Colorado

○ Colorado, New Mexico, Oklahoma, and Texas

15. Lake Michigan borders how many U.S. states?

○ 3 ○ 4 ○ 5

16. Kansas City is in both Kansas and what other U.S. state?

○ Missouri ○ Nebraska ○ Oklahoma

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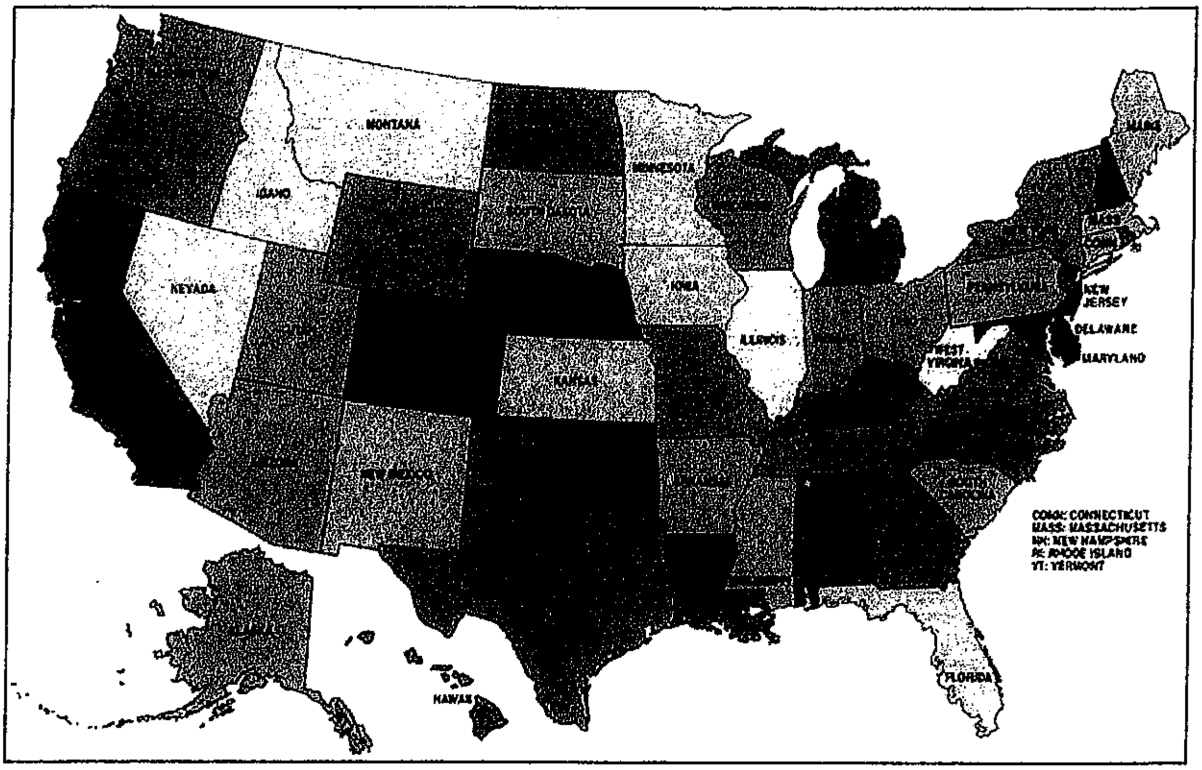
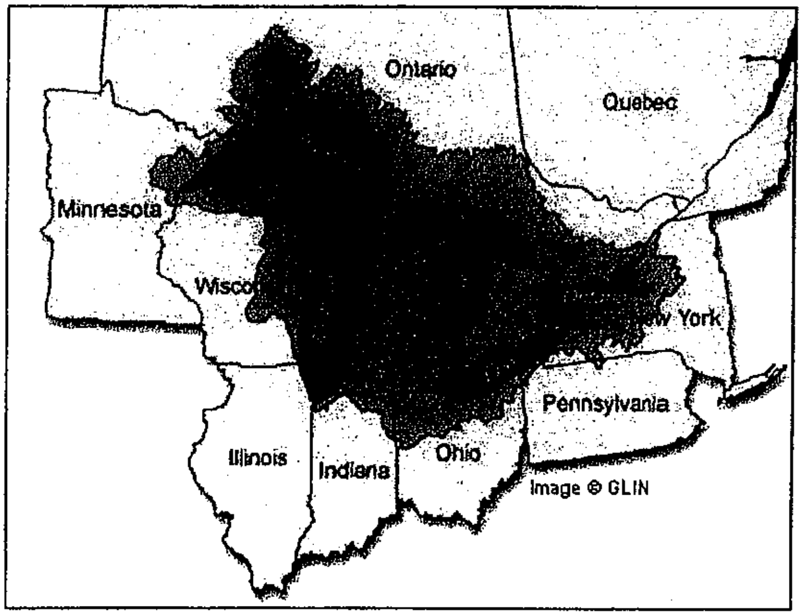


Map of the USA



The Great Lakes area

HOW MUCH DO YOU KNOW ABOUT AUSTRALIA ?

1. Which is the second largest continent?

❍ Asia ❍ South America ❍ Australia (Oceania) ❍ Africa ❍ Europe

2. Australia is the ... largest country in the world?

❍ 4th ❍ 6th ❍ 2nd ❍ 26th ❍ 11th

3. The Aborigines used the boomerang as a ...

❍ tool of communication ❍ weapon ❍ religious symbol

❍ sports equipment ❍ toy for their children to exercise for hunting

4. What is the number of inhabitants in Australia?

❍ 70 million ❍ 10 million ❍ 80 million ❍ 40 million ❍ 20 million

5. What is the capital of Australia?

❍ Toronto ❍ Canberra ❍ Sydney ❍ Melbourne ❍ Wellington

6. Which two oceans does Australia touch?

❍ Pacific and Atlantic ❍ Pacific and Arctic ❍ Atlantic and Arctic

❍ Atlantic and Indian ❍ Pacific and Indian

7. What is the largest and the most populous city in Australia?

❍ Melbourne ❍ Canberra ❍ Sydney ❍ Perth ❍ Alice Springs

8. What is Australia also called?

❍ the Down Under land ❍ the Green Island ❍ the Bush land ❍ the Queen's Pearl

9. What is a didgeridoo?

❍ an aboriginal musical instrument ❍ a barbecue set ❍ a native bird

❍ a kangaroo ❍ a poisonous snake

10. What is a common nickname for non native Australians?

❍ Yankees ❍ Aussies ❍ Possums ❍ Brucees ❍ Tommies

11. What type of animal is the kookaburra?

O a fish O a kangaroo O a snake O a bird

12. When does Winter begin in Australia?

O June O December O March O January O September

13. What is the name of the large island off the southern coast of Australia?

O New Zealand O Hawai O Man O Guam O Tasmania

14. What do koalas eat?

O gum leaves O insects O grass O bamboo O people

15. Which European flag can you recognise in the Australian flag?

O Dutch O Portuguese O British O Spanish O none

16. When did the First Fleet of 11 ships with male convicts arrive in Australia?

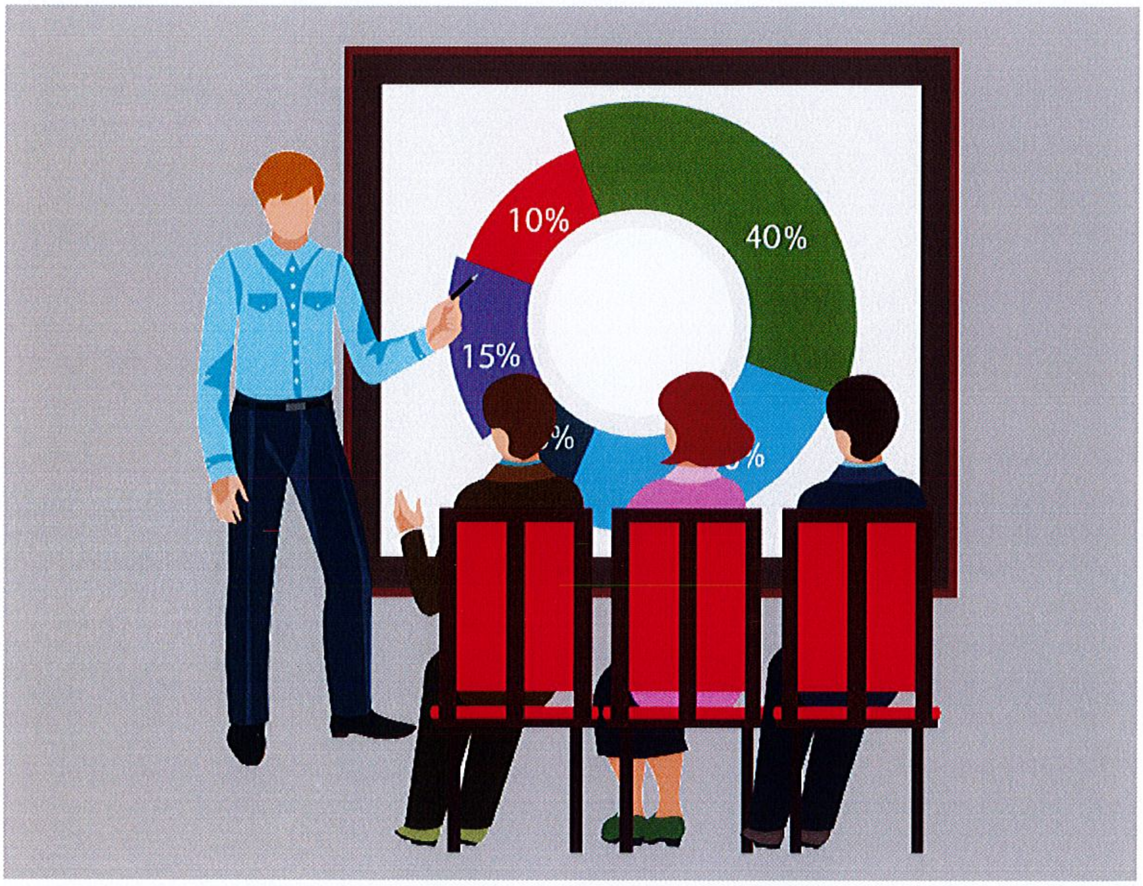
O 1830 O 1512 O 1670 O 1788 O 1492

17. Can you quote <u>at least</u> 3 famous Australian personalities ?

O .... O .... O ....

O .... O ....

Presentation



STRUCTURING YOUR PRESENTATION

A – BEING CLEAR ABOUT YOUR OBJECTIVE

Being clear about your objective is the first and most important rule for giving an effective presentation. If you yourself are not clear about the main message of your presentation, then your audience will find your presentation confusing.

B – ORGANIZING THE INFORMATION

Academic presentations are not like after-dinner speeches. Their main function is not to entertain but to provide information. So it is vitally important that the information is presented clearly. Ways of organizing the information include:

- chronological sequence
- most important to least important
- general to particular
- one point of view compared with another point of view.

Using familiar information structures like these helps the audience to follow your presentation more easily.

C – SIGNALLING THE STRUCTURE

Planning a well-structured presentation is not enough. When you actually give your presentation, you must make its structure clear to the listeners. Remember: you may have a plan and know the structure of your talk, but the listeners do not know it unless you tell them! They need to be guided through the spoken information. To do this, you need to use what are often called *signposts* and *language signals.*

➔ **'Signposting'** gives an advance view of the organization of the whole presentation, or of the next section.

Examples of 'signposting':

- Organization of the whole presentation: ***First*** *I will tell you something about..., **then** I will present..., and **finally** I will add...*
- Organization of the next section: *There are **three aspects** that need to be considered: **economic**, **legal** and **psychological**. The **economic aspect**...*

➔ **Language signals** are words and phrases that tell the listener where you are in the presentation, where you are taking them next and where they have just been. They may signal either: the topic of the whole talk; the beginning or end of a section of the talk; a new point in a list; a contrasting point; an example; or a point of special importance.

Examples of language signals:

- The topic of the talk: *I want to focus on...*
- A complete section: *And now I'd like to turn to the issue of...*
- A new point in a list: *Secondly, ...*
- A contrasting point: *However, others believe that...*
- An example: *In some countries, for example India and Thailand, ...*
- A point of special importance: *I would like to emphasize the importance of...*

The distinction between signposting and language signals is not important. Indeed, some people use the terms interchangeably. But taken together their function is important. If the main points of your talk are well-organised AND clearly signalled, you are well on the way to making an effective and clear presentation.

Source: K. Anderson, J. Maclean, T. Lynch. *Study Speaking. A Course in Spoken English for Academic Purposes.* Cambridge: CUP, 2004.

SIGNPOSTS AND LANGUAGE SIGNALS – CHECKLIST

INTRODUCING THE TALK	I'd like to I'm going to I want to	talk about discuss tell you about		
	What I'd like to do What I'm going to do What I want to do	IS	to explain to describe to give you an account of	
ORDERING THE POINTS (TIME ORDER)	To begin with Second(ly) Finally	At the beginning Then At the end	Next	At the start After that
ORDERING THE POINTS (LISTING AND ADDING)	First(ly)	Second(ly) A second reason Another point Also Last(ly)		Third(ly) The third aspect Other factors In addition Finally
STARTING A NEW SECTION	Now Moving on to Turning to What...?	If we move on to If we turn to Why...?	How...?	I'd like to move on to I'd like to turn to Which...?
TRANSITION	Having considered..., let us move on to...			
CONTRASTING	But On the other hand	However By contrast	Nevertheless	
REPHRASING	That is	In other words		To put it another way
GIVING AN EXAMLPLE	For example Such as Say To give you an example Let me give you an example	For instance Like	Including An example of this is Here is an example	
EMPHASIZING	Actually Importantly It's clear that	In fact Surprisingly Clearly	Indeed Interestingly Obviously	
	I'd like to underline / highlight / emphasize / stress It's important to bear in mind / keep in mind / remember			
CONCLUDING	So To summarize I'd like to finish by saying that I'd like to conclude now with a few remarks about	Finally Summing up	To conclude	In conclusion

2/4

Source: K. Anderson, J. Maclean, T. Lynch. *Study Speaking. A Course in Spoken English for Academic Purposes.* Cambridge: CUP, 2004.

The time

It is important that you keep to time – especially in an academic setting where marks may be deducted if you talk for longer than allocated. Make yourself a note before you start as to the time you need to finish by, keep an eye on the clock and if you run out of time, stop. Audiences welcome talks that finish on time – or a bit before.

After a presentation

Once the talk is over, the audience may still have some questions. When handling questions remember to:

- **Appear interested**. Give your questioner your full attention and put them at ease if they appear nervous.
- **Summarise the question.** Rephrasing the question not only gives you time to think, and confirms with the questioner that you have understood, but also ensures that the rest of the audience have heard it.
- **Answer the question set**. The temptation, if you don't know the answer, is to talk about something else. Try and stick to the topic and if you don't know, offer to take their details and find out for them.
- **Don't talk too long.** The time for questions is always limited and there may be other questioners waiting for their turn. Try and keep your answers succinct and to the point.

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3/4

PRESENTATION SKILLS

This advice sheet will help you to deliver an oral presentation with confidence, by lookin at what should be considered **before, during, and after** a talk.

Before a presentation

The success of a good presentation lies in the preparation. Take time to think about:

- **The audience** – who are they, how many and what do they already know?
- **The occasion** – is it formal or informal? A lecture, a debate, a speech?
- **The point** – what is the purpose of the talk?
- **The environment** – what is the size and layout of the room, and what facilities will be available (OHP)?

Once this has been considered, it's time to **gather, select and structure** your material.

Gathering

There are many sources of information available to you, make sure you assess the authority (who wrote it?), currency (how up-to-date is it?) and accuracy of a source befo you rely on it to support a point in your presentation.

Selecting

Often when you are asked to give a talk you will need to distil a large amount of information into a short time period. You need to be ruthless in the way that you prioritis information. Too much information can confuse an audience.

- What is centrally relevant?
- What can be left out?
- What is supporting information?
- Will handouts help?

Structuring

A clear structure to your presentation will not only provide you with a clear path to follov but also help your audience. Think about:

- What are your main points?
- In what order do they need to be discussed?
- What secondary information should come under each of your headings?

Either side of your main argument, remember to write:

• **An introduction**

This should welcome your audience, introduce the key themes of your presentation, and the order in which you will present them. This will lay a map down in the minds of the audience.

• **A conclusion**

This should summarise the main points of your presentation and perhaps introduce a final point or question to linger in the minds of your audience.

Managing your props: notes, visual aids, and handouts

Notes

You'll need to think about how you are going to deliver your presentation. Some people memorise the whole talk, others read the entire thing from their notes. A middle ground is probably the best way. Familiarise yourself with your material to the point that you will only need structured notes to guide you. This saves you from forgetting what you memorised, or losing your place in reams of text.

Visual aids

Visual aids are helpful both to you as the speaker, and to your audience. They can help illustrate your points and avert the audience's gaze which helps if you're nervous. They also help to retain the audience's interest, giving them another means by which they can understand the point you are making. No matter the form of visual aid, ensure they are visible to all, legible, and remember to remove them when you've finished with them to avoid distraction.

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Handouts

Providing handouts is another good way of reinforcing your message and providing supplementary material that there may not be time to present.

Managing nerves

Nervousness is probably the biggest problem that most inexperienced speakers face. Actually, it's good to feel a bit nervous, as this provides the adrenalin rush we need to give a good performance. However, excessive nerves can have the opposite effect and no-one enjoys the physical or emotional symptoms of fear. So how can nerves be managed?

- **Practice, practice, practice:** Rehearse in front of the mirror, or with friends. Feeling prepared goes a long way to alleviating your nerves.
- **Name your fears:** Write down exactly what it is you're afraid of, then you can devise strategies to cope.
- **What is the worst case scenario?** Even if the talk fails miserably, you will not die. Thinking of the worst case scenario often puts things back in perspective.
- **Relaxation techniques:** Regular deep breathing gives your body the oxygen it needs to burn off excess adrenalin, thus calming you down. A walk should have the same effect.

"If you are over-nervous, it does not mean you cannot be a successful speaker, it merely means you have more work to do".
Turk, Christopher. (1985) Effective Speaking: communicating in speech. London: Spon. P112

4/4

During a presentation

When the day finally arrives and your turn has come, don't be in a rush to start and 'get over and done with'. Take your time to 'set out your stall', ensure your notes are in order, your visual aids in place and that the environment is as you want it to give you confidence during the presentation. Give some thought to **your audience, your voice, your body and the time.**

Your audience

Remembering that the audience are a group of real people, who are on your side (not an enemy), and with a genuine interest in what you have to say, goes a long way to helping you communicate with them effectively. It also helps alleviate nerves.

"If I were asked which was the main advice I would give a novice speaker, I would choose these three:
1. Trust and like the audience, do not fear and confront them
2. Look at them
3. Smile

The second and third of these are, of course, the ways in which the first is expressed.
Turk, Christopher. (1985) Effective Speaking: communicating in speech. London: Spon P39

Your voice

There are estimates that the words we use count for only 7% of the message we communicate. The remaining 93% comes from the tone of voice, facial expressions, gestures and so on. When thinking about our voices we need to ensure they are:
• **Audible** – some rooms have better acoustics than others, but nerves can cause our volume to decrease. Keep your head up and speak slowly and clearly, aiming at the person at the back of the room.
• **Interesting** – concentration spans are short so retain interest by varying the tone of your voice. Asking a question naturally causes this to happen.
• **Appropriately paced** – Research has shown that we don't speak more quickly during presentations, but the number of natural pauses in our speech decreases. It may feel artificial, but insert enough pauses in your talk to allow the audience to take in all the information. One trick is to add a couple of extra seconds of silence as you change slides.

Your body

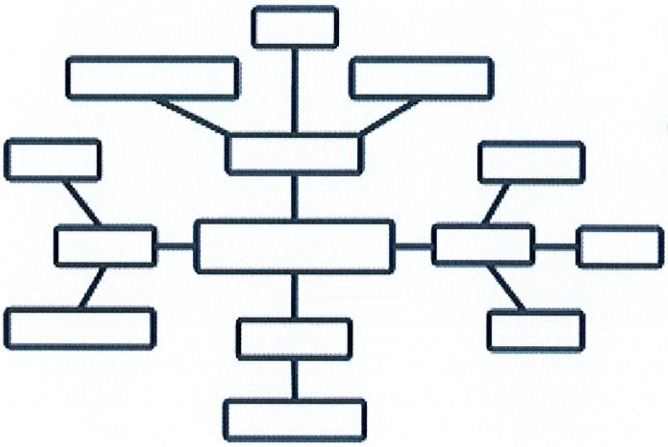
Non-verbal communication speaks as much as our words and voices. When speaking remember:
• **Eye contact**. Keep in contact with your audience, look at them, try and make eye contact, and if the group is spread out make sure you look around the room to involve them all. If you are too nervous to make eye contact, try focusing on people's forehead – this gives the impression you're making eye contact!
• **Don't fidget**. It is hard to listen to the content of a talk if the speaker is pacing up and down or fiddling with her glasses.

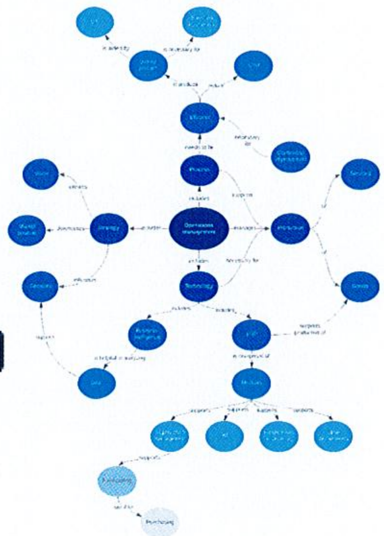
<u>**Life Map**</u>

In groups of two or three, read the following text, use it as an inspiring tool and draw your colleague life map in order to present it to the class.

But what is a life map?

A life map is a visual which shows the important moments of somebody's life. It can have a cloud shape or a basic algorithmic aspect.





Remember that you are presenting the past, the present, but also the future.

Make it as clear as possible and use an easy language to explain it to the others.

Good luck and do not forget, it is <u>**marked**</u>!

What's on Your Life Map?

By johanna July 19, 2017 question of the week No Comments

I was coaching a client recently, and he said something fascinating. "That wasn't on my life map. I hadn't even thought of it."

I asked him more questions, and he explained that he had this idea of a life map. He knew where he wanted to go, and he had several ways to get there. (My role was to help him see other alternatives, for destinations and paths.)

A life map is a great metaphor. Maps show you alternative paths to your destination. Maps might provide you an idea about the distances between locations. And, if you're like me, you like seeing the variety of names on the maps.

The problem arises when we think there is just one path on our life maps.

Years ago, I met a woman looking for a new job. I asked her what she wanted to do and she said, "I'm a Cobol programmer."

I said, "So, you want a job as a developer, right?"

She frowned and said, "No. I want a job as a Cobol programmer."

Oops. She had one destination and one path on her life map.

Each of us has our destination. (I have several possible destinations.) The real key is how many paths do you have to achieve your destination?

Every map has alternatives. In this map, it's about backup paths for interconnectedness. For ourselves, it's about alternative paths.

That woman who was determined to remain a Cobol (and nothing else) programmer had one and only one path. She treated her life map as a directed graph. (A directed graphstarts in one place and ends in another, following a directed sequence. Not necessarily linear, but directed.) She had one alternative on her life map.

But, life is an undirected graph. We try something, we decide if we want to do more of it and if so, we continue. Maybe we add something else. Maybe we back up and try an alternative. There is no defined start or end.

Before I settled on the management part of my career, I had this career path: 18

Developer->project manager->developer->manager->project manager->tester->project manager->manager->director->developer->manager.

I stayed in what we might call the "platform" side of software products: operating systems, embedded systems, that kind of thing. But, I had an undirected graph for my career.

I don't know what the "right" idea is for your career or your life. I know that for me, exploring the undirected graph excites me and fulfills me. I like exploring my life map.

The more options I create, and the more experiments I try, the deeper my life map alternatives are. The deeper my alternatives, the more adaptable and resilient I am.

That is the question this week: What's on your life map?

In this section you are going to work in groups of 3 or 4 students.

Each of you has a special task and must focus on:

- Vocabulary
- Grammar
- Content
- Power Point of the topics above

First, read the text once or twice to pick up the general idea.

Next, make a list of the vocabulary which needs to be explained and the explanation must be in **ENGLISH**.

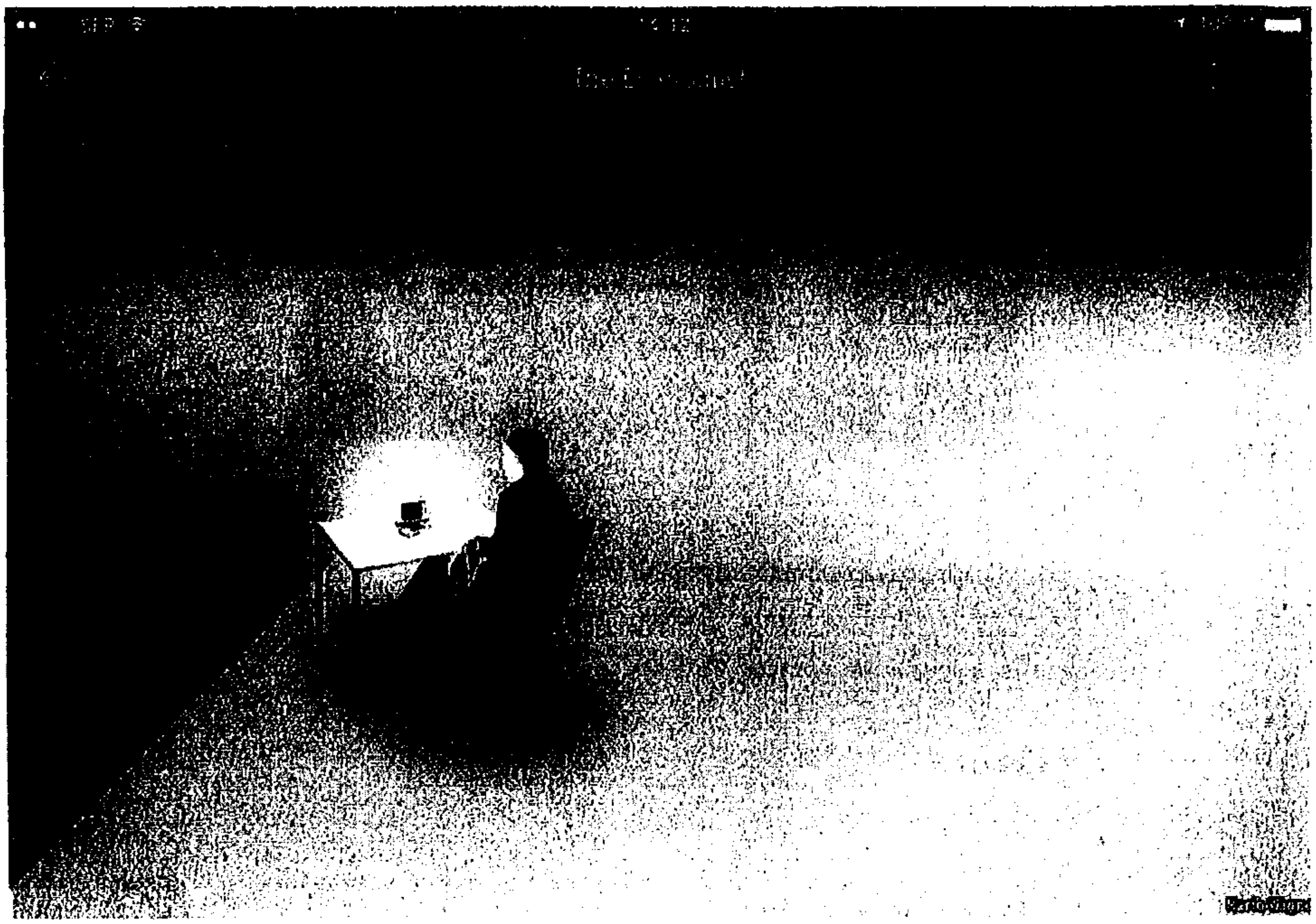
Then, focus on one or two grammar points which you choose to develop according to the text.

And finally, try to explain the journalist's main idea using your **OWN** words. Do not copy and paste!

All this must be put on 4 or 5 Power Point slides maximum to be presented to the class.

This is going to help you prepare your marked presentation.

Good luck.



After Moore's law

Double, double, toil and trouble

After a glorious 50 years, Moore's law—which states that computer power doubles every two years at the same cost—is running out of steam. Tim Cross asks what might replace it

IN 1971 a small company called Intel released the 4004, its first ever microprocessor. The chip, measuring 12 square millimetres, contained 2,300 transistors—tiny electrical switches representing the 1s and 0s that are the basic language of computers. The gap between each transistor was 10,000 nanometres (billionths of a metre) in size, about as big as a red blood cell. The result was a miracle of miniaturisation, but still on something close to a human scale. A child with a decent microscope could have counted the individual transistors of the 4004.

The transistors on the Skylake chips Intel makes today would flummox any such inspection. The chips themselves are ten times the size of the 4004, but at a spacing of just 14 nanometres (nm) their transistors are invisible, for they are far smaller than the wavelengths of light human eyes and microscopes use. If the 4004's transistors were blown up to the height of a person, the Skylake devices would be the size of an ant.

The difference between the 4004 and the Skylake is the difference between computer behemoths that occupy whole basements and stylish little slabs 100,000 times more powerful that slip into a pocket. It is the difference between telephone systems operated circuit by circuit with bulky electromechanical switches and an internet that ceaselessly shuttles data packets around the world in their countless trillions. It is a difference that has changed everything from metal-bashing to foreign policy, from the booking of holidays to the designing of H-bombs.

It is also a difference capable of easy mathematical quantification. In 1965 Gordon Moore, who would later become one of the founders of Intel, a chipmaker, wrote a paper noting that the number of electronic components which could be crammed into an integrated circuit was doubling every year. This exponential increase came to be known as Moore's law.

In the 1970s the rate of doubling was reduced to once every two years. Even so, you would have had to be very brave to look at one of Intel's 4004s in 1971 and believe that such a law would continue to hold for 44 years. After all, double something 22 times and you have 4m times more of it, or perhaps something 4m times better. But that is indeed what has happened. Intel does not publish transistor counts for its Skylake chips, but whereas the 4004 had 2,300 of them, the company's Xeon Haswell E-5, launched in 2014, sports over 5 billion, just 22 nm apart.

Moore's law is not a law in the sense of, say, Newton's laws of motion. But Intel, which has for decades been the leading maker of microprocessors, and the rest of the industry turned it into a self-fulfilling prophecy. That fulfilment was made possible largely because transistors have the unusual quality of getting better as they get smaller; a small transistor can be turned on and off with less power and at greater speeds than a larger one. This meant that you could use more and faster transistors without needing more power or generating more waste heat, and thus that chips could get bigger as well as better.

Making chips bigger and transistors smaller was not easy; semiconductor companies have for decades spent heavily on R&D, and the facilities —"fabs"—in which the chips have been made have become much more expensive. But each time transistors shrank, and the chips made out of them became faster and more capable, the market for them grew, allowing the makers to recoup their R&D costs and reinvest in yet more research to make their products still tinier.

The demise of this virtuous circle has been predicted many times. "There's a law about Moore's law," jokes Peter Lee, a vice-president at Microsoft Research: "The number of people predicting the death of Moore's law doubles every two years." But now the computer industry is increasingly aware that the jig will soon be up. For some time, making transistors smaller has no longer been making them more energy-efficient; as a result, the operating speed of high-end chips has been on a plateau since the mid-2000s (see chart). And while the benefits of making things smaller have been decreasing, the costs have been rising.

This is in large part because the components are approaching a fundamental limit of smallness: the atom. A Skylake transistor is around 100 atoms across, and the fewer atoms you have, the harder it becomes to store and manipulate electronic 1s and 0s. Smaller transistors now need trickier designs and extra materials. And as chips get harder to make, fabs get ever more expensive.

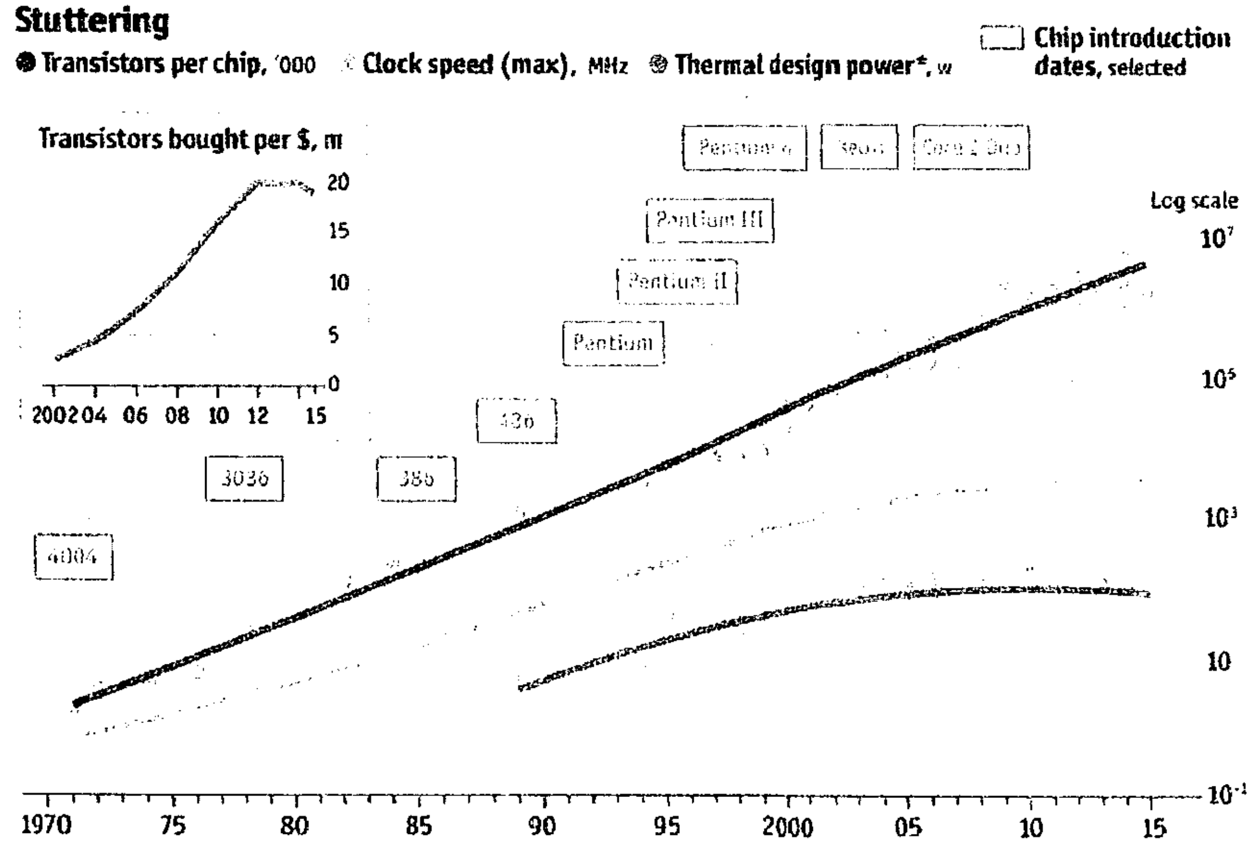
Handel Jones, the CEO of International Business Strategies, reckons that a fab for state-of-the-art microprocessors now costs around $7 billion. He thinks that by the time the industry produces 5nm chips (which at past rates of progress might be in the early 2020s), this could rise to over $16 billion, or nearly a third of Intel's current annual revenue. In 2015 that revenue, at $55.4 billion, was only 2% more than in 2011. Such slow increases in revenue and big increases in cost seem to point to an obvious conclusion.

"From an economic standpoint, Moore's law is over," says Linley Gwennap, who runs the Linley Group, a firm of Silicon Valley analysts.

The pace of advance has been slowing for a while. Marc Snir, a supercomputing expert at Argonne National Laboratory, Illinois, points out that the industry's International Technology Roadmap for Semiconductors, a collaborative document that tries to forecast the near future of chipmaking, has been over-optimistic for a decade. Promised manufacturing innovations have proved more difficult than expected, arriving years late or not at all.

Brian Krzanich, Intel's boss, has publicly

Stuttering



Sources: Intel; Bob Colwell; Linley Group; International Business Strategies; *The Economist* *Maximum safe power consumption admitted that the firm's rate of progress has slowed. Intel has a biennial "tick-tock" strategy: in one year it will bring out a chip featuring smaller transistors ("tick"); the following year it tweaks that chip's design ("tock") and prepares to shrink the transistors again in the following year. But when its first 14nm chips, codenamed Broadwell, ticked their way to market in 2014 they were nearly a year behind schedule. The tick to 10nm that was meant to follow the tock of the Skylakes has slipped too; Intel has said such products will not now arrive until 2017. Analysts reckon that because of technological problems the company is now on a "tick-tock-tock" cycle. Other big chipmakers have had similar problems.

Moore's law has not hit a brick wall. Chipmakers are spending billions on new designs and materials that may make transistors amenable to a bit more shrinkage and allow another few turns of the exponential crank. They are also exploring ways in which performance can be improved with customised designs and cleverer programming. In the past the relentless doubling and redoubling of computing power meant there was less of an incentive to experiment with other sorts of improvement.

Try a different route

More radically, some hope to redefine the computer itself. One idea is to harness quantum mechanics to perform certain calculations much faster than any classical computer could ever hope to do. Another is to emulate biological brains, which perform impressive feats using very little energy. Yet another is to diffuse computer power rather than concentrating it, spreading the ability to calculate and communicate across an ever greater range of everyday objects in the nascent internet of things.

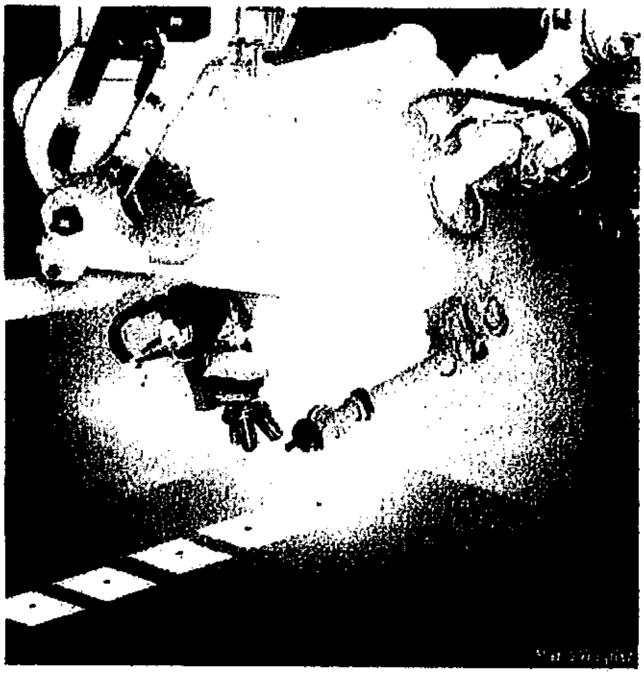
Moore's law provided an unprecedented combination of blistering progress and certainty about the near future. As that certainty wanes, the effects could be felt far beyond the chipmakers faced with new challenges and costs. In a world where so many things—from the cruising speed of airliners to the median wage—seem to change little from decade to decade, the exponential growth in computing power underlies the future plans of technology providers working on everything from augmented-reality headsets to self-driving cars. More important, it has come to stand in the imagination for progress itself. If something like it cannot be salvaged, the world would look a grimmer place.

At the same time, some see benefits in a less predictable world that gives all sorts of new computing technologies an opportunity to come into their own. "The end of Moore's law could be an inflection point," says Microsoft's Dr Lee. "It's full of challenges—but it's also a chance to strike out in different directions, and to really shake things up." ■

More Moore

The incredible shrinking transistor

New sorts of transistors can eke out a few more iterations of Moore's law, but they will get increasingly expensive



THANKS to the exponential power of Moore's law, the electronic components that run modern computers vastly outnumber all the leaves on the Earth's trees. Chris Mack, a chipmaking expert, working from a previous estimate by VLSI Research, an analysis firm, reckons that perhaps 400 billion billion ($4x10^{20}$) transistors were churned out in 2015 alone. That works out at about 13 trillion a second. At the same time they have become unimaginably small: millions could fit on the full stop at the end of this sentence.

A transistor is a sort of switch. To turn it on, a voltage is applied to its gate, which allows the current to flow through the channel between the transistor's source and drain (see first diagram). When no current flows, the transistor is off. The on-off states represent the 1s and 0s that are the fundamental language of computers.

The silicon from which these switches are made is a semiconductor, meaning that its electrical properties are halfway between those of a conductor (in which current can flow easily) and an insulator (in which it cannot). The electrical characteristics of a semiconductor can be tweaked, either by a process called "doping", in which the material is spiced with atoms of other elements, such as arsenic or boron, or by the application of an electrical field.

In a silicon transistor, the channel will be doped with one material and the source and drain with another. Doping alters the amount of energy required for any charge to flow through a semiconductor, so where two differently doped materials abut each other, current cannot flow. But when the device is switched on, the electric field from the gate generates a thin, conductive bridge within the channel which completes the circuit, allowing current to flow through.

For a long time that basic design worked better and better as transistors became ever smaller. But at truly tiny scales it begins to break down. In modern transistors the source and drain are very close together, of the order of 20nm. That causes the channel to leak, with a residual current flowing even when the device is meant to be off, wasting power and generating unwanted heat.

Heat from this and other sources causes serious problems. Many modern chips must either run below their maximum speeds or even periodically switch parts of themselves off to avoid overheating, which limits their performance. Chipmakers are trying various methods to avoid this. One of them, called strained silicon, which was introduced by Intel in 2004, involves stretching the atoms of the silicon crystal further apart than normal, which lubricates the passage of charge carriers through the channel, reducing the heat generated.

In another technique, first adopted in 2007, metal oxides are used to combat the effects of tunnelling, a quantum phenomenon in which particles (such as electrons) on one side of a seemingly impermeable barrier turn up on the other side without ever passing through the intervening space. Developing more such esoteric techniques may allow chipmakers to go on shrinking transistors for a little longer, but not much.

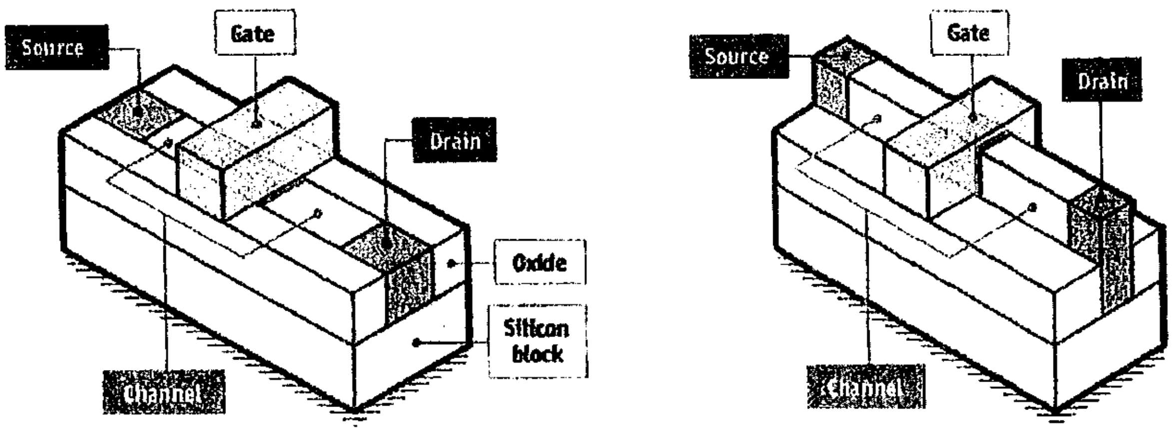
The 3D effect

Beyond that, two broad changes will be needed. First, the design of the transistor will have to be changed radically. Second, the industry will have to find a replacement for silicon, the electrical properties of which have already been pushed to their limits.

One solution to the problem of leaking current is to redesign the channel and the gate. Conventionally, transistors have been flat, but in 2012 Intel added a third dimension to its products. To enable it to build chips with features just 22nm apart, it switched to transistors known as "finFET", which feature a channel that sticks

Better by design

Standard transistor | **finFET transistor**



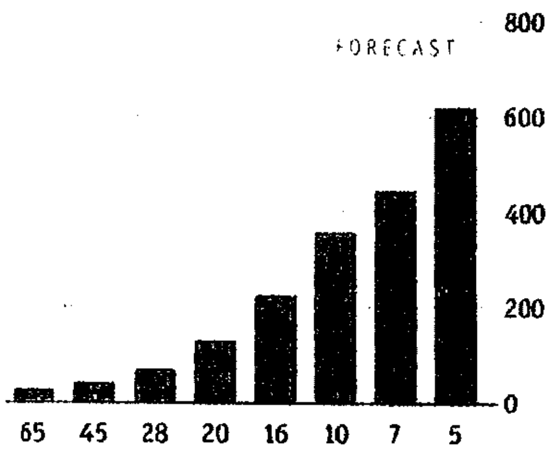
A transistor is a switch. Ordinarily, current cannot flow. When a voltage is applied to the **gate**, the channel becomes conductive, current flows from the source to the drain, and the transistor switches on.

A finFET transistor raises the channel above the block of silicon upon which the device sits. That allows the **gate** to wrap around three sides of the channel, improving its electrical properties.

Source: *The Economist*

This can't go on

Design cost by chip component size in nm, $m



Source: International Business Strategies

up from the surface of the chip. The gate is then wrapped around the channel's three exposed sides (see second diagram), which gives it much better control over what takes place inside the channel. These new transistors are trickier to make, but they switch 37% faster than old ones of the same size and consume only half as much power.

The next logical step, says Mr Snir of Argonne National Laboratory, is "gate-all-around" transistors, in which the channel is surrounded by its gate on all four sides. That offers maximum control, but it adds extra steps to the manufacturing process, since the gate must now be built in multiple sections. Big chipmakers such as Samsung have said that it might take gate-all-around transistors to build chips with features 5nm apart, a stage that Samsung and other makers expect to be reached by the early 2020s.

Beyond that, more exotic solutions may be needed. One idea is to take advantage of the quantum tunnelling that is such an annoyance for conventional transistors, and that will only get worse as transistors shrink further. It is possible, by applying electrical fields, to control the rate at which tunnelling happens. A low rate of leakage would correspond to a 0; a high rate to a 1. The first experimental tunnelling transistor was demonstrated by a team at IBM in 2004. Since then researchers have been working to commercialise them.

In 2015 a team led by Kaustav Banerjee, of the University of California, reported in *Nature* that they had built a tunnelling transistor with a working voltage of just 0.1, far below the 0.7V of devices now in use, which means much less heat. But there is more work to be done before tunnelling transistors become viable, says Greg Yeric of ARM, a British designer of microchips: for now they do not yet switch on and off quickly enough to allow them to be used for fast chips.

Jim Greer and his colleagues at Ireland's Tyndall Institute are working on another idea. Their device, called a junctionless nanowire transistor (JNT), aims to help with another problem of building at tiny scales: getting the doping right. "These days you're talking about [doping] a very small amount of silicon indeed. You'll soon be at the point where even one or two misplaced dopant atoms could drastically alter the behaviour of your transistor," says Dr Greer.

Instead, he and his colleagues propose to build their JNTs, just 3nm across, out of one sort of uniformly doped silicon. Normally that would result in a wire rather than a switch: a device that is uniformly conductive and cannot be turned off. But at these tiny scales the electrical influence of the gate penetrates right through the wire, so the gate alone can prevent current flowing when the transistor is switched off.

Whereas a conventional transistor works by building an electrical bridge between a source and a drain that are otherwise insulated, Dr Greer's device works the other way: more like a hose in which the gate acts to stop the current from flowing. "This is true nanotechnology," he says. "Our device only works at these sorts of scales. The big advantage is you don't have to worry about manufacturing these fiddly junctions."

Material difference

Chipmakers are also experimenting with materials beyond silicon. Last year a research alliance including Samsung, GlobalFoundries, IBM and State University New York unveiled a microchip made with components 7nm apart, a technology that is not expected to be in consumers' hands until 2018 at the earliest. It used the same finFET design as the present generation of chips, with slight modifications, but although most of the device was built from the usual silicon, around half of its transistors had channels made from a silicon-germanium (SiGe) alloy.

This was chosen because it is, in some ways, a better conductor than silicon. Once again, that means lower power usage and allows the transistor to switch on and off more quickly, boosting the speed of the chip. But it is not a panacea, says Heike Riel, the director of the physical-sciences department at IBM Research. Modern chips are built from two types of transistor. One is designed to conduct electrons, which carry a negative charge. The other sort is designed to conduct "holes", which are places in a semiconductor that might contain electrons but happen not to; these, as it turns out, behave as if they were positively charged electrons. And although SiGe excels at transporting holes, it is rather less good at moving electrons than silicon is.

Future paths to higher performance along these lines will probably require both SiGe and another compound that moves electrons even better than silicon. The materials with the most favourable electrical properties are alloys of elements such as indium, gallium and arsenide, collectively known as III-V materials after their location in the periodic table.

The trouble is that these materials do not mix easily with silicon. The spacing between the atoms in their crystal lattices is different from that in silicon, so adding a layer of them to the silicon substrate from which all chips are made causes stress that can have the effect of cracking the chip.

The best-known alternative is graphene, a single-atom-thick (and hence two-dimensional) form of carbon. Graphene conducts electrons and holes very well. The difficulty is making it stop. Researchers have tried to get around this by doping, squashing or squeezing graphene, or applying electric fields to change its electrical properties. Some progress has been made: the University of Manchester reported a working graphene transistor in 2008; a team led by Guanxiong Liu at the University of California built devices using a property of the material called "negative resistance" in 2013. But the main impact of graphene, says Dr Yeric, has been to spur interest in other two-dimensional materials. "Graphene sort of unlocked the box," he says.

"Now we're looking at things like sheets of molybdenum disulphide, or black phosphorous, or phosphorous-boron compounds." Crucially, all of those, like silicon, can easily be switched on and off.

If everything goes according to plan, says Dr Yeric, novel transistor designs and new materials might keep things ticking along for another five or six years, by which time the transistors may be 5nm apart. But beyond that "we're running out of ways to stave off the need for something really radical."

His favoured candidate for that is something called "spintronics". Whereas electronics uses the charge of an electron to represent information, spintronics uses "spin", another intrinsic property of electrons that is related to the concept of rotational energy an object possesses. Usefully, spin comes in two varieties, up and down, which can be used to represent 1 and 0. And the computing industry has some experience with spintronics already: it is used in hard drives, for instance.

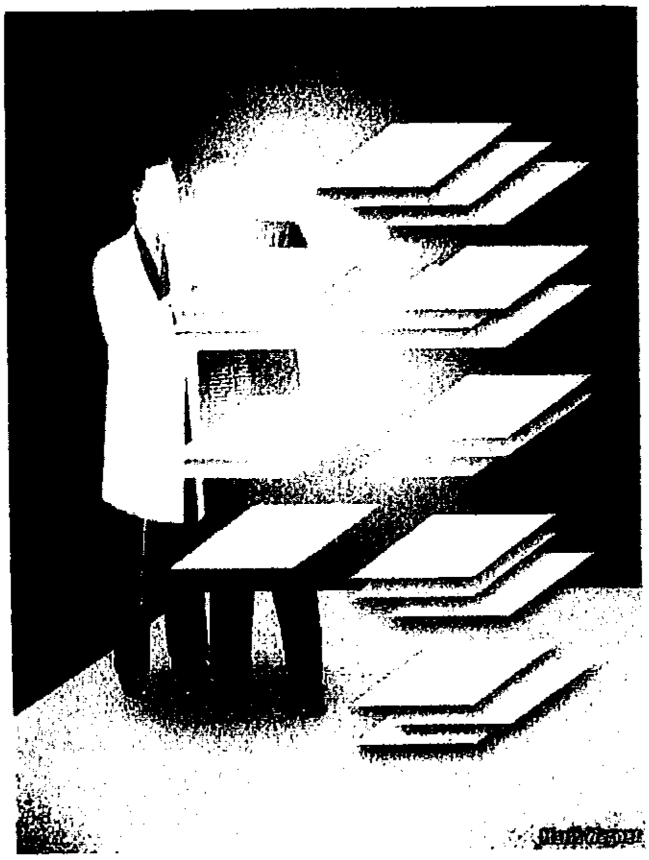
Research into spintronic transistors has been going on for more than 15 years, but none has yet made it into production. Appealingly, the voltage needed to drive them is tiny: 10-20 millivolts, hundreds of times lower than for a conventional transistor, which would solve the heat problem at a stroke. But that brings design problems of its own, says Dr Yeric. With such minute voltages, distinguishing a 1 or a 0 from electrical noise becomes tricky.

"It's relatively easy to build a fancy new transistor in the lab," says Linley Gwennap, the analyst. "But in order to replace what we're doing today, you need to be able to put billions on a chip, at a reasonable cost, with high reliability and almost no defects. I hate to say never, but it is very difficult." That makes it all the more important to pursue other ways of making better computers. ■

New designs

Taking it to another dimension

How to get more out of existing transistors



STRICTLY speaking, Moore's law is about the ever greater number of electronic components that can be crammed onto a given device. More generally, though, it is used as shorthand for saying that computers are always getting better. As transistors become harder and harder to shrink, computing firms are starting to look at making better use of the transistors they already have. "Managers in the past wouldn't want to invest a lot in intensive design," says Greg Yeric at ARM. "I think that's going to start shifting."

One way is to make the existing chips work harder. Computer chips have a master clock; every time it ticks, the transistors within switch on or off. The faster the clock, the faster the chip can carry out instructions. Increasing clock rates has been the main way of making chips faster over the past 40 years. But since the middle of the past decade clock rates have barely budged.

Chipmakers have responded by using the extra transistors that came with shrinking to duplicate a chip's existing circuitry. Such "multi-core" chips are, in effect, several processors in one, the idea being that lashing several slower chips together might give better results than relying on a single speedy one. Most modern desktop chips feature four, eight or even 16 cores.

But, as the industry has discovered, multi-core chips rapidly hit limits. "The consensus was that if we could keep doing that, if we could go to chips with 1,000 cores, everything would be fine," says Doug Burger, an expert in chip design at Microsoft. But to get the best out of such chips, programmers have to break down tasks into smaller chunks that can be worked on simultaneously. "It turns out that's really hard," says Dr Burger. Indeed, for some mathematical tasks it is impossible.

Another approach is to specialise. The most widely used chips, such as Intel's Core line or those based on ARM's Cortex design (found in almost every smartphone on the planet) are generalists, which makes them flexible. That comes at a price: they can do a bit of everything but excel at nothing. Tweaking hardware to make it better at dealing with specific mathematical tasks "can get you something like a 100- to 1,000-

fold performance improvement over some general solution", says Bob Colwell, who helped design Intel's Pentium chips. When Moore's law was doubling performance every couple of years at no cost anyway, there was little incentive to customise processing this way. But now that transistors are not necessarily getting faster and cheaper all the time, those tradeoffs are changing.

Something special

That was Sean Mitchell's thinking when, a decade ago, he co-founded a company called Movidius. The firm designs chips for use in computer vision, a booming field with applications in everything from robotics to self-driving cars to augmented reality. Movidius has since raised nearly $90m in funding.

"When we looked at the general-purpose chips out there," says Dr Mitchell, "we found that they were very inefficient." So Dr Mitchell and his co-founders set about designing their own specialised microprocessor.

"We've got to process high-resolution images, each containing millions of pixels, and coming in at 60, 90 or even 120 frames per second," he says. By tweaking the hardware to the task at hand—by providing exactly the mix of computational resources necessary for the mathematics of visual processing while leaving out any of the extraneous logic that would allow a general-purpose chip to perform other tasks—Movidius's Myriad 2 chip can crunch huge amounts of visual information but use less than a watt of power (which is about 20% of the consumption of the chips in smartphones and only about 1% of those in desktop computers). In January the firm announced a deal with Google.

Custom-built chips are already in use in other parts of the computing industry. The best-known examples are the graphics chips used to improve the visuals of video games, designed by firms such as Nvidia and AMD and first marketed to consumers in the mid-1990s. Intel's newer Pentium chips also come with built-in specialised logic for tasks such as decoding video. But there are downsides. Designing new chips takes years and can cost tens or even hundreds of millions of dollars. Specialised chips are also harder to program than general-purpose ones. And, by their very nature, they improve performance only on certain tasks.

A better target for specialised logic, at least at first, might be data centres, the vast computing warehouses that power the servers running the internet. Because of the sheer volume of information they process, data centres will always be able to find a use for a chip that can do only one thing, but do it very well.

With that in mind, Microsoft, one of the world's biggest software firms and providers of cloud-computing services, is venturing into the chip-design business. In 2014 it announced a new device called Catapult that uses a special kind of chip called a field-programmable gate array (FPGA), the configuration of which can be reshaped at will. FPGAs offer a useful compromise between specialisation and flexibility, says Dr Burger, who led the team that developed Catapult: "The idea is to have programmable hardware alongside programmable software." When one task is finished, an FPGA can be reconfigured for another job in less than a second.

The chips are already in use with Bing, Microsoft's search engine, and the company says this has doubled the number of queries a server can process in a given time. There are plenty of other potential applications, says Peter Lee, Dr Burger's boss at Microsoft. FPGAs excel when one specific algorithm has to be applied over and over again to torrents of data. One idea is to use Catapult to encrypt data flowing between computers to keep them secure. Another possibility is to put it to work on voice- and image-recognition jobs for cloud-connected smartphones.

The technology is not new, but until now there was little reason to use it. What is new is that "the cloud is growing at an incredible rate," says Dr Burger. "And now that Moore's law is slowing down, that makes it much harder to add enough computing capacity to keep up. So these sorts of post-Moore projects start to make economic sense."

At the IBM research lab on the shores of Lake Zurich, ambitions are set even higher. On a table in one of the labs sits a chip connected by thin hoses to a flask of purple-black liquid. Patrick Ruch, who works in IBM's Advanced Thermal Packaging group, sees this liquid as the key to a fundamental redesign of data centres. He and his colleagues think they can shrink a modern supercomputer of the sort that occupies a warehouse into a volume about the size of a cardboard box—by making better use of the third dimension.

Leaving aside innovations like finned transistors (see previous article), modern chips are essentially flat. But a number of companies, including IBM, are now working on stacking chips on top of each other, like flats in a tower block, to allow designers to pack more transistors into a given area. Samsung already sells storage systems made from vertically stacked flash memory. Last year Intel and Micron, a big memory-manufacturer, announced a new memory technology called 3D Xpoint that also uses stacking.

IBM's researchers are working on something slightly different: chip stacks in which slices of memory are sandwiched between slices of processing logic. That would allow engineers to pack a huge amount of computing into a tiny volume, as well as offering big performance benefits. A traditional computer's main memory is housed several centimetres from its processor. At silicon speeds, a centimetre is a vast distance. Sending signals across such distances also wastes energy. Moving the memory inside the chip cuts those distances from centimetres to micrometres, allowing it to shuttle data around more quickly.

But there are two big problems with 3D chips. The first is heat. Flat chips are bad enough; in a conventional data centre thousands of fans blowing hot air out of the server racks emit a constant roar. As more layers are added, the volume inside the chip, where the heat is generated, grows faster than the outside area from which it can be removed.

The second problem is getting electricity in. Chips communicate with the outside world via hundreds of metal "pins" on their undersides. Modern chips are so power-hungry that up to 80% of these pins are reserved for transporting electricity, leaving only a few to get data in and out. In 3D those constraints multiply, as the same number of pins must serve a much more complicated chip.

IBM hopes to kill two birds with one stone by fitting its 3D chips with miniscule internal plumbing. Microfluidic channels will carry cooling liquid into the heart of the chip, removing heat from its entire volume at once. The firm has already tested the liquid-cooling technology with conventional, flat chips. The microfluidic system could ultimately remove around a kilowatt of heat—about the same as the output of one bar of an electric heater—from a cubic centimetre of volume, says Bruno Michel, the head of the group (see Brain scan).

But the liquid will do more than cool the chips: it will deliver energy as well. Inspired by his background in biology, Dr Michel has dubbed the liquid "electronic blood". If he can pull it off, it will do for computer chips what biological blood does for bodies: provide energy and regulate the temperature at the same time. Dr Michel's idea is a variant of a flow battery, in which power is provided by two liquids that, meeting on either side of a membrane, produce electricity.

Flow batteries are fairly well understood. The electricity industry has been studying them as a way to store intermittent power from renewable energy sources. Dr Michel's system is still many years away from commercial deployment, but the principle has been established: when Dr Ruch switches on the flow, the chip to which the hoses are connected flickers into life—without a plug or a wire in sight. ■

Brain scan

Bruno Michel

IBM's head of advanced micro-integration reckons biology holds the key to more energy-efficient chips

IN 2011 a supercomputer called Watson, built by IBM, beat two top-rank human champions at "Jeopardy!", an American quiz show. This caused great excitement. Unlike chess, a game of abstract reason and logic, "Jeopardy!" is full of puns, *double entendres* and wordplay; just the sort of thing meant to stump computers. But Bruno Michel, who heads the advanced micro-integration group at IBM's research lab in Zurich, says it was not a fair fight. "Do you know how much power [Watson] consumes? At the time it was something like 80kW. That's thousands of times more than the humans it was playing against."

Dr Michel argues that computers are extremely inefficient machines, both in terms of the electricity they consume and the space they take up. A typical desktop machine or a server in a data centre, he reckons, uses only about 0.0001% of its volume to crunch numbers, and perhaps 1% to shuttle the results around. The rest is mostly empty space. The laws of physics set a limit to how efficiently information can be processed, but modern computers perform at only about 0.00004% of that theoretical maximum, he calculates. So for now a big data centre consumes tens of megawatts of power, almost all of which is transformed, literally, into hot air.

Moore's law used to keep a lid on electricity usage even as computing capacity raced ahead because smaller transistors needed less power. That is no longer true. "Nowadays the cost of buying a computer or a data centre is less than the cost of running it for a few years," says Dr Michel. "That's a paradigm shift." Data centres already consume 2% of all the electricity produced in the world.

Dr Michel's benchmark for efficiency is evolution; his original training was in mechanical engineering, but he fell in love with biology after reading a genetics textbook. After earning a PhD in biochemistry and biophysics from the

University of Zurich, he joined IBM's Zurich lab to work with the scanning tunnelling microscope developed there in 1981. It won its inventors a Nobel prize, allowing scientists to see and manipulate individual atoms. That job led to a project on manufacturing technology for flat-screen displays. "I get fascinated by new things, and then I want to start working on them," he says. "But my advice is: if you want to work in a new field, don't be driven by creativity—be driven by impact."

That is how he got involved in his current work on more energy-efficient chips. "In the middle of the past decade there was a panic in the chip industry—soon we won't be able to keep these things cool," he notes. At the same time energy policy was becoming more important as climate change moved up the political agenda.

Biology's secret weapon, he thinks, is the spidery, fractally branching network of blood vessels that supply energy to the brain, allowing most of its volume to be turned over to useful data-processing tasks. As near as neuroscientists can tell, a mammalian brain uses about 70% of its volume for moving information around, 20% for processing it and the remaining 10% to keep everything in the right place and supplied with nutrients. In doing all these things, a human brain consumes about 20 watts of power. That makes it roughly 10,000 times more efficient than the best silicon machines invented by those brains, Dr Michel reckons.

One of his favourite charts compares the density and efficiency of brains with a string of computing technologies going back to the second world war. All of them fall on a straight line, suggesting that to match the energy efficiency of the brain, scientists will have to emulate its density.

He is now working on a project to build an electronic version of the blood that channels energy to biological brains. "It was something like 200 years after the invention of the steam engine before mechanical engineering began to catch up with biology in terms of efficiency," he says. "It would be good if computing could accomplish the same thing in half the time." ■

Alternatives

Wait for it

A pipeline of new technologies to prolong Moore's magic

THE world's IT firms spend huge amounts on research and development. In 2015 they occupied three of the top five places in the list of biggest R&D spenders compiled by PricewaterhouseCoopers, a consultancy. Samsung, Intel and Microsoft, the three largest, alone shelled out $37 billion between them. Many of the companies are working on projects to replace the magic of Moore's law. Here are a few promising ideas.

Optical communication: the use of light instead of electricity to communicate between computers, and even within chips. This should cut energy use and boost performance (Hewlett-Packard, Massachusetts Institute of Technology).

Better memory technologies: building new kinds of fast, dense, cheap memory to ease one bottleneck in computer performance (Intel, Micron).

Quantum-well transistors: the use of quantum phenomena to alter the behaviour of electrical-charge carriers in a transistor to boost its performance, enabling extra iterations of Moore's law, increased speed and lower power consumption (Intel).

Developing new chips and new software to automate the writing of code for machines built from clusters of specialised chips. This has proved especially difficult (Soft Machines).

Approximate computing: making computers' internal representation of numbers less precise to reduce the numbers of bits per calculation and thus save energy; and allowing computers to make random small mistakes in calculations that cancel each other out over time, which will also save energy (University of Washington, Microsoft).

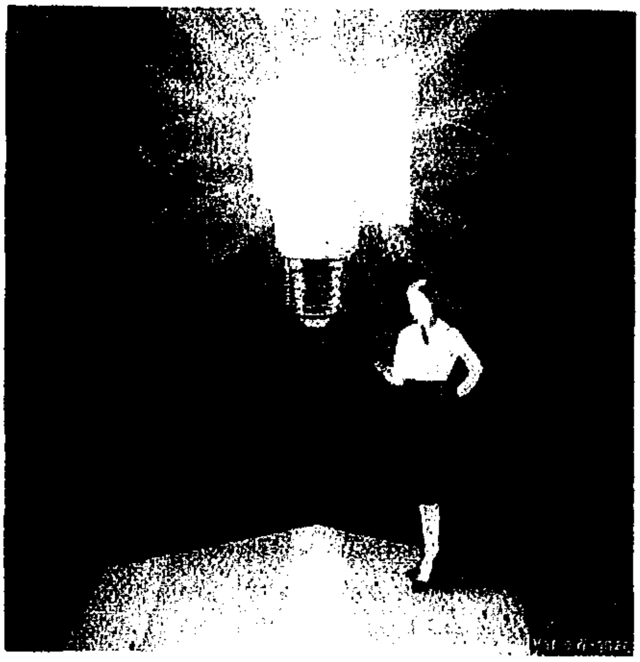
Neuromorphic computing: developing devices loosely modelled on the tangled, densely linked bundles of neurons that process information in animal brains. This may cut energy use and prove useful for pattern recognition and other AI-related tasks (IBM, Qualcomm).

Carbon nanotube transistors: these rolled-up sheets of graphene promise low power consumption and high speed, as graphene does. Unike graphene, they can also be switched off easily. But they have proved difficult to mass-produce (IBM; Stanford University). ■

What comes next

Horses for courses

The end of Moore's law will make the computer industry a much more complicated place



WHEN Moore's law was in its pomp, life was simple. Computers got better in predictable ways and at a predictable rate. As the metronome begins to falter, the computer industry will become a more complicated place. Things like clever design and cunning programming are useful, says Bob Colwell, the Pentium chip designer, "but a collection of one-off ideas can't make up for the lack of an underlying exponential."

Progress will become less predictable, narrower and less rapid than the industry has been used to. "As Moore's law slows down, we are being forced to make tough choices between the three key metrics of power, performance and cost," says Greg Yeric, the chip designer at ARM. "Not all end uses will be best served by one particular answer."

And as computers become ever more integrated into everyday life, the definition of progress will change. "Remember: computer firms are not, fundamentally, in it to make ever smaller transistors," says Marc Snir, of Argonne National Laboratory. "They're in it to produce useful products, and to make money."

Moore's law has moved computers from entire basements to desks to laps and hence to pockets. The industry is hoping that they will now carry on to everything from clothes to smart homes to self-driving cars. Many of those applications demand things other than raw performance. "I think we will see a lot of creativity unleashed over next decade," says Linley Gwennap, the Silicon Valley analyst. "We'll see performance improved in different ways, and existing tech used in new ways."

Mr Gwennap points to the smartphone as an example of the kind of innovation that might serve as a model for the computing industry. Only four years after the iPhone first launched, in 2011, smartphone sales outstripped those of conventional PCs. Smartphones would never have been possible without Moore's law. But although the small, powerful, frugal chips at their hearts are necessary, they are not sufficient. The appeal of smartphones lies not just in their performance but in their light, thin and rugged design and their modest power consumption. To achieve this, Apple has been heavily involved in the design of the iPhone's chips.

And they do more than crunch numbers. Besides their microprocessors, smartphones contain tiny versions of other components such as accelerometers, GPS receivers, radios and cameras. That combination of computing power, portability and sensor capacity allows smartphones to interact with the world and with their users in ways that no desktop computer ever could.

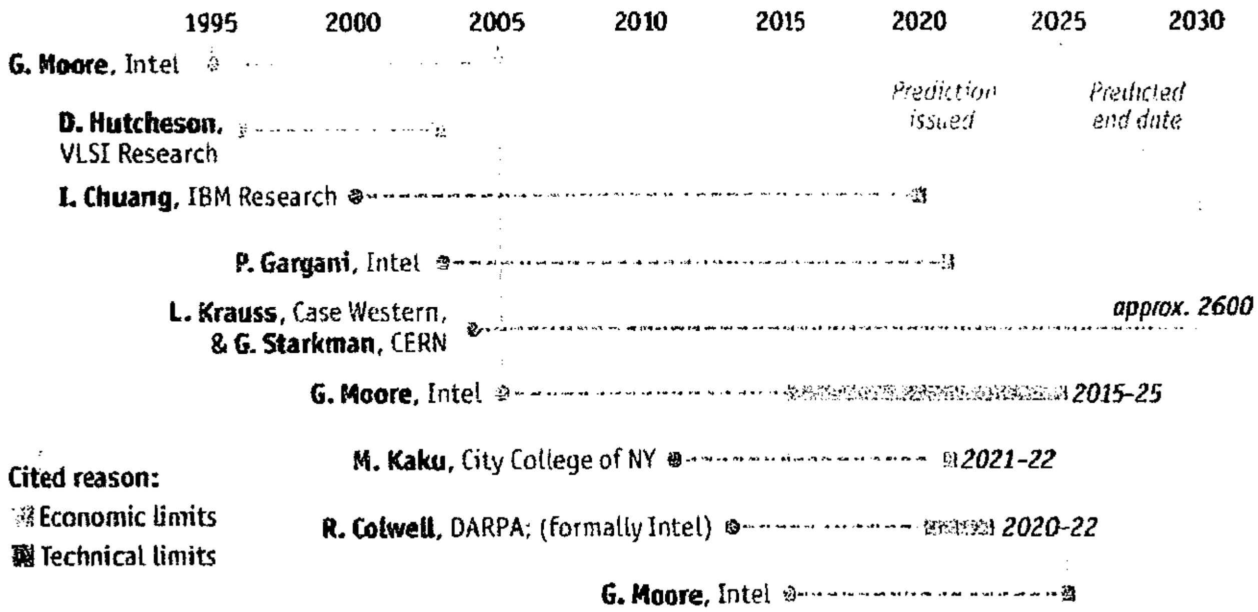
Virtual reality (VR) is another example. This year the computer industry will make another attempt at getting this off the ground, after a previous effort in the 1990s. Firms such as Oculus, an American startup bought by Facebook, Sony, which manufactures the PlayStation console, and HTC, a Taiwanese electronics firm, all plan to launch virtual-reality headsets to revolutionise everything from films and video games to architecture and engineering.

A certain amount of computing power is necessary to produce convincing graphics for VR users, but users will settle for far less than photo-realism. The most important thing, say the manufacturers, is to build fast, accurate sensors that can keep track of where a user's head is pointing, so that the picture shown by the goggles can be updated correctly. If the sensors are inaccurate, the user will feel "VR sickness", an unpleasant sensation closely related to motion sickness. But good sensors do not require superfast chips.

The biggest market of all is expected to be the "internet of things"–in which cheap chips and sensors will be attached to everything, from fridges that order food or washing machines that ask clothes for laundering instructions to paving slabs in cities to monitor traffic or pollution.

Faith no Moore

Selected predictions for the end of Moore's law



Sources: Intel; press reports; *The Economist*

Gartner, a computing consultancy, reckons that by 2020 the number of connected devices in the world could run to 21 billion.

Never mind the quality, feel the bulk

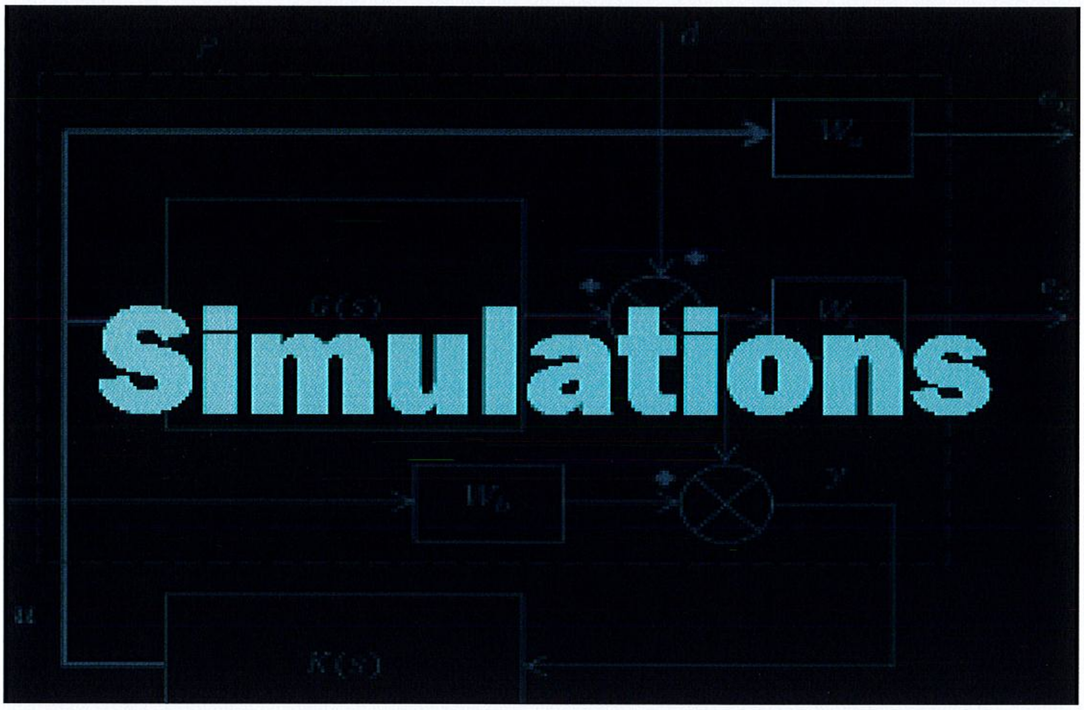
The processors needed to make the internet of things happen will need to be as cheap as possible, says Dr Yeric. They will have to be highly energy-efficient, and ideally able to dispense with batteries, harvesting energy from their surroundings, perhaps in the form of vibrations or ambient electromagnetic waves. They will need to be able to communicate, both with each other and with the internet at large, using tiny amounts of power and in an extremely crowded radio spectrum. What they will not need is the latest high-tech specification. "I suspect most of the chips that power the internet of things will be built on much older, cheaper production lines," says Dr Yeric.

Churning out untold numbers of low-cost chips to turn dumb objects into smart ones will be a big, if unglamorous, business. At the same time, though, the vast amount of data thrown off by the internet of things will boost demand for the sort of cutting-edge chips that firms such as Intel specialise in. According to Dr Yeric, "if we really do get sensors everywhere, you could see a single engineering company—say Rolls Royce (a British manufacturer of turbines and jet engines) —having to deal with more data than the whole of YouTube does today."

Increasingly, though, those chips will sit not in desktops but in the data centres that make up the rapidly growing computing "cloud". The firms involved keep their financial cards very close to their chests, but making those high-spec processors is Intel's most profitable business. Goldman Sachs, a big investment bank, reckons that cloud computing grew by 30% last year and will keep on expanding at that rate at least until 2018.

The scramble for that market could upend the industry's familiar structure. Big companies that crunch a lot of numbers, such as Facebook and Amazon, already design their own data centres, but they buy most of their hardware off the shelf from firms such as Intel and Cisco, which makes routers and networking equipment. Microsoft, a software giant, has started designing chips of its own. Given the rapid growth in the size of the market for cloud computing, other software firms may soon follow.

The twilight of Moore's law, then, will bring change, disorder and plenty of creative destruction. An industry that used to rely on steady improvements in a handful of devices will splinter. Software firms may begin to dabble in hardware; hardware makers will have to tailor their offerings more closely to their customers' increasingly diverse needs. But, says Dr Colwell, remember that consumers do not care about Moore's law per se: "Most of the people who buy computers don't even know what a transistor does." They simply want the products they buy to keep getting ever better and more useful. In the past, that meant mostly going for exponential growth in speed. That road is beginning to run out. But there will still be plenty of other ways to make better computers. ■


Simulations

■ BY CAR : *EN VOITURE*

a car crash : *un accident de voiture*
injured : *blessé*
killed : *tué*
material damage : *dégâts matériels*
to hit : *heurter*
to collide into, to bump into : *entrer en collision avec*
to swerve: *faire une embardée*
to skid: *déraper*
to lose control: *perdre le contrôle*
to avoid: *éviter*
to run over somebody: *écraser quelqu'un*
the highway code: *le code de la route*
a car driver : *un automobiliste*
the driving licence : *le permis de conduire*
to respect/to exceed speed limits : *respecter/dépasser les limitations de vitesse*
to reduce speed : *réduire sa vitesse*
to speed along : *aller à toute vitesse*
at full speed : *à toute vitesse*
to slow down : *ralentir*
to overtake : *doubler*
to drive under the influence of alcohol : *conduire en état d'ivresse*
to go through a red light: *brûler un feu*
to fine: *condamner à une amende*
a penalty, a fine : *une amende*
a crossroads: *un croisement*
a junction: *un carrefour*
a roundabout : *un rond point*
to accelerate : *accélerer*
to have a breakdown : *tomber en panne*
to have the car serviced: *faire réviser sa voiture*
to run out of petrol: *tomber en panne d'essence*
to brake: *freiner*
the handbrake: *le frein à main*
the gear box: *la boîte de vitesses*
to change gear : *changer de vitesse*
a safety belt : *une ceinture de sécurité*
the driving mirror : *le rétroviseur*
the steering wheel : *le volant*
the horn: *le klaxon*
to hoot the horn: *klaxonner*
the engine: *le moteur*
a tyre: *un pneu*
a car licence: *une carte grise*
to insure the vehicle : *assurer le véhicule*
second-hand : *d'occasion*

On the road: Vocabulary Game

Use these definitions to find the right driver's vocabulary in English

1) A legal document which allows you to drive a car: ....

2) What you need to use to slow the car down ....

3) A road sign with three alternating colours ....

4) Something you must wear to protect yourself in the car ....

5) Round object used to direct the car ....

6) When there are too many cars and circulation stops ....

7) If you drive much too fast the police give these ....

8) If you park the car in the wrong place you get a ....

9) A circular shaped crossroads ....

10) A place where two roads meet ....

11) Used to cross the road in safety ....

12) If your car has a puncture you get a ....

Can you find the French equivalent for the following?

The highway code ....

To swerve ....

To breakdown ....

To change gear ....

To insure the car ....

To drive under the influence of alcohol..

To go through a red light ....

To hoot the horn ....

To run over somebody ....

The Accident

An accident occurred in Leicester, on the corner of Oxford Road and Maple Avenue. Both streets are wide and well-paved. The accident took place in the daytime; the skies were clear and the visibility was good. The following people were involved:

Mr/s Dalton: 78 years old and hard of hearing. Is colour-blind and tends to be rather careless. Hates cars and city traffic and tries to ignore them.

Mr/s Panix: 24 years old and rather neurotic. Is nervous behind the wheel and drives cautiously.

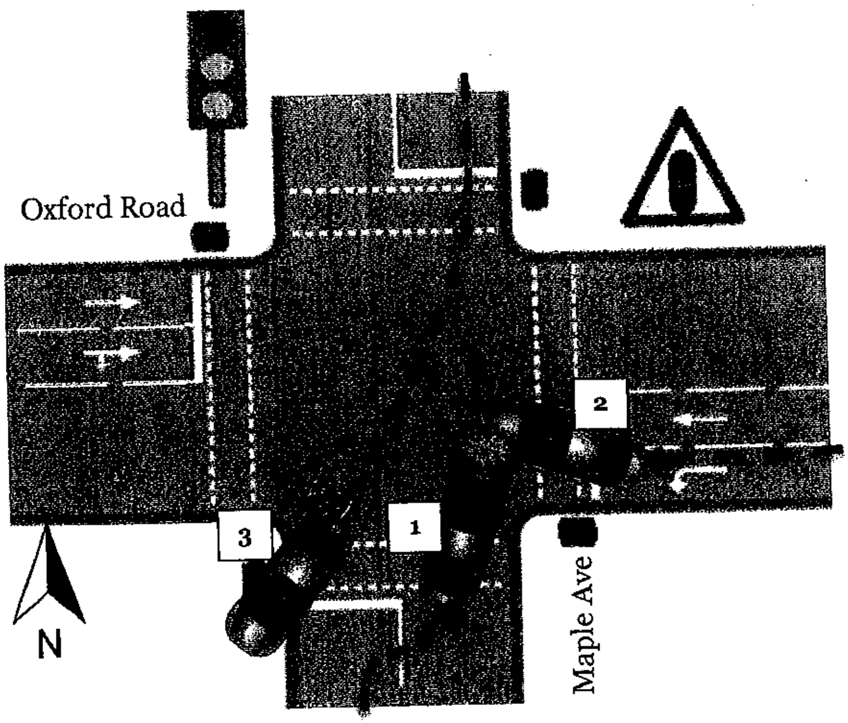
Mr/s Jagg: 20 years old, and rather 'wild' - drives a sports car, fast!

Mr/s Impetchus: 42 years old, parent of two small boys. Is generally careful, but when tired can be impulsive and impatient.

What Happened?
Mr/s Dalton was walking from the southeast corner of the crossroads to the southwest corner. Had just crossed the center line on a red light when suddenly noticed a car approaching rapidly from the south.

Mr/s Jagg was travelling north on Maple Avenue at about 45mph (75km/h) when he first saw Mr/s Dalton. Braked, but seeing that the car wasn't going to stop in time, swerved to the right and ran into Mr/s Impetchus's car, which was stopped at the traffic lights but which was extended six feet (approx 2m) into the crossroads. As this was taking place, Mr/s Panix was approaching the lights from the north at about 20mph. Seeing the accident, she stepped on the brakes but they didn't work. The car swerved to avoid the other two cars, but hit Mr/s Dalton and then ran into a lamppost. Mr/s Dalton was taken to the hospital with a broken leg and bruises. Mr/s Panix was treated for shock.

Who's to blame? *In this simulation, you may be a judge, one of the protagonists, one of their lawyers, or an eyewitness. You will participate in a hearing in a court of law.*



Identify the drivers of the cars on the plan

1).......................

2).......................

3).......................

Simulation : The Oil Slick

Due to terrible weather conditions (high winds, huge waves etc) an oil tanker, called the Henrika, has just sunk off the North West coast of Britain. It sank at exactly 6.00 on Friday 11th November.

Two thousand tonnes of crude oil have leaked from her hold causing an enormous oil slick which is creating damage to the coastal areas, and to the coastal flora and fauna. Fishing, tourism and the local economy have been seriously affected in the towns of Portapool, Westpoint and Old Haven.

A trial is being held in a law court to determine who is responsible for the damage.

People present:

- The Judge, who will organize the trial and come to a decision at the end.

The representatives of the Northern Light shipping company :

- The captain of Henrika who will explain why the oil tanker sank.
- The insurance broker for the Northern Lights shipping company.
- The lawyer for the Northern Lights shipping company.
- A representative from the Weather Station, which issued a warning of imminent bad weather at 20.00 on Thursday 10th November

The local inhabitants :

- Two fishermen who can no longer fish in the coastal waters due to the oil slick
- An owner of a beach shop whose trade has completely stopped since the oil slick has damaged the beaches
- A restaurant owner who no longer has any customers as nobody wants to visit the town anymore
- A local resident whose land looks out onto the coast

The local authorities :

- The mayors of

1) Portopool – a fishing port and nature reserve
2) West Point – a tourist resort with good beaches and the economic heart
3) Old Haven – an old fishing village which has been transformed into a fashionable expensive resort with only 4 and 5 star hotels

- Their lawyers

The Oil company (TEXO)

- A representative of the company

The Government representatives:

- The Minister of the Environment
- His/her under secretary

Others :

- 2 members of the Royal Society for the Protection of Birds
- 2 members of the Friends of the Earth
- A journalist from the local newspaper

Everyone wants to defend their own interests and and should present their arguments to the court.

Stabbed in the Back

On the 24th of November last year, Mrs Wilson stabbed her husband with a knife, killing him. But was it a mistake, or murder?

Mr and Mrs Wilson had been married for three years. The marriage was not a happy one. Mrs Wilson had had several affairs, often receiving lovers at their family home. Mr Wilson had, at least twice, beaten his wife severely. On one of these occasions she went to hospital and the police were involved. No charges were pressed. Approximately three months before the stabbing, Mrs Wilson began seeing her latest lover, Mr Hislop. The relationship was probably kept a secret from Mr Wilson until the 24th of November.

On the 24th of November, Mr Wilson returned home from work on his lunch break with his colleague, Mr Carmichael. While Mr Carmichael waited outside, Mr Wilson entered the house, and found Mrs Wilson and Mr Hislop in bed together. A fight immediately followed in the bedroom between Mr Hislop and Mr Wilson. Mr Wilson knocked Mr Hislop unconscious by hitting him with a lamp. Mr Hislop remained unconscious for the next 40 minutes until the ambulance crew arrived. He was not seriously injured.

While the two men were fighting, Mrs Wilson went downstairs and got a knife from the kitchen. She ran back upstairs with the knife. What happened next is not clear. She chased her husband downstairs. A few seconds later, Mrs Wilson stabbed Mr Wilson from behind in the downstairs corridor of their house. He died from a fatal wound within a few minutes.

The 5 Witnesses: Their Statements to the Police

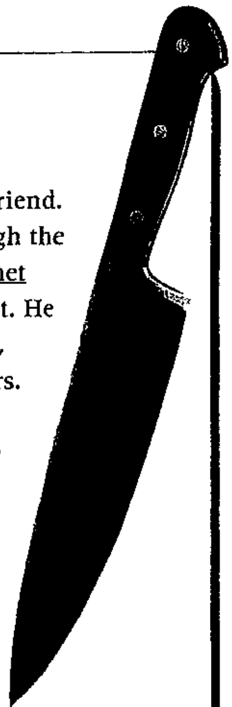
1 Mrs Patel: Next door neighbour
She says that she heard arguments and fights quite often, and saw Mrs Wilson's bruises afterwards. She also saw Mrs Wilson's lovers coming and going. She had agreed with Mrs Wilson to keep the affairs secret. The two women were quite close friends.

2 Dr Simms: Pathologist who carried out the autopsy on Mr Wilson's body
He found two stab wounds in the back, one of which was not serious, the other was fatal. Dr Simms is not sure which wound occurred first.

3 Mr Hislop: Mrs Wilson's lover
He was only a witness to the first part of the fight and was unconscious when the stabbing occurred.

4 Mr Carmichael
Mr Wilson's colleague and good friend. He saw part of the incident through the windows of the house, although net curtains made clear vision difficult. He saw Mrs Wilson come downstairs, take the knife and go back upstairs. He also saw her chase Mr Wilson downstairs but he isn't sure if she jumped or fell on top of him just before the stabbing.

5 Mrs Wilson: The accused
She says that the stabbing was an accident and that she fell on top of her husband after running down the stairs.



You are going to role-play the trial of Mrs Wilson. Your teacher will give each of you a role to play and tell you how long you have to prepare for the trial. Decide carefully what your character would say and how he/she would act in the situation. You are free to interpret the role as you like, but make sure you don't contradict the information you are given. The witnesses must appear in the above order.

Vocabulary check

stab (v)	– drive a knife or sharp object into someone or something
severely	– strongly
press charges	– prosecute / take to court
unconscious	– like they are sleeping
fatal	– causing death
wound (n)	– a cut in the skin
pathologist	– somebody who examines dead bodies to find out why they died
autopsy	– examination of a dead body
net curtains	– thin white curtains that are difficult to see through

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Audio – Video Comprehension

Audio- Video Comprehension 1

Fill in the gaps in the following recording and write your answers in the chart below: /20

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20

China's 1 emissions have reached 2 6.8 billions metric tons a year. It continues to open 3 coal - 4 fired plants at a frenzied pace and its cities are some of the most polluted and smoggiest in the world. But is this the future? It may sound like a pipedream but China is actually leading the way in 5 renewable energy production and investment.

China's 6 hydro power capacity is already the largest in the world and is expected to double to 7 2 thousand mega-watts by 2020. China's 8 solar 9 panel production accounts for more than 40% of the local supply. Beijing is also developing the world's biggest 10 wind power project. Its nickname is "Three Gorges on the land" and it will eventually create more energy than the Three Gorges 6 hydroelectric 11 dam (barrage)

- "It is clear that since 2001 when there were perhaps 3 players in the 10 wind 12 turbines sector, now there's about 70, so we can see there's been an increase in terms of companies who are dealing with 10 wind 12 turbines 13 manufacturing, of course not talking about all the components suppliers that are coming in."

In 14 2008 China installed more 10 wind capacity than any one country in Europe, and Beijing plans to boost 10 wind generated electricity by 15 hundreds giga watts over the next decade.

- "They want to develop their own industry so local companies are really at the forefront of what will be a big global industry, and you know, they are doing that very rapidly with major companies in 10 wind 12 turbines, developing in 8 solar power and in other technologies like 16 electric cars as well."

And it's not just domestic players either. Big western conglomerates such as General Electric are also cashing in with plans to send over 400 12 2008 s to China in

47

the next 2 years. But the 10 wind s of change are slow. So far, 10 wind energy makes up just 17 0.4% of China's electricity supply. And the country's 18 transmission power grid struggles with the intermittent nature of the weather. Paradoxically, for every 10 wind 19 farm there's a back-up 3 power 4 plant power plant.

Despite this, the green revolution is well under way. And although China will probably never be the poster child for a low 20 carbon nation, there is comfort in knowing that the world's biggest emitter is beginning to clean up its act.

<u>Audio – Video Comprehension 2</u>

Are these questions TRUE or FALSE? Tick the correct answer **10 pts**

1. a) The American army is currently using robots to fight wars
   ☒ true ☐ false
   Justify from the recording :
   ....
   ....

   b) The first robot designed by the Moscow University team was a combat robot
   ☐ true ☒ false
   Justify from the recording :
   bomb detecting and destroying
   ....

   c) The Russians have only recently started work on projects with robots
   ☐ true ☒ false
   Justify from the recording :
   ....
   ....

   d) Robot tanks were first used during the Second World War
   ☐ true ☒ false
   Justify from the recording :
   Russia finish war
   ....

   e) The Americans have dominated robot development for decades
   ☐ true ☐ false
   Justify from the recording :
   us took the leads
   ....

2/ Answer the following questions about the recording : **10pts**

a) Give two different types of robots being used in Afghanistan 2 pts

- ....
- ....

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b) Fill in the gaps with the words you hear to describe what this robot does: 3pts

First it analyses the package with these sensors here, and then destroys whatever explosive inside with high - powered water jets just here.

c) i) What 2 things can the spy robot do? 2 pts

- look around corners
- look at the first floor window

ii) What equipment does it use? 1 pt

- an extensible arm with camera

d) What was the first robot tank able to do by itself? 2 pts

- attacks
- shot on it own

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<u>Audio - Video Comprehension 3</u>

<u>Drivetrain</u>: transmission
<u>Neural-networks</u>: réseaux de neurones artificiels

A/ Comprehension questions :

1. Give the 2 adjectives used to describe the new car:
   -
   -

2. What is its top speed?……………………………………………………………

3. What is the main energy source in the car?

……………………………………………………………………………………………

4. a) According to Chris Newman, who has examined the new car?

……………………………………………………………………………………………

   b) What do they say about this new system?

……………………………………………………………………………………………

5. What do these numbers correspond to:

   4………………………………………………………………………………

   25……………………………………………………………………………

   3………………………………………………………………………………

   4000…………………………………………………………………………

6. Give an example of a problem the neural-networks help the car avoid:

……………………………………………………………………………………………

7. Is this car for sale now? Circle the answer: YES / NO Justify your answer

....
....
....

B/ Fill in the gaps exercise from the video:

This project is about re-inventing the 1________. Inside each 1________ is a separate 2_________ motor. The 3________for that comes from here – a bank of 4_________ 5a_________. But each time the 1________ 6________, that energy is 7________ and put back into the 5a_________
In the 8________ of the car is a very small petrol 9________, smaller than a motorbike's. And that generates more 3________ for the 5b________. Critically, it gives this car a range of 10________ miles. That gets round the big problem with other
5b________ cars – they take a long time to 11__________.

=} Write your answers in the chart below:

1/	2/	3/
4/	5a/	5b/
6/	7/	8/
9/	10/	11/

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Problèmes de vocabulaire

Vous avez déjà remarqué dans la langue courante la ressemblance de nombreux mots français et anglais. En anglais scientifique, la proportion du nombre de termes d'origine grecque ou latine que l'on retrouve également en français est encore plus élevée que dans la langue générale.

Cependant certains mots qui ont une orthographe presque identique voire semblable dans les deux langues ont des sens différents : il s'agit des « ***faux amis*** ».

actually : en réalité, en fait, vraiment
compass : boussole
consistent : logique
currently : actuellement
engine : moteur
eventually : finalement
evidence : preuves
hazard : danger
issue : numéro de revue ; problème, question
large : grand
lecture : conférence
location : emplacement
physician : médecin
prejudice : préjugé
résumé : curriculum vitae
scholar : savant, érudit
sensible : raisonnable
to achieve : accomplir
to deceive : tromper
to resume : reprendre
to sort : trier
to supply : fournir

Les pluriels irréguliers : il s'agit des noms dont le pluriel n'et ni en -s ni en -es.

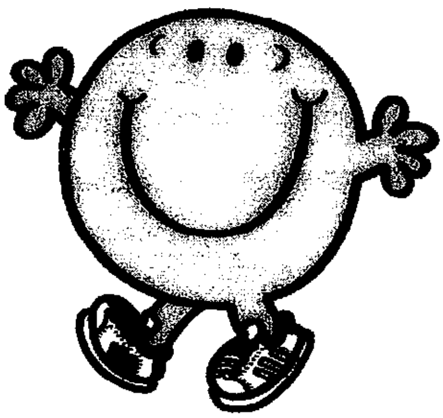
analysis : analyses (prononc : iz)
apex : apexes, apices (sommet)
automaton : automata
axis : axes
basis : bases (base, sens général)
base : bases (base, math, chimie)
crisis : crises
criterion : criteria
datum : data
hypothesis : hypotheses
phenomenon : phenomena
series : series (série)
stimulus : stimuli
stratum : strata
thesis : theses

Les adjectifs terminés par -ic ou -ical : ces adjectifs sont particulièrement nombreux dans les sciences

acoustic/ acoustical	astrological	aerodynamic
analogic/analogical	chemical	algebraic
astronomic/astronomical	critical	atmospheric
biologic/biological	cylindrical	atomic
geologic/geological	mathematical	automatic
geometric/geometrical	mechanical	basic
	meteorological	botanic
	numerical	elastic
	physical	electronic
	practical	ionic
	spherical	kinetic
	statistical	logarithmic
	theoretical	metallic
	technical	metric
		realistic
		scientific

Quelques cas particuliers :

- **electric** charge/current/shock/guitar, etc. mais **electrical** engineering
- **economic** (ce qui a trait à l'économie) mais **economical** (ce qui fait faire des économies)
- **historic** (qui fait date) mais **hist orical** (qui appartient à l'histoire)



LES VERBES IRREGULIERS

Infinitif	Prétérit	Participe Passé	Traduction
be	was / were	been	être
become	became	become	devenir
begin	began	begun	commencer
bet	bet	bet	parier
bid	bid	bid	offrir (un prix)
bite	bit	bitten	mordre
blow	blew	blown	souffler
break	broke	broken	casser
bring	brought	brought	apporter
build	built	built	construire
burn	burnt	burnt	brûler
buy	bought	bought	acheter
cast	cast	cast	jeter, distribuer les rôles de
catch	caught	caught	attraper
choose	chose	chosen	choisir
come	came	come	venir
cost	cost	cost	coûter
cut	cut	cut	couper
deal	dealt	dealt	distribuer
do	did	done	faire
draw	drew	drawn	dessiner
dream	dreamt	dreamt	rêver
drink	drank	drunk	boire
drive	drove	driven	conduire
eat	ate	eaten	manger
fall	fell	fallen	tomber
feed	fed	fed	nourrir
feel	felt	felt	sentir, éprouver
fight	fought	fought	combattre
find	found	found	trouver
fly	flew	flown	voler
forbid	forbade	forbidden	interdire

Infinitif	Prétérit	Participe Passé	Traduction
forget	forgot	forgotten	oublier
freeze	froze	frozen	geler
get	got	got	obtenir
give	gave	given	donner
go	went	gone	aller
grow	grew	grown	grandir
hang	hung	hung	pendre, accrocher
have	had	had	avoir
hear	heard	heard	entendre
hide	hid	hidden	(se) cacher
hit	hit	hit	frapper, atteindre
hold	held	held	tenir
hurt	hurt	hurt	blesser
keep	kept	kept	garder
know	knew	known	savoir, connaître
lay	laid	laid	poser à plat
lead	led	led	mener
lean	leant	leant	s'appuyer
learn	learnt	learnt	apprendre
leave	left	left	laisser, quitter
lend	lent	lent	prêter
let	let	let	permettre, louer
lie	lay	lain	être étendu
light	lit	lit	allumer
lose	lost	lost	perdre
make	made	made	faire, fabriquer
mean	meant	meant	signifier
meet	met	met	(se) rencontrer
pay	paid	paid	payer
put	put	put	mettre
read	read	read	lire
ring	rang	rung	sonner
rise	rose	risen	s'élever, se lever
run	ran	run	courir
say	said	said	dire
see	saw	seen	voir

Infinitif	Prétérit	Participe Passé	Traduction
sell	sold	sold	vendre
send	sent	sent	envoyer
set	set	set	fixer
shake	shook	shaken	secouer
shine	shone	shone	briller
shoot	shot	shot	tirer
show	showed	shown	montrer
shrink	shrank	shrunk	rétrécir
shut	shut	shut	fermer
sing	sang	sung	chanter
sink	sank	sunk	couler
sit	sat	sat	être assis
sleep	slept	slept	dormir
smell	smelt	smelt	sentir (odorat)
speak	spoke	spoken	parler
spend	spent	spent	dépenser
spoil	spoilt	spoilt	gâcher, gâter
stand	stood	stood	être debout
steal	stole	stolen	voler, dérober
stick	stuck	stuck	coller
sting	stung	stung	piquer
stink	stank	stunk	puer
strike	struck	struck/stricken	heurter, percuter
swim	swam	swum	nager
swing	swung	swung	se balancer
take	took	taken	prendre
teach	taught	taught	enseigner
tell	told	told	dire, raconter
think	thought	thought	penser
throw	threw	thrown	jeter
understand	understood	understood	comprendre
wake	woke	woken	(se) réveiller
wear	wore	worn	porter (des vêtements)
win	won	won	gagner
write	wrote	written	écrire

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